6. Marine Physical Processes

This chapter of the Scoping Report describes the potential impacts arising from the construction, operation and maintenance and decommissioning of the Eastern Green Link 3 (EGL 3) hereafter referred to as 'the Project' on marine physical processes. The marine physical environment includes the following elements:

- Hydrodynamics including water levels, currents, waves and winds;
- Geomorphology including bathymetry, geology, surficial sediments and substrate; and
- Sediment transport, including suspended sediment.

In addition, water and sediment quality is also included in this chapter due to the close linkages with marine physical processes.

There may be interrelationships related to the potential effects on marine physical processes and other disciplines. Therefore, please also refer to the following chapters:

- Chapter 7 – Intertidal and Subtidal Benthic Ecology: will identify the potential impacts on supporting habitats and key prey species for marine mammals and marine reptiles.
- Chapter 8 – Fish and Shellfish: will identify the potential impacts on key prey species for marine mammals and marine reptiles.
- Chapter 9 – Intertidal and Offshore Ornithology.
- Chapter 10 – Marine Mammals and Marine Reptiles.
- Chapter 12 – Commercial Fisheries.
- Chapter 14 – Marine Archaeology.

6.1. Study Area Definition

The Scoping Boundary for the Project extends from MHWS in England to MHWS in Scotland. It is nominally 1 km wide, 500 m either side of the centreline, but however, it widens in areas where there is still optionality in the design e.g., to allow for micro-routeing around potential seabed features. It is anticipated that the Marine Licence application boundary will ultimately be 500 m following refinement and rationalisation as the MEA and design process evolves.

There are two proposed Landfalls in England being considered at this stage of the marine environmental assessment process; Anderby Creek and Theddlethorpe. These options will be subject to further technical feasibility work and stakeholder consultation and will be refined to one preferred option for inclusion in the subsequent Marine Licence application for the Project.

The Study Area for marine physical processes includes the Scoping Boundary plus an additional 15 km either side. This buffer is informed by the tidal excursion, which varies along the proposed submarine cable corridor. Regional scale modelling tools indicate that the largest tidal excursions occur at both the English and Scottish proposed landfalls where they are 10 km on a mean tide (equivalent to around 14 km on a spring tide). Locally, some larger excursions can occur. In other areas of the proposed submarine cable corridor tidal excursions are much shorter, being around 5 km on a mean tide. The adoption of a 15 km buffer throughout provides a precautionary approach. The extent of the Study Area will be reviewed and refined for the Marine Environmental Assessment (MEA).

Kilometre Points (KPs) are used throughout this Chapter to provide context as to where within the Study Area a feature lies. KP 0 is defined at the Anderby Creek Landfall. As there are still alternative Landfalls being considered, KPs have been created along the longest route from the proposed English Landfall at Anderby Creek, around the Holderness Offshore Marine Conservation Zone (MCZ) to the proposed Scottish Landfall at Sandford Bay. The KPs for this route are referenced as KP0 – KP575.3. Alternative options, which branch off this longest route, are routed from the proposed English Landfall at Theddlethorpe to the point where it converges with the longest route (referenced as T_KP0 to T_KP18); and through Holderness Offshore MCZ, which is referenced as KP0 to H_KP40.

6.2. Data Sources

Data sources for the baseline characterisation will be presented in accordance with relevant guidance for the topic. The datasets that will be used to inform the description of the baseline environment for the MEA are described in the following sub-sections.

6.2.1. Site-specific Survey Data

A site-specific geophysical survey will be carried out along the length of the proposed submarine cable corridor (including the landfall). The width of the survey will nominally be 500 m, but this may increase to 1 km in some area if there are features of interest. Preliminary interpretation of the geophysical data will be undertaken onboard the survey vessel and environmental sampling stations will be selected based on this interpretation. Chemical analysis of the grab samples will be undertaken which will be used to inform the MEA.

A method statement for the survey works will be agreed with regulators prior to the survey commencing.

6.2.2. Publicly Available Data

A desk-based review of publicly available data sources (literature and GIS mapping files) would be used to supplement the site-specific geophysical/geotechnical surveys and to describe the wider baseline marine physical environment. Table 6-1 lists the key data sources which would be used in the assessment.

Table 6-1: Key publicly available data sources for Marine Physical Processes

Data Source	Description	Coverage	
		English Study Area	Scottish Study Area
The European Marine Observation and Data Network (EMODnet, 2020)	Digital Terrain Model (DTM)	✓	✓
UK Hydrographic Office (UKHO, 2014)	Admiralty bathymetric survey data used to generate navigational charts and a major data source in the EMODnet DTM.	✓	✓
Admiralty Total Tide (ATT) software package	Tidal planes and tidal diamonds informing water levels and tidal flows	✓	✓
Environment Agency Coastal Design Sea Levels for the UK (EA, 2018)	Coastal flood boundary conditions around the coast	✓	✓
UK climate change projections (UKCP, 2018)	Sea level rise predictions along the coast	✓	✓
UK Renewable Atlas (ABPmer, 2017)	Maps of tidal range (spring and neap), peak tidal flows (spring and neap) and mean tidal ellipses, annual wave heights and wind speeds.	✓	✓
SEASTATES (ABPmer, 2018)	Modelled hindcast wind and wave data.	✓	✓
Climate System Forecast Reanalysis (CFSR) (Saha et al., 2010)	Hourly hindcast wind data at 0.2 degree resolution, spanning 44 years (1979 to 2023), used to drive SEASTATES.	✓	✓
British Geological Society (BGS, 2021)	Maps of seabed sediments, quaternary deposit thickness and structural geology offshore.	✓	✓
Shoreline Management Plan – SMP3 (Scott Wilson, 2010).	Local annual surveys of coastline	✓	
Joint Nature Conservation Committee (JNCC) Coasts and seas of the UK (Barne et al., 1996)	Region 3 North-east Scotland: Cape Wrath to St. Cyrus – description of coastal landform, sediment transport and geology.		✓
JNCC Coasts and seas of the UK (Barne et al., 1995)	Region 6 Eastern England: Flamborough Head to Great Yarmouth – description of coastal landform, sediment transport and geology.	✓	
Kenyon and Cooper (2005)	Sediment transport pathways in the North Sea	✓	✓
Cefas (2016)	Suspended Particulate Matter (SPM) – monthly, seasonal and annual maps	✓	✓

Data Source	Description	Coverage	
		English Study Area	Scottish Study Area
Database on the Marine Environment (DOME, 2023)	Sediment quality data	✓	✓
Environment Agency Bathing Waters map and monitoring data (Magic, 2023)	Water quality	✓	
SEPA bathing waters (SEPA, 2023)	Water quality		✓
JNCC (2023)	Marine Designated Sites shape file layer.	✓	✓
Marine Scotland	Scoping reports on Scottish Offshore Wind Farm (OWF) developments including Morven (RPS, 2023a), Ossian (RPS, 2023b) and Muir Mhòr (GoBe, 2023).		✓
Crown Estate Marine Data Exchange	Environmental Impact Assessment Report (EIAR) for English OWF projects including Triton Knoll (RWE Npower, 2012), Lincs, Lynn and Inner Dowsing (Offshore wind power, 2003), Hornsea 1 and 2.	✓	
Marine Scotland	National Marine Plan interactive Marine Scotland - National Marine Plan Interactive (atkinsgeospatial.com)		

6.2.3. Additional Studies

Beyond the collection of site-specific geophysical and geotechnical survey data, no additional studies are proposed to inform this assessment.

6.3. Consultation

Consultation on the proposed Offshore Scheme has not yet commenced for the marine physical processes topic.

Consultation will be undertaken with relevant stakeholders to supplement desk-top review, geophysical, geotechnical and physical-chemical data acquisition, studies and assessment as required.

The following bodies will be consulted during the MEA process, as a minimum to ensure the most-up-to-date information is collated.

Table 6-2: List of stakeholders to be consulted

England	Scotland
Marine Management Organisation (MMO)	Marine Directorate – Licencing Operations Team (MD-LOT)
Centre for Environment, Fisheries and Aquaculture Science (Cefas)	Centre for Environment, Fisheries and Aquaculture Science (Cefas)
Joint Nature Conservation Committee (JNCC)	Joint Nature Conservation Committee (JNCC)
Natural England (NE)	NatureScot
The Crown Estate	Crown Estate Scotland
Environment Agency	Scottish Environmental Protection Agency (SEPA)

6.4. Baseline Characterisation

This section has been split into the following sub-sections to provide an overview of the marine physical processes baseline in the Study Area:

- English baseline characterisation
- Scottish baseline characterisation

6.4.1. English Baseline Characterisation KP 0 – KP 431.4

6.4.1.1. Bathymetry and seabed features

The EMODnet Digital Terrain Model (DTM) has been used to inform the baseline understanding of bathymetry and tidal levels across the Study Area. The DTM is based on bathymetric data from various sources including UKHO survey data.

Water depths across the English Study Area generally increase with distance along the proposed submarine cable corridor, being 25 m below mean sea level (MSL) offshore of Spurn Head at KP 90, 55 m below MSL offshore of Flamborough Head at KP 150 and 75 m below MSL at the northern end of the English Study Area at KP 300 (Figure 6.1, Drawing: C01494_EGL3_BATH_002).

Other than the gradual deepening along the proposed submarine cable corridor, significant bathymetric features in the English Study Area are constrained to within approximately 50 km of the Lincolnshire coast where the naturally deep channel of the Silver Pit lies adjacent to numerous shoals and banks including the Triton Knoll sand bank, Inner Dowsing Falls and Outer Dowsing Shoal.

6.4.1.2. Water Levels

Data from the UK renewables atlas (ABPmer, 2017) and the ATT software package have been used to inform the baseline understanding on tidal levels across the Study Area, while data from the Environment Agency's coastal flood boundary conditions (EA, 2018) and from the UK climate change projections (UKCP18) have been used to inform the baseline understanding of non-tidal influences on water levels.

Water levels in the English Study Area are predominantly driven by tidal processes. Tides in the English Study Area are semi-diurnal, with two high and two low tides per day. Tidal planes have been extracted from the ATT software package at Skegness (at the southern extent of the Study Area on the coast) and at T022B (approximately 28 km west of KP 395) and are given in Table 6-3.

Table 6-3: Tidal levels extracted from ATT at locations in the English Study Area

	Tide Level (m relative to MSL)	
	Skegness	T022B – approx. 28 km west of KP 395
Highest Astronomical Tide (HAT)	3.6	1.9
MHWS	2.9	-
Mean High Water Neap (MHWN)	1.36	-
Mean Low Water Neap (MLWN)	-1.5	-
Mean Low Water Spring (MLWS)	-3.1	-
Lowest Astronomical Tide (LAT)	-3.8	-2.1

Non-tidal or meteorological effects can also influence the water level. The height of a 1 in 200-year return period storm surge near the proposed landfalls in the English Study Area is 4.8 m above MSL (EA, 2018).

UKCP18 suggests an increase in MSL of more than 0.7 m at 2100 along the Lincolnshire coastline. Future changes in storm surges have been predicted to be indistinguishable from background variation (Lowe et al., 2009), although extreme surge level event frequency is likely to increase (IPCC, 2021).

6.4.1.3. Currents

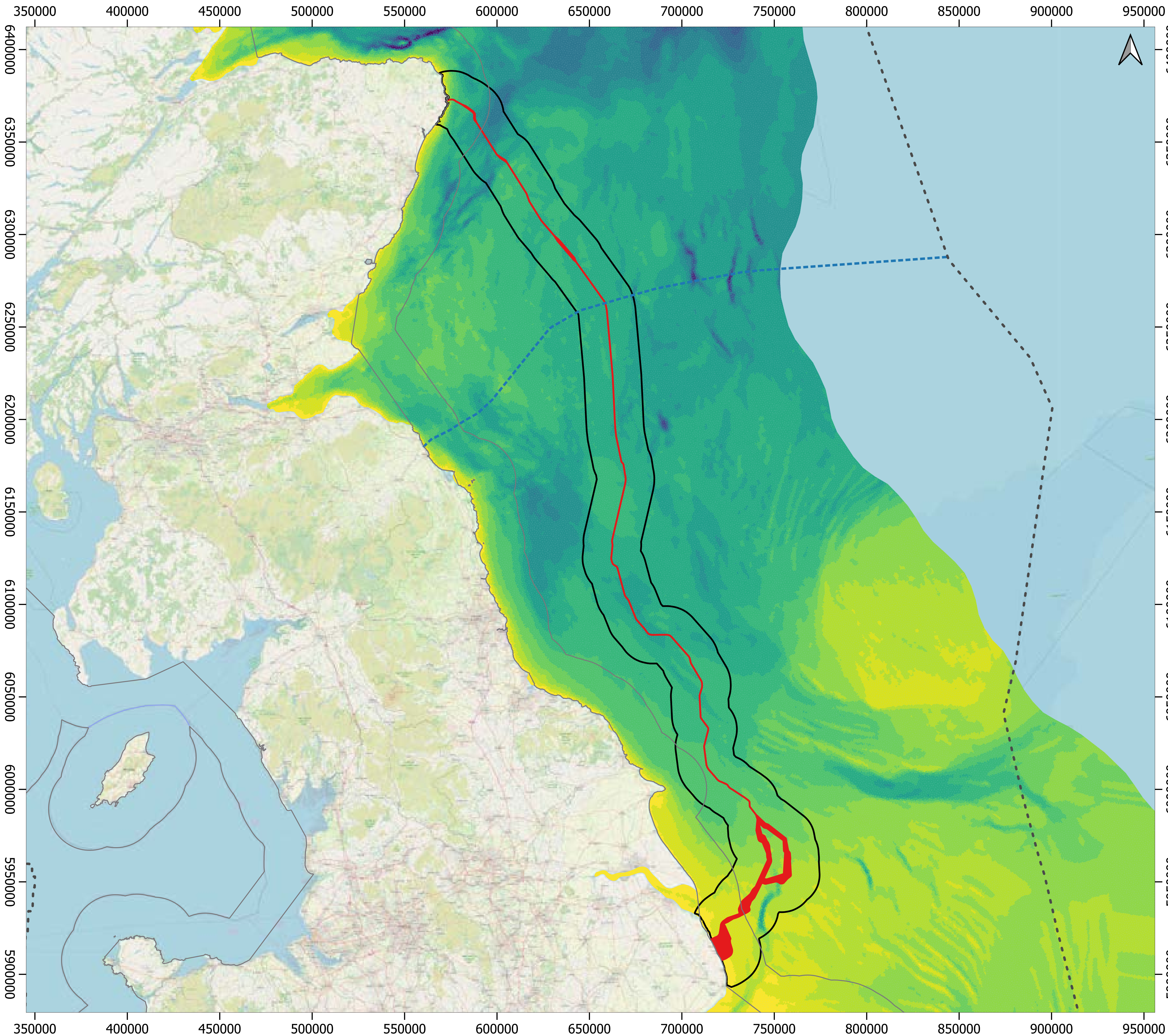
Data from the UK renewables atlas (ABPmer, 2017) and the ATT software package have been used to inform the baseline understanding on tidal flows across the English Study Area. Peak spring tidal flows across the English Study Area are shown in Figure 6.2 (Drawing: C01494_EGL3_GEO_005).

Tidal currents in the English Study Area are generally orientated southwards on the flood tide and northwards on the ebb tide. The currents close to the proposed landfalls in the English Study Area are bi-directional in nature, aligned with the coast, while currents become slightly more orbital in nature offshore. Fastest currents occur offshore of Spurn Head where peak spring tide current speeds are up to approximately 1.4 m/s. Current speeds reduce inshore and in a northward direction with spring tide current speeds of 1 m/s close to the proposed landfalls and of 0.45 m/s at the northern end of the English Study Area. Peak neap current speeds are approximately half the quoted peak spring tide current speeds.

There is a slight dominance in the southward flowing flood currents, particularly in the southern part of the English Study Area. Superimposed on the regional scale flow pattern, local flow variations can be expected to occur in response to bathymetric features (for example to realign with channel features, or around banks).

Surge driven flows in the Study Area are not expected to contribute significantly to sediment transport (Kenyon and Cooper, 2005).

Figure 6-1: Bathymetry (Drawing: C01494_EGL3_BATH_002).



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Bathymetry

C01494-EGL3-BATH-002-B

Exclusive Economic Zone Limit (EEZ)

Scottish Adjacent Waters

12NM Limit

EGL 3 Scoping Boundary

15km Study Area

EMODnet Bathymetry 2020 (metres)

-186.3
-180.0
-170.0
-160.0
-150.0
-140.0
-130.0
-120.0
-110.0
-100.0
-90.0
-80.0
-70.0
-60.0
-50.0
-40.0
-30.0
-20.0
-10.0

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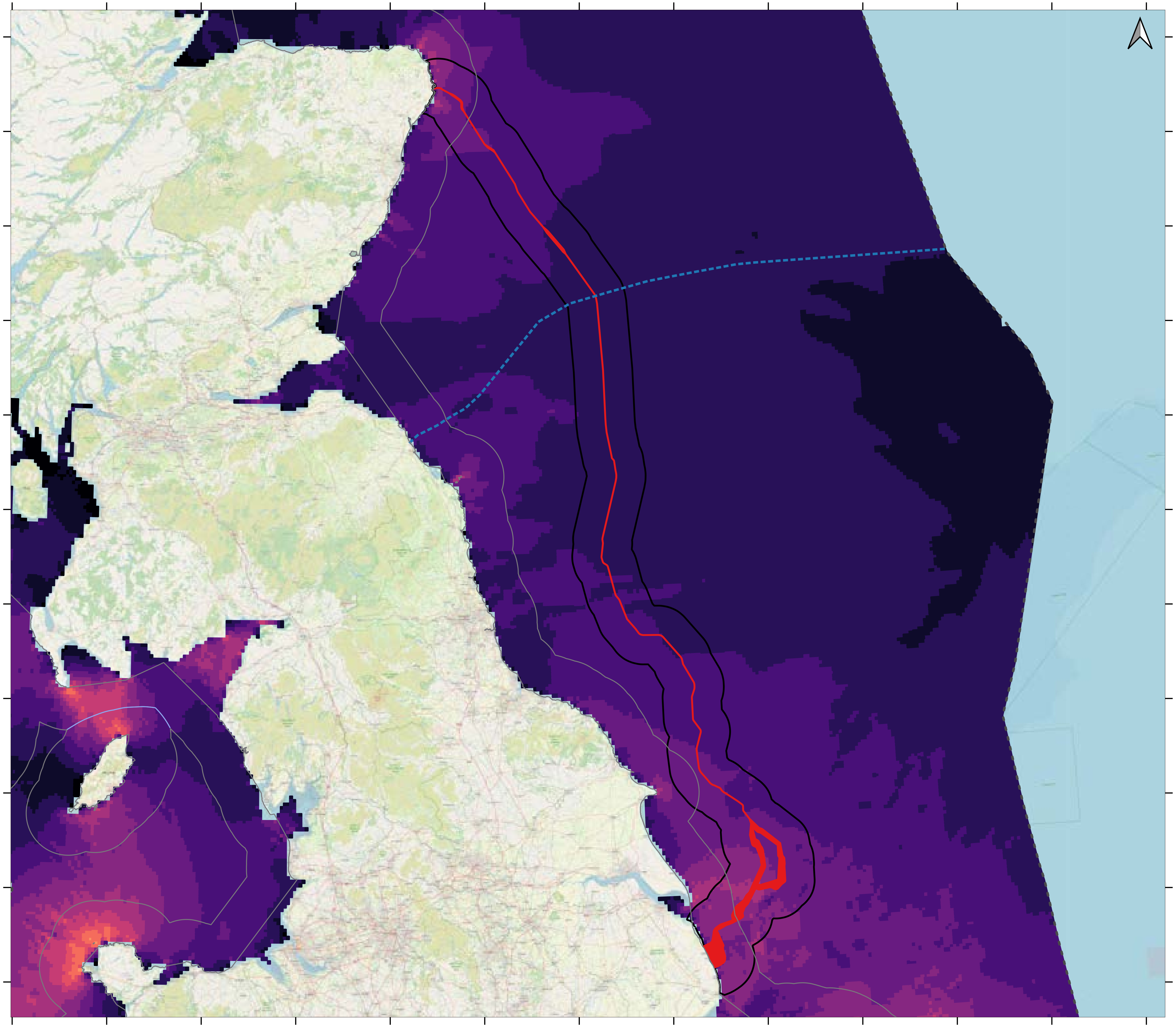

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Peak Flow for a Mean Spring Tide

C01494-EGL3-GEO-005-B

- Exclusive Economic Zone Limit (EEZ)
- Scottish Adjacent Waters
- 12NM Limit
- EGL 3 Scoping Boundary
- 15km Study Area

Peak Flow ABPmer 2017 (m/s)

- <0.11
- 0.11 - 0.26
- 0.26 - 0.51
- 0.51 - 0.76
- 0.76 - 1.01
- 1.01 - 1.26
- 1.26 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2 - 2.51
- 2.51 - 3.01
- 3.01 - 3.51
- 3.51 - 4
- >4.00

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6.4.1.4. Winds and Waves

Climatological wind and wave data from SEASTATES (ABPmer, 2018) have been used to inform the baseline understanding of the wind and wave climate across the English Study Area. SEASTATES is driven by the CFSR wind dataset (Saha et al., 2010).

Prevailing winds across the English Study Area are from the south to west sectors. The strength of the winds increases with distance offshore (due to the effect of coastal sheltering to the dominant wind directions inshore), with mean wind speeds of 6.4 m/s at KP 14 (close to the proposed landfalls), increasing to 8.1 m/s at KP 306 (close to the northern extent of the English Study Area). Wind roses at KP 14 and KP 306 are shown in Figure 6.3.

The wave climate across the English Study Area is controlled by a combination of locally generated wind waves and swell waves generated elsewhere in the North Sea. The primary wave direction along the proposed submarine cable corridor changes, with waves most frequently from the northeast close to the proposed landfalls and from the north further offshore. This change reflects the varying fetch lengths for different wind directions with distance along the proposed submarine cable corridor.

In addition to the change in direction, wave heights reduce in an inshore direction as a result of friction effects in the shallower nearshore waters. Mean significant wave heights close to the northern extent of the English Study Area (at KP 306) are 1.7 m, reducing to 0.6 m close to the proposed landfalls (at KP 14). There is a seasonal trend in the wave climate with smallest mean significant wave heights in the summer months and largest mean significant wave heights in the winter months (up to 2.1 m at KP 306). Wave roses at KP 14 and KP 306 are shown in Figure 6.3.

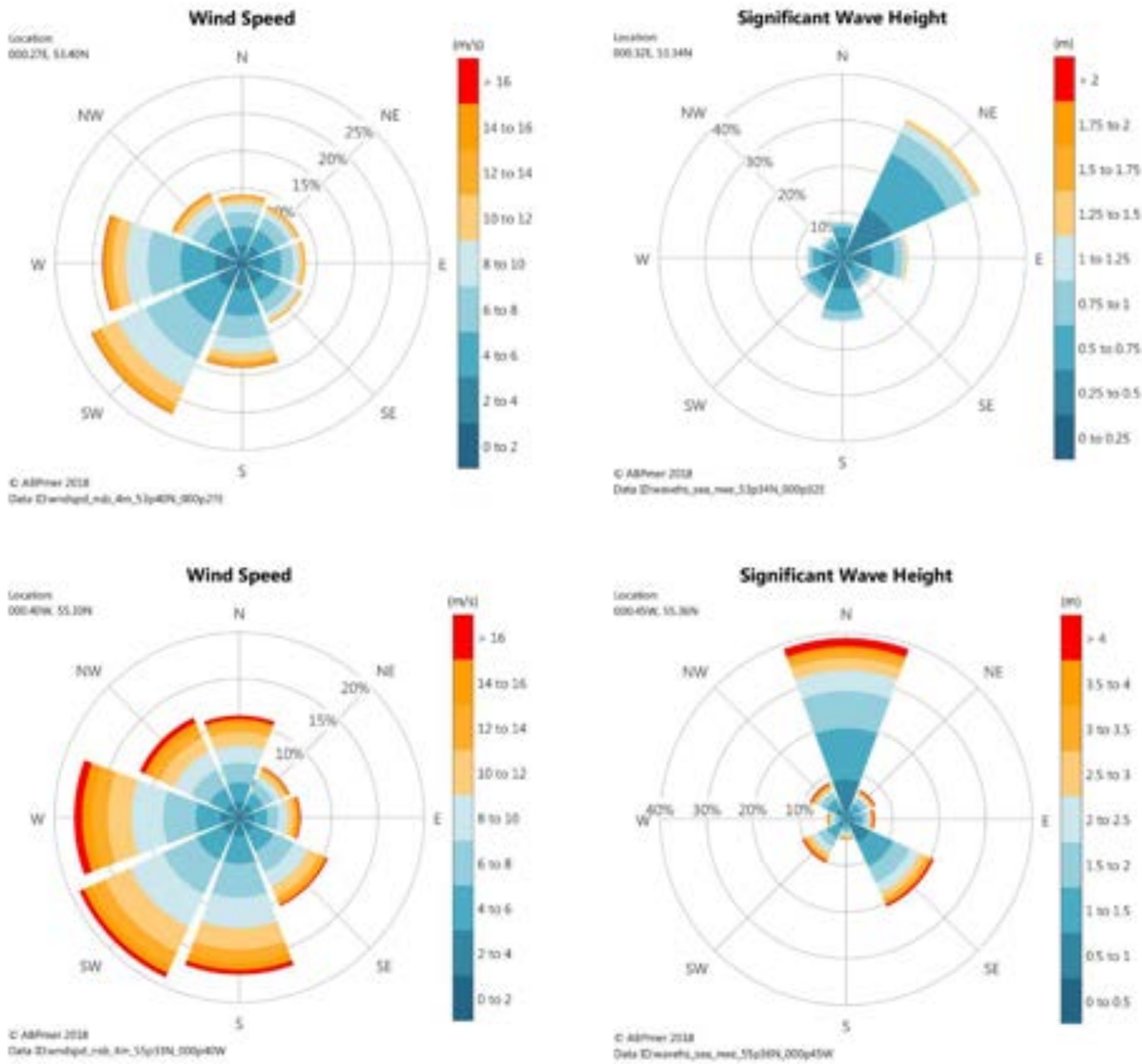


Figure 6-3: Wind and wave roses at KP 14 (upper panels) and KP 306 (lower panels) (ABPmer, 2018).

6.4.1.5. Geology and Seabed Sediments

The bedrock geology across the English Study Area is characterised by chalk at the southern end of the proposed submarine cable corridor, mudstone and limestone to the north of Flamborough Head and undifferentiated Triassic rocks (mix of rock, siliciclastic, argillaceous and sandstone) at the northern extent.

The thickness of Quaternary deposits across the Study Area is typically between 5 and 20 m, with some localised patches of thicker deposits (of more than 50 m) in the southern section of the proposed submarine cable corridor (mainly to the south of Spurn Point) and some areas of thinner deposits (less than 5 m) offshore to the north of Flamborough Head.

Surficial sediments in the English Study Area are predominantly a mix of sands and gravels, with sandy gravel dominating at the southern end and close to the proposed landfalls, transitioning to sand with some patches of slightly gravelly sand, gravelly sand and sandy gravel at the northern extent of the English Study Area (Figure 6.4, Drawing: C01494_EGL3_GEO_006).

The English Study Area intersects some active marine aggregate extraction zones including Humber (Area 514) 1, 2, 3 and 4 to the north of the proposed submarine cable corridor close to KP 53 and Off Saltfleet (Area 197), Humber Estuary (Area 400 and Area 106) and Humber Overfalls (Area 493) to the south of the proposed submarine cable corridor close to KP 29, all of which are licenced until at least the end of 2029.

6.4.1.6. Geomorphology and Sediment Transport

Net sediment transport in the English Study Area is southwards close to shore, driven by the tidal asymmetry (with residual tidal flows to the south) (Kenyon and Cooper, 2005). Further offshore there is a bed-load parting zone, beyond which the net sediment transport is northwards. The proposed submarine cable corridor between KP 89 and the KP 155 lies close to the bed load parting zone in an area of low net sediment transport. Further north the sediment transport is driven by wave action and little sediment transport is expected (with wave driven transport restricted to shoals and/or storm events).

6.4.1.7. Coastal Geomorphology

The coastline within the English Study Area extends along the Lincolnshire coast from Sand Hail Flats in the north to just north of Gibraltar Point in the south. The coastline is generally made up of soft geology (predominantly gravelly sand and gravelly muddy sand) with many wide sandy beaches to Donna Nook, decreasing in width towards Mablethorpe. The beaches and sand flats are accreting, fed by sediment from the eroding Holderness cliffs, with a greater build up occurring at the top of the beaches than at the bottom resulting in a steepening of the beaches (Scott Wilson, 2010).

At Donna Nook and Gibraltar Point there is extensive and well-developed saltmarsh. In some locations (including Donna Nook, Saltfleetby and Gibraltar Point) sand dunes have formed.

The beaches between Saltfleetby and Gibraltar Point are formed of a thin layer of sand, overlying clay. Historically during storms, the thin layer of sand has been eroded exposing the underlying clay. To counter this erosion the Environment Agency has undertaken beach nourishment along the entire coast between Mablethorpe and Skegness. Much of this coastline also has a variety of 'hard' defences and dunes behind the beaches which, along with the ongoing beach nourishment, provide protection against flooding.

The Lincolnshire shoreline management plan along the coastline within the English Study Area is to hold the line.

6.4.1.8. Sediment and Water Quality

Data from the Cefas Suspended Sediment Climatology model (Cefas, 2016) show that over the period between 1998 – 2015, mean SPM values are approximately 35 mg/l close to the proposed landfalls (up to KP 7) reducing to 15 mg/l at KP 30 and 5 mg/l at KP 50. SPM is less than 1 mg/l from KP 172 to the northern extent of the English Study Area (Figure 6.5, Drawing: C01494_EGL3_GEO-004).

The proposed submarine cable corridors pass through the Water Framework Directive (WFD) Lincolnshire water body, which is classed as a moderately exposed macrotidal water body (Water body ID GB640402492000). There are designated bathing waters (BW) at Mablethorpe Town, Moggs Eye and Anderby. All three have achieved 'Excellent' status for 2022, having maintained this classification for the last four bathing seasons (based on samples taken from 2018 through to 2022). Unofficially, it is considered by the Environment Agency that the full coastline from Mablethorpe to Anderby is a bathing water.

The concentrations of metals in sediments within the North Sea are generally higher in the coastal zone and around estuaries, decreasing offshore indicating that river input and run-off from land are significant sources. The sediments within the English Study Area are typically coarse sediments (sands and gravels with only low mud content), which pose a low risk for anthropogenic contaminants.

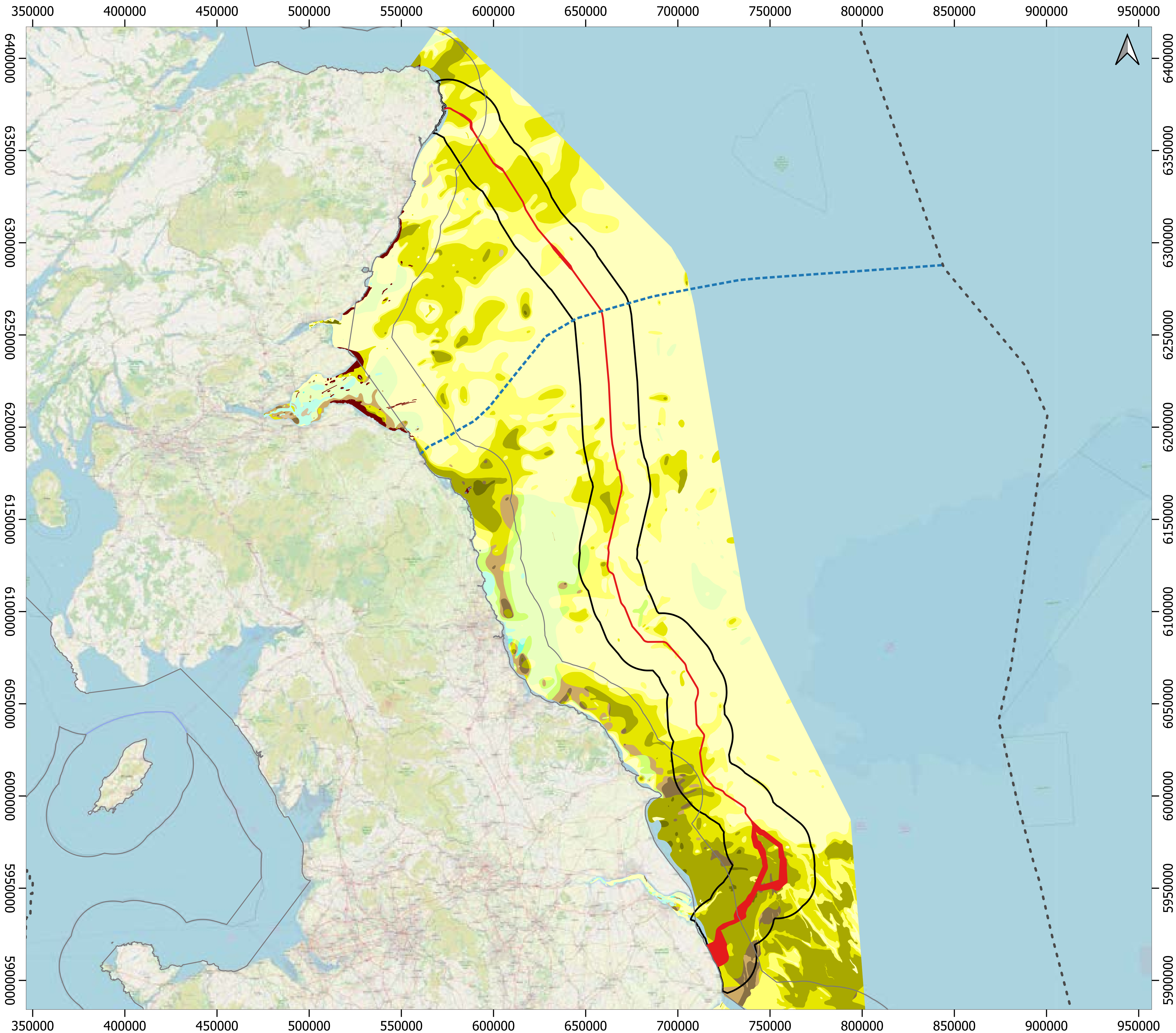
Analysis of sediment quality samples from the International Council for the Exploration of the Sea (ICES) DOME Portal (DOME, 2023) was conducted along the full length of the proposed submarine cable corridor. Reported concentrations of arsenic, mercury, cadmium, chromium, copper, nickel, lead and zinc were checked for all available samples. For all sample records, contaminant levels were below Cefas Action Level (AL) 1. Sediment sampling from OWF studies also concluded that seabed sediment does not contain significant levels of pollution (although these studies were constrained to the southern part of the proposed submarine cable corridor only).

There are numerous closed disposal sites within the English Study Area, many of which are associated with OWF developments. These closed disposal sites include Spurn Head (HU100), Hornsea disposal area (HU209), Triton Knoll (HU204), West of Inner Dowsing Bank (HU200) and Sheringham Shoal drillings (HU123). One active dredge disposal site exists within the English Study Area - the Hornsea OWF disposal area (HU205).

The proposed submarine cable corridor passes through an area of gas fields, some of which remain in production. For the most part the proposed submarine cable corridor avoids passing through active gas fields, the only exception to this is the Wollaston gas field at KP 137. Gas fields could be a potential source of sediment contamination, however as noted above, analysis of sediment samples indicated no elevated contaminants above Cefas AL 1 (including at a sampling site within 3 km of the Wollaston gas field).

Seabed Sediments

C01494-EGL3-GEO-006-B



- Exclusive Economic Zone Limit (EEZ)
- Scottish Adjacent Waters
- 12NM Limit
- EGL 3 Scoping Boundary
- 15km Study Area

Seabed Sediment 250k

- 1.1.1 Mud
- 1.1.2 (gravelly) Mud
- 1.2.1 sandy Mud
- 1.2.2 (gravelly) sandy Mud
- 1.3.1 muddy Sand
- 1.3.2 (gravelly) muddy Sand
- 2.1.1 Sand
- 2.1.2 (gravelly) Sand
- 3.1.1 gravelly Sand
- 3.2.1 sandy Gravel
- 3.3.1 Gravel
- 4.1.1 gravelly Mud
- 4.2.1 muddy Gravel
- 4.3.1 gravelly muddy Sand
- 4.4.1 muddy sandy Gravel
- 5. Rock & boulders
- 6. No data at this level of Folk

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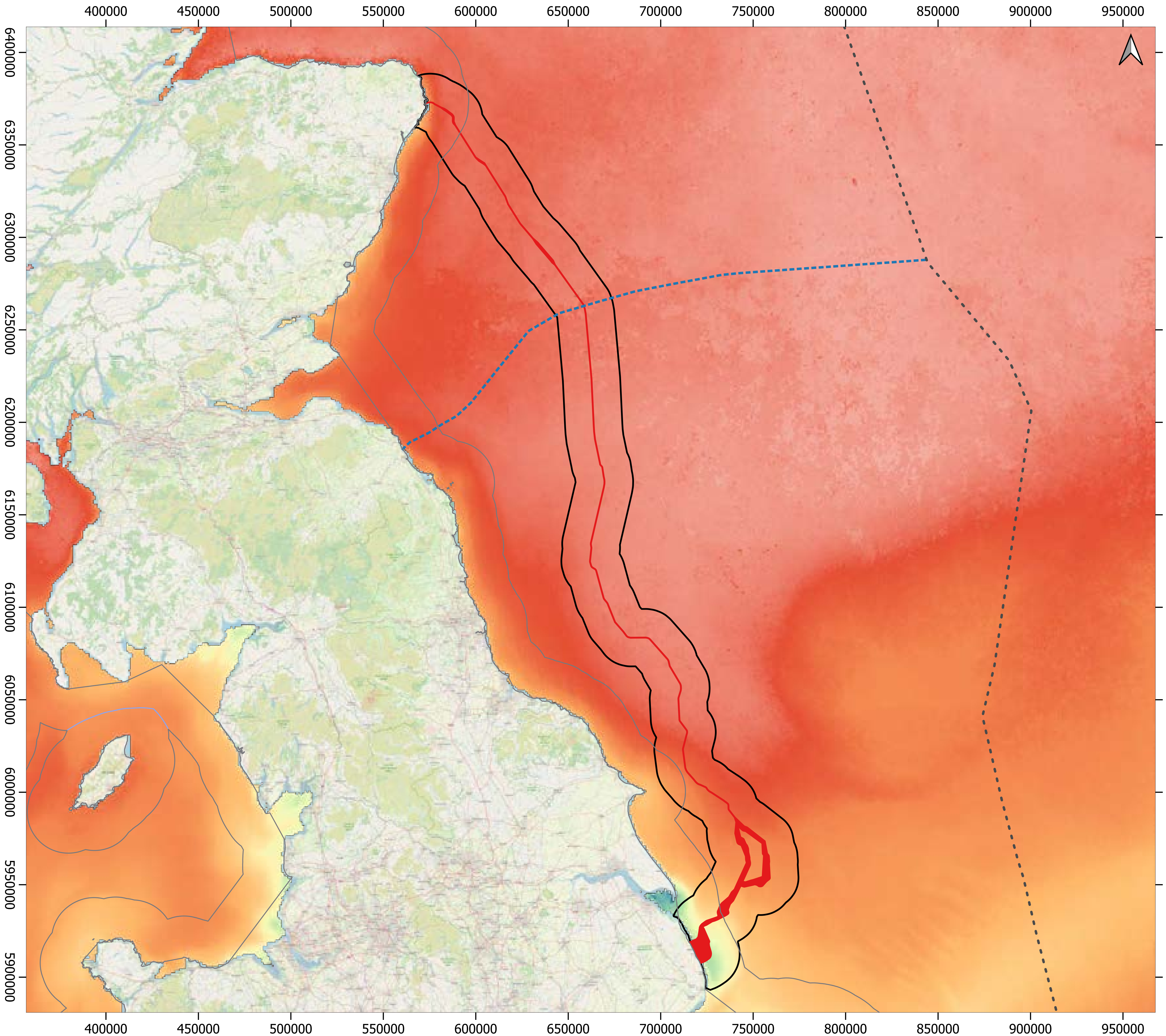

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Annual Mean Suspended Particulate Matter

C01494-EGL3-GEO-004-B

- Exclusive Economic Zone Limit (EEZ)
- Scottish Adjacent Waters
- 12NM Limit
- EGL 3 Scoping Boundary
- 15km Study Area

SPM Mean Cefas 2016 (mg/l)

- 1
- 2
- 5
- 10
- 15
- 20
- 25
- 30
- 40
- 50
- 60

0 10 20 NM

0 10 20 KM

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6.4.1.9. Designated Sites – England

Designated sites in the Study Area, which are designated for the protection and conservation of marine habitats of relevance to marine physical processes are shown in Figure 6.6 (Drawing: C01494_EGL3_PROT_012) (JNCC, 2023).

The proposed submarine cable corridor passes through the following designated sites:

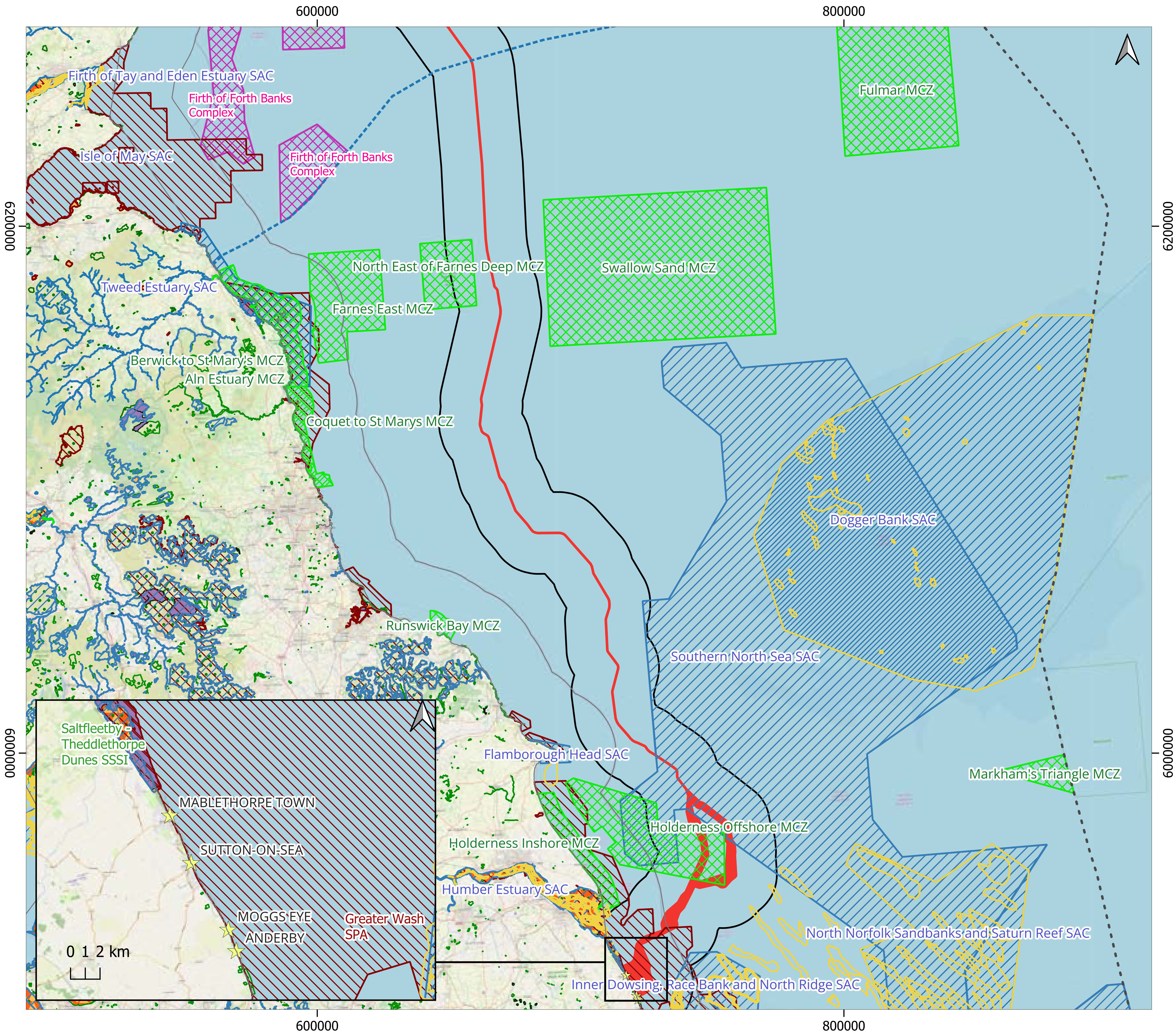
- Greater Wash Special Protection Area (SPA): which supports breeding and foraging areas for a large number of bird species. Specific marine habitats protected here include intertidal mudflats and sandflats, subtidal sandbanks and biogenic reef;
- Holderness Offshore Marine Conservation Zone (MCZ): an area of mixed coarse sediment and sand, supporting habitats for a wide variety of species, such as, ocean quahog, crustaceans (crabs and shrimp), starfish and sponges. The site is also a spawning and nursing ground for a range of fish species; and also includes the northern tip of the Silver Pit North Sea glacial tunnel valleys.
- Southern North Sea Special Area of Conservation (SAC): an area of importance for harbour porpoise. The mixed seabed of coarse and sandy sediments found here are an important physical characteristic, as these are preferred by harbour porpoise, due to availability of prey.
- Saltfleetby-Theddlethorpe Dunes and Gibraltar Point Special Area of Conservation (SAC): an extensive and complex area which exhibits a range of dune types including shifting dunes, fixed dunes with herbaceous vegetation and dunes which supports sea-buckthorn *Hippophae rhamnoides.* The dune slacks at this site are part of a successional transition between a range of dune features, and some have developed from saltmarsh to freshwater habitats.

In addition, the following designated sites lie within the wider English Study Area:

- Inner Dowsing, Race Bank and North Ridge SAC: a site characterised by sandbanks and biogenic reefs, protecting benthic communities & ecology;
- The North East of Farnes Deep MCZ: characterised by predominantly sandy sediment, with patches of gravelly sand and mud also lies within the English Study Area. The site is important for its 'mosaic of habitats' supporting a diverse range of marine flora and fauna; and
- Annex I Subtidal sand banks: there are a number of Annex I subtidal sand bank features which partially lie within the Study Area.

The Saltfleetby to Theddlethorpe Dunes Sites of Special Scientific Interest (SSSI) also lies within the English Study Area. The site is designated for important tidal sand and mudflats, marshes and sand dunes. The proposed submarine cable corridor for the alternative landfall option at Theddlethorpe passes through the southern edge of this SSSI.

Please also refer to Chapter 5 Designated Sites for further information on protected sites and features.



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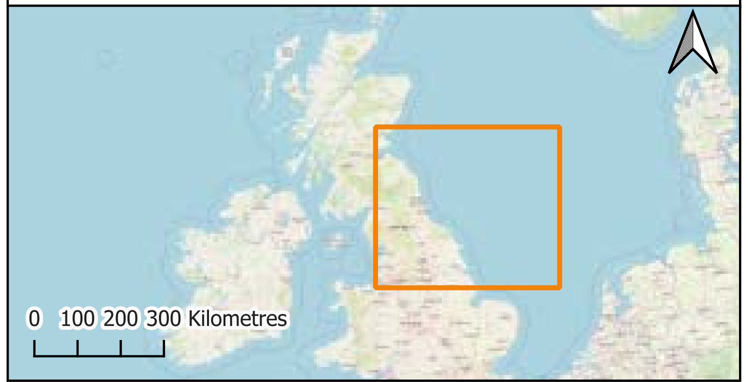
Designated Sites and Bathing Waters in the English Study Area

C01494-EGL3-PROT-012-B



- Exclusive Economic Zone Limit (EEZ)
- Scottish Adjacent Waters
- 12NM Limit
- EGL 3 Scoping Boundary
- 15km Study Area
- Annex I Sandbanks
- Designated Bathing Waters

Designated Sites

- Special Area of Conservation (SAC)
- Marine Conservation Zone (MCZ)
- Special Protection Area (SPA)
- Nature Conservation Marine Protected Area (NCMPA)
- National Nature Reserve (NNR)
- Site of Special Scientific Interest (SSSI)
- RAMSAR Site

0 10 20 NM

0 25 50 KM

Date	27/10/2023
Coordinate System	ETRS89 / UTM Zone 30N
Projection	Universal Transverse Mercator (UTM)
Unit	Meters
Scale at A3	1:1,400,000
Created	MH
Reviewed	RW/SP
Authorised	AF

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6.4.2. Scottish Baseline Characterisation KP 431.4 – KP 575.3

6.4.2.1. Bathymetry and seabed features

The bathymetry in the Scottish Study Area is relatively flat, being 60 to 70 m below MSL across much of the proposed submarine cable corridor. Close to the Scottish coast the bathymetry deepens to approximately 100 m below MSL as the proposed submarine cable corridor crosses the southern edge of the Buchan Deep (approximately 20 km offshore) and then steeply shoals to the coast (Figure 6.1, Drawing: C01494_EGL3_BATH_002).

6.4.2.2. Water Levels

Data from the UK renewables atlas (ABPmer, 2017) and the ATT software package have been used to inform the baseline understanding on tidal levels across the Study Area, while data from the Environment Agency's coastal flood boundary conditions (EA, 2018) and from the UK climate change projections (UKCP18) have been used to inform the baseline understanding of non-tidal influences on water levels.

Water levels in the Study Area are predominantly driven by tidal processes. Tides in the Study Area are semi-diurnal, with two high and two low tides per day. The tides vary slightly across the Scottish Study Area, with spring tidal ranges of approximately 2.5 m at the southern extent, increasing to just over 3 m at the proposed landfall (see tidal planes from ATT software in Table 6-4 at Peterhead which lies approximately 2 km north of the proposed landfall). The tide arrives from the north so that the time of high water at the proposed landfall occurs approximately two to three hours before the time of high water at the southern extent of the Scottish Study Area.

Non-tidal or meteorological effects can also influence the water level. The height of a 1 in 200-year return period storm surge near the proposed landfall in the Scottish Study Area is 2.9 m above MSL (EA, 2018).

UKCP18 suggests an increase in MSL of 0.5 m to 0.6 m in 2100 along the Aberdeenshire coastline. Future changes in storm surges have been predicted to be indistinguishable from background variation (Lowe et al., 2009), although extreme surge level event frequency is likely to increase (IPCC, 2021).

Table 6-4: Tidal levels extracted from ATT at Peterhead

Tidal Plane	Tide Level (m relative to MSL)
HAT	2.0
MHWS	1.6
MHWN	0.8
MLWN	-0.9
MLWS	-1.8
LAT	-2.4

6.4.2.3. Currents

Data from the UK renewables atlas (ABPmer, 2017) and the ATT software package have been used to inform the baseline understanding on tidal flows across the Study Area.

Tidal currents vary in terms of both current speed and direction across the Scottish Study Area. In the south of the Scottish Study Area tidal currents are orientated approximately north-south (with flows on the flood tide in a southward direction), while further north the currents realign northeast-southwest to follow the coastline. The currents are orbital offshore and become more bi-directional as the proposed submarine cable corridor approaches the proposed landfall.

Slowest currents occur offshore of the Firth of Forth where spring tide current speeds are approximately 0.4 m/s at KP 428 (Figure 6.2, Drawing: C01494_EGL3_GEO_005). Current speeds increase in a northward direction with spring tide current speeds of 0.8 m/s at KP 558 and 1.0 m/s close to the proposed landfall. Peak neap current speeds are just over half of the quoted peak spring tide current speeds.

There is a slight dominance in the magnitude of peak northward flowing ebb currents, although the duration of the southward flowing flood currents tend to last slightly longer. The net effect is a slight residual in northward tidal flow. Superimposed on this regional scale flow pattern, local flow variations can be expected to occur in response to bathymetric features (for example to realign with channel features).

Surge driven flows in the Study Area are not expected to contribute significantly to sediment transport (Kenyon and Cooper, 2005).

6.4.2.4. Winds and Waves

Climatological wind and wave data from SEASTATES (ABPmer, 2018) have been used to inform the baseline understanding of the wind and wave climate across the Study Area. SEASTATES is driven by the CFSR wind dataset (Saha et al., 2010).

Prevailing winds across the Scottish Study Area are from the south to west sectors. The strength of the winds increases with distance offshore (due to the effect of coastal sheltering), resulting in slightly higher wind speeds offshore of the Firth of Forth, with mean wind speeds of 8.1 m/s at KP 428, than at the proposed landfall (with a mean wind speed of 7.6 m/s at KP 558). Wind roses at KP 428 and KP 558 are shown in Figure 6.7.

The wave climate across the Study Area is controlled by a combination of locally generated wind waves and swell waves generated elsewhere in the North Sea. The primary wave direction along the proposed submarine cable corridor is from the north. The frequency of waves from other directions is controlled by the varying fetch lengths for different wind directions with distance along the proposed submarine cable corridor, with waves from the south and west each occurring for around 15% of the time offshore of the Firth of Forth (at KP428) and waves from the south and southeast occurring for around 20% of the time close to the proposed landfall (at KP558). The baseline wave climate description is informed by a regional hindcast and it is expected that at the proposed landfall, the dominance of waves from the north and the southeast will be significantly reduced by the sheltering effect of Little Petrie to the north and The Skerry to the southeast.

Mean significant wave heights in the Scottish Study Area are typically around 1.7 m, with higher mean significant wave heights of around 2.5 m in the winter. Wave roses at KP 428 and KP 558 are shown in Figure 6.7.

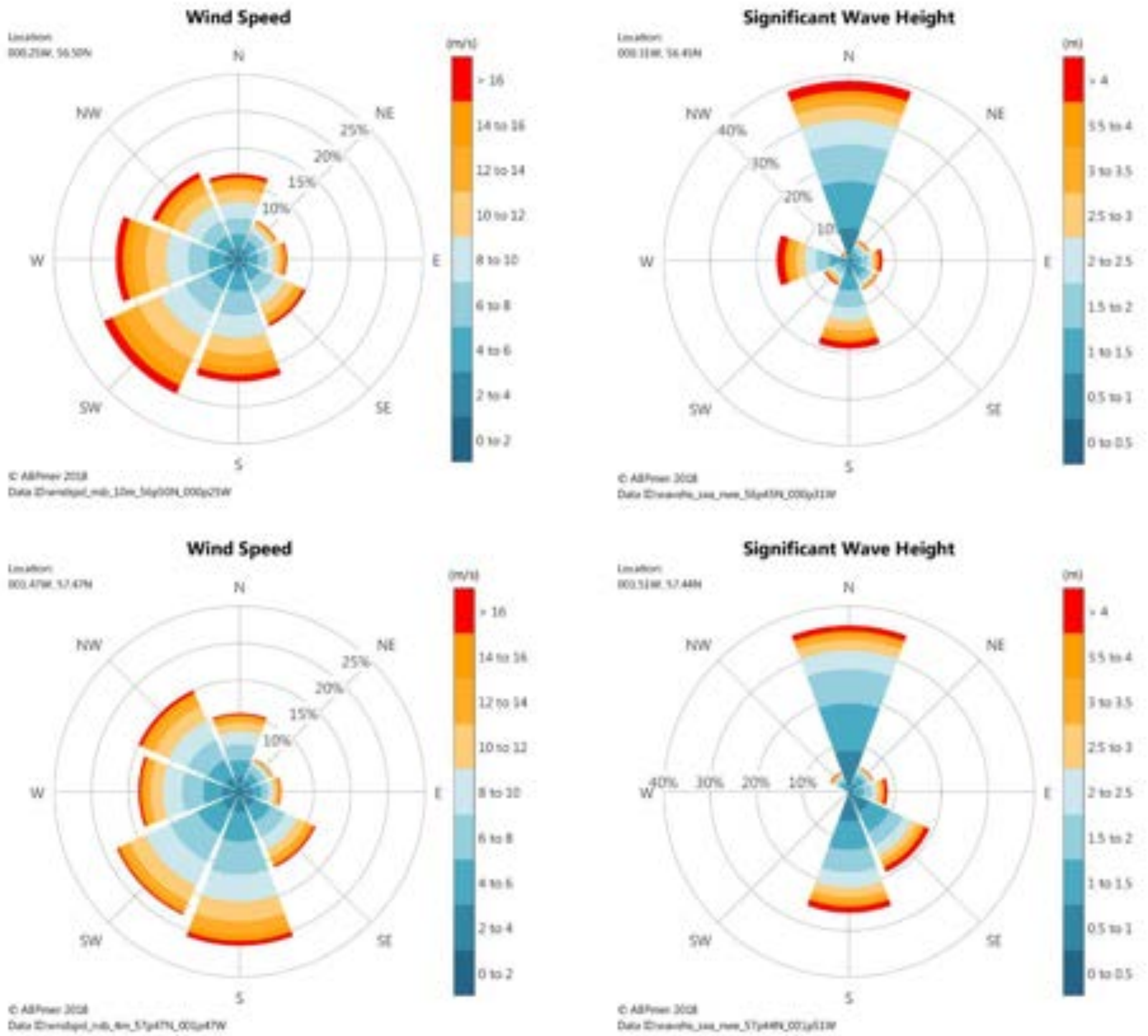


Figure 6-7: Wind and wave roses at KP 428 (upper panels) and KP 558 (lower panels) (ABPmer, 2018).

6.4.2.5. Geology and Seabed Sediments

The bedrock geology across the Scottish Study Area is characterised by Triassic rocks (mix of rock, siliciclastic, argillaceous and sandstone) along much of the proposed submarine cable corridor. Close to the proposed landfall the bedrock geology varies with areas of mudstone and gypsum-stone, old red sandstone and igneous rock (basalt).

The thickness of quaternary deposits across the Study Area is typically between 5 and 20 m, with an area of thicker deposits (30 to 50 m) close to the proposed landfall.

Surficial sediments in the Scottish Study Area are predominantly sand with some discrete patches of slightly gravelly sand, gravelly sand and sandy gravel at both the southern and northern extents of the proposed submarine cable corridor (Figure 6.4, Drawing: C01494_EGL3_GEO_006).

6.4.2.6. Geomorphology and Sediment Transport

In the Scottish Study Area, the sediment transport is driven by wave action and the net sediment transport is low (with wave driven transport restricted to shoals and/or storm events). As the proposed submarine cable corridor approaches landfall, the net sediment transport is to the north, driven by tidal flows. At the northern end of the Study Area there is a bed-load convergence zone, indicated by the presence of large sandwaves (Kenyon and Cooper, 2005).

The direction of sediment transport is driven mainly by tidal currents, although the mobilisation of sediment is likely to be initiated by waves during storm events. Sand transport rates are generally relatively low due to the relatively deep depths and weak tidal currents. In addition, there are no local significant sediment sources (with low sediment inputs from rivers and the granite cliffs which are resistant to marine erosion).

The geophysical survey for the Morven OWF indicated that megaripples with heights of 0.5 m were present across much of the area surveyed (RPS, 2023a). The megaripples were reported to be generally orientated from west to east, with their lee slope facing south, indicative of a dominant southward current direction, this opposes the net transport further north along the coast. Numerous boulders and cobbles were found to present, particularly in the troughs between megaripples, indicating that the surficial sands are likely to be relatively thin. Similarly, the geophysical survey for the Ossian OWF identified some megaripples and sandwaves indicative of a mobile bed, noting a net southward transport but at very low rates, expected to be driven by wave activity (RPS, 2023b).

6.4.2.7. Coastal Geomorphology

The coastline within the Scottish Study Area extends from Rattray Head in the north to just south of Whinnyfold. The coastline is characterised by alternating sections of cliffs (which vary in height from 20 m to 40 m) and sandy dune backed beaches (Barne et al., 1996). Sedimentary rocks are of the Old Red Sandstone Supergroup, with a few large masses of Caledonian intrusive rocks present including the Peterhead Granite, which outcrops for around 20 km between St. Fergus and Cruden Bay, forming rocky platforms and cliffs. The cliffs transition to a dune-backed bay-head beach at Cruden Bay.

6.4.2.8. Sediment and Water Quality

Data from the Cefas Suspended Sediment Climatology model (Cefas, 2016) show that over the period between 1998 – 2015, mean SPM values are approximately 1 mg/l throughout much of the Scottish Study Area. SPM values increase slightly close to landfall, however, remain low, being less than 3 mg/l (Figure 6.5, Drawing: C01494_EGL3_GEO-004).

The proposed submarine cable corridor passes through the WFD Ugie Estuary to Buchan Ness (Peterhead) water body, which is classed as a heavily modified water body on account of physical alterations that cannot be addressed without a significant impact on navigation (Water body ID UKSC200131). There are two designated BWs within the Study Area, with Peterhead (Lido) classed as 'Excellent' since 2018, and Cruden Bay currently holding a 'Good' status (held since its addition in 2019).

Analysis of sediment quality samples from the International Council for the Exploration of the Sea (ICES) DOME Portal (DOME, 2023) was conducted along the full length of the proposed submarine cable corridor. Reported concentrations of arsenic, mercury, cadmium, chromium, copper, nickel, lead and zinc were checked for all available samples within the Study Area. For all sample records, contaminant levels were below Cefas AL1. Sediment sampling from the Morven OWF also found contaminants to be below AL1, except for slightly elevated concentrations of arsenic at a single location in the far north of their study area (RPS, 2023a). However, levels remained below AL2.

The proposed submarine cable corridor passes though the now closed South Buchan Ness disposal area (CR100). Other closed disposal areas also lie within the Study Area including South Buchan Ness B (CR105), Middle Buchan Ness (CR090) and Middle Buchan Ness B (CR095). Two open disposal sites also lie within the Study Area including Peterhead (CR070) and North Buchan Ness (CR080) which are located approximately 2 km north of the proposed submarine cable corridor.

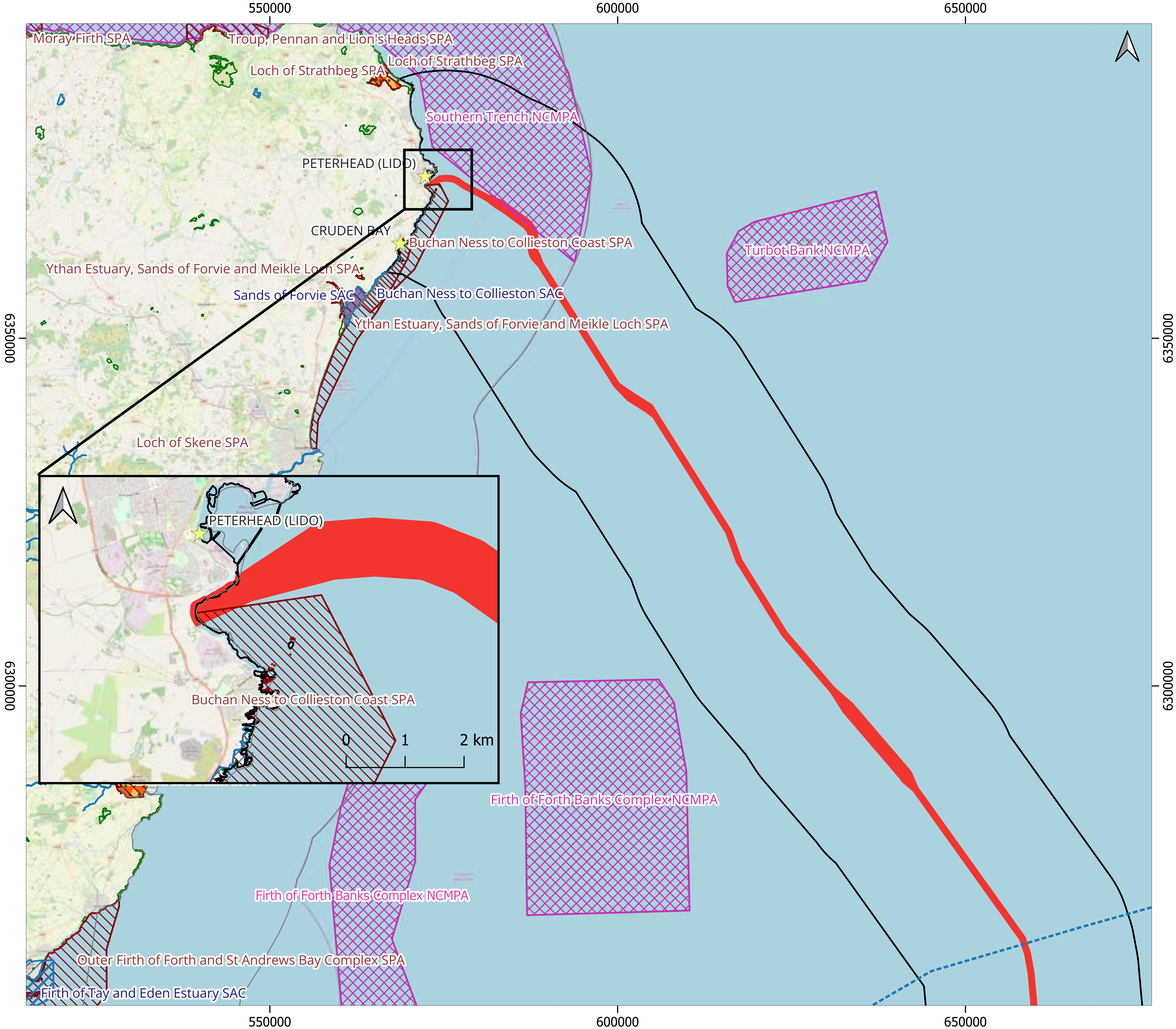
The proposed submarine cable corridor crosses the Forties to Cruden Bay oil pipeline.

6.4.3. Designated Sites - Scotland

Designated sites in the Study Area, which are designated for the protection and conservation of marine habitats of relevance to physical processes are shown in Figure 6.8 (Drawing: C01494_EGL3_PROT_013). The proposed submarine cable corridor crosses the Buchan Ness to Collieston Coast Special SPA. This SPA is designated for its vegetated sea cliffs and offshore stacks, which support a scattered but considerable colony of cliff-nesting seabirds.

Two coastal SSSI's are also present in the Study Area:

- Bullers of Buchan Coast: this is located approximately 2.5 km to the south of the proposed landfall and is designated for the cliffs, slopes and inshore stacks which are features of special geological and biological interest; and
- Collieston to Whinnyfold Coast: this is located approximately 12 km to the south of the proposed landfall and is designated for nationally important colonies of cliff nesting seabirds. It forms part of the Buchan Ness to Collieston SPA.



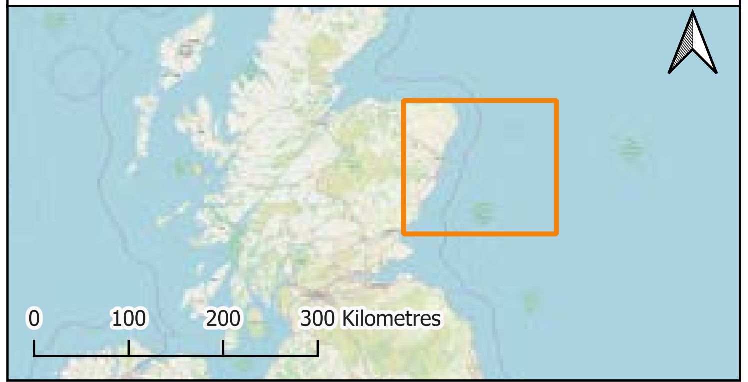
collaborative environmental advisers

nationalgrid

Scottish & Southern Electricity Networks

Designated Sites and Bathing Waters within Scottish Study Area

C01494-EGL3-PROT-013-B



- Exclusive Economic Zone Limit (EEZ)
- Scottish Adjacent Waters
- 12NM Limit
- EGL 3 Scoping Boundary
- 15km Study Area
- Designated Bathing Waters

Designated Sites

- Special Area of Conservation (SAC)
- Special Protection Area (SPA)
- Nature Conservation Marine Protected Area (NCMPA)
- National Nature Reserves (NNR)
- Site of Special Scientific Interest (SSSI)
- RAMSAR Sites

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6.5. Proposed Assessment Methodology

A more detailed literature review will be developed for the MEA to expand on the high-level overview provided within this chapter of the MEA Scoping Report. Project-specific survey data will be used to enhance the understanding of the baseline conditions, with a focus on geophysical, geotechnical and benthic survey data.

The additional data will be used to inform the Cable Burial Risk Assessment (CBRA) which will consider:

- micro-routeing;
- minimum burial depths along the proposed submarine cable corridor;
- identification of potential burial tools and methods; and
- methods of cable protection where full cable burial cannot be achieved, or risk of subsequent cable exposure is high.

Existing studies from comparable projects (the 'Evidence Base') will be used to further inform the likely scale of any potential impacts.

The marine physical processes MEA will follow the general assessment approach outlined in Chapter 4 (Marine Environmental Assessment Approach) of this MEA Scoping Report. The assessment of potential effects will be established using the standard Source-Pathway-Receptor Approach.

The assessment of marine physical processes will follow the guidance documents listed below where they are specific to this topic:

- 'General advice on assessing potential impacts of and mitigation for human activities on Marine Conservation Zone (MCZ) features, using existing regulation and legislation' (JNCC and Natural England, 2011);
- European Site Casework Guidance: How to consider plans and projects affecting Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) (NatureScot, 2022)
- 'OSPAR Assessment of the Environmental Impacts of Cables' (OSPAR, 2009);
- 'Review of Cabling Techniques and Environmental Effects applicable to the Offshore Wind farm Industry'. Department for Business Enterprise and Regulatory Reform in association with Defra (BERR, 2008); and
- 'Advice Note Eighteen: The Water Framework Directive' (Planning Inspectorate, 2017).

The Study Area for the physical processes baseline within the MEA will be as currently outlined but will be further refined to focus on the final submarine cable route and may be further refined to consider the variation in tidal excursion along the proposed submarine cable corridor. The scope of the marine physical processes assessment is to characterise the baseline physical processes within the Study Area and to consider the magnitude and duration of potential impacts of the Project.

The assessment approach includes a range of desktop analyses and spreadsheet-based models and this will be supplemented by evidence from analogous assessments and monitoring data.

Currently both open cut trenching and trenchless construction techniques are proposed construction methods for the intertidal zones. For trenchless techniques (for example Horizontal Directional Drilling (HDD)) there will be no impact on the intertidal zone from construction activities. For open-cut trenching, a cofferdam may be required, and this could have an influence of along-shore sediment transport. A review of the baseline along-shore transport and associated drivers would be undertaken and used to qualify the potential for impact. Depending on the outcome of this qualitative assessment, numerical modelling tools may be applied to further quantify the potential impact.

Spreadsheet based models will be applied to assess the potential Suspended Sediment Concentration (SSC) and sedimentation associated with installation activities for a range of hydrodynamic conditions, sediment types and release rates to capture the impact (in terms of plume extent, concentration, duration of increases and extent and thickness of deposits on the seabed). The assessment will focus on the realistic worst case installation scenario. The available baseline information and planned geophysical, geomorphological and benthic surveys will provide the data inputs for this assessment. The effects will be assessed in terms of the difference caused relative to the normal range of natural occurrence and variability.

In view of the low percentage of fines present in the sediments along the proposed submarine cable corridor and due to the large existing evidence base, which includes multiple similar assessments using numerical modelling tools to assess impacts from cable installation for a range of methods, no new numerical hydrodynamic modelling is presently considered to be required.

The assessment of operational impacts associated with changes to the substrate and water depths associated with cable protection measures will quantify the areas of impact and relative changes in water depth. This will be considered alongside baseline information, results from the benthic survey and expert judgement to determine the likely impact on receptors.

A WFD assessment will be undertaken to assess the potential impacts of the Project on water and sediment quality. It is proposed that the WFD assessment will be presented as a technical appendix, and the results of the assessment will be presented within the Marine Physical Processes chapter of the MEA. The assessment of water quality impacts will focus on the impact on turbidity using spreadsheet-based models, with release of contaminated sediments having been scoped out of the assessment.

6.6. Scope of Assessment

A range of potential impacts on marine physical processes have been identified which may occur during the installation, operation (including maintenance and repair), and decommissioning phases of the proposed Project. The decision on whether an impact should be further assessed with the MEA is based on whether potentially significant impacts may arise. A summary of the proposed assessment scope is provided in Table 6-1.

A precautionary approach has been taken and where there is no strong evidence-base or the significance is uncertain at this stage the impact has been scoped 'in' to the MEA.

Marine physical processes are best described as pathways, rather than as receptors. While outputs from the marine physical processes assessments will be reported in a stand-alone MEA chapter, for the most part it is not practical for the outputs to be accompanied by statements of effect of significance. Instead, the information on changes to the marine physical processes pathways will be used to inform other MEA topic assessments including:

- Chapter 7 – Intertidal and Subtidal Benthic Ecology;
- Chapter 8 – Fish and Shellfish Ecology;
- Chapter 9 – Intertidal and Offshore Ornithology;
- Chapter 10 – Marine Mammals and Marine Reptiles; and
- Chapter 12 – Commercial Fisheries.

The scoping of indirect impacts from the identified marine physical processes pathways will be assessed within the relevant topics.

The physical processes features which are considered as potential receptors will be guided by the tidal excursion and consideration of sediment transport and seabed movement and will include:

- The adjacent coastline, particularly at proposed landfalls and in adjacent SSSIs (including Saltfleetby to Theddlethorpe Dunes and the Bullers of Buchan Coast SSSIs);
- Nationally or internationally designated sites with seabed/sedimentary or geological interest features below MHWS; and
- Designated bathing waters.

Table 6-5: Scoping assessment of impacts on physical processes

Potential Impacts	Project Activities	Sensitive Receptors	Scoping Justification		
			Construction	Operation (including repair and maintenance)	Decommissioning
Disturbance of sub-tidal seabed morphology	Boulder clearance. Pre-sweeping Cable burial and trenching Deposit of external cable protection Trenchless solution exit pits or flotation pits	Seabed geomorphology Subtidal Benthic Habitats Fish and Shellfish Ornithology Commercial fisheries	IN – While seabed preparation and submarine cable installation activities have the potential to directly disturb the seabed morphology, the proposed submarine cable corridor has been routed to avoid seabed features such as sandbanks, sandwaves and notable bathymetric depressions. However, there remains the potential for some pre-sweeping and there is potential for the requirement for deposits of external cable protection in some areas.	OUT – If the cable is installed correctly the likelihood of it requiring maintenance and repair is significantly reduced. However, there remains the potential that localised repair works or remedial external cable protection may be required. In these circumstances pre-sweeping may be required to expose the section of cable in need of repair.	OUT - The significance of the effect of removing the cable during decommissioning is similar or of lower magnitude than construction.
Disturbance of intertidal morphology	Cable burial and trenching Deposit of external cable protection Trenchless solution exit pits flotation pits.	Intertidal and coastal geomorphology	IN – At this stage of scoping no decision has been made on the installation technique to be used. As noted in the project description this may be either a trenchless technique or an open cut technique. The open cut trenching option may require a cofferdam which would pose a barrier to along-shore coastal processes (although any effect would be short-lived) and as such this has been scoped in at this stage.	OUT – If the cable is installed correctly the potential for cable exposure due to any natural coastal retreat is minimal. The proposed landfalls are sited in areas of either low erosion, net accretion or where coastal management practices are to hold the line.	OUT - The significance of the effect of removing the cable during decommissioning is similar or of lower magnitude than construction.
Temporary increase and deposition of suspended sediments	Boulder clearance, pre-lay grapnel runs/ Cable burial / trenching	Water quality Seabed substrates Subtidal Benthic Habitats Fish and Shellfish Ornithology Commercial shellfisheries	IN – Sediment suspended during installation of the submarine cable could result in temporary increases in SSC and subsequent deposition once material re-settles to the bed.	OUT - If the cable is installed correctly the likelihood of it requiring maintenance and repair is significantly reduced. In the event that localised repair work is required, the significance of the effect will be of lower magnitude than during installation, being constrained to a smaller area.	OUT - It is expected that decommissioning activities will result in a lower magnitude effect than that already considered during construction.
Modifications to tidal and wave regimes and associated impacts to morphological features	Construction impacts, Presence of seabed cable protection,	Currents, water levels, waves bathymetry and seabed features.	OUT – The Project will have a narrow footprint in relation to the scale of physical processes driven by flow and wave action. Any effects will be highly localised and of a short duration. Scour/erosion may occur during construction; however, the landfall works will be of a short duration, and localised.	OUT – Changes in depth from cable protection will be minimal relative to the total water depth (not more than 5% reduction in depth) and will not significantly alter flows or waves.	OUT - There will be short term, localised disruption of the tide, wave and sediment transport regime while the cables are removed. Any effects will be highly localised and of a short duration.
Release of contaminated sediments	Seabed activity such cable burial and trenching	Water quality Subtidal Benthic Habitats Fish and Shellfish	OUT – The temporary resuspension of contaminants in sediments has the potential to result in adverse effects on water quality. However, there are no records indicating the presence of contaminated sediments within the Study Area at levels	OUT - If the cable is installed correctly the likelihood of it requiring maintenance and repair is significantly reduced. However, there remains the potential that localised repair works, or remedial external cable protection may be required.	OUT – There will be short term disruption of the sediments while the cables are removed but the effect will be a lower rate of

Potential Impacts	Project Activities	Sensitive Receptors	Scoping Justification		
			Construction	Operation (including repair and maintenance)	Decommissioning
		Ornithology Commercial shellfisheries	requiring further investigation, all sample records discussed above showed contaminant levels were below Cefas AL1.	In these circumstances the significance of the effect will be of lower magnitude than during construction.	sediment disturbance than during construction.
Accidental releases or spills of materials or chemicals	Presence of project vessels and equipment	Water quality & sediment quality	OUT - Project vessels and contractors will comply with the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78 which relate to pollution from oil from equipment, fuel tanks etc and release of sewage (black and grey water). It is a legal requirement that all vessels have a Shipboard oil pollution emergency plan (SOPEP). Compliance with Regulations will be sufficient to minimise the risk to the environment and no significant impacts are predicted.		
Temperature Increase	During the operation of a t HVDC cable heat losses occur because of the resistance in the cable/conductor.	Sediment quality	OUT – not relevant to construction.	OUT - There are no specific regulatory limits applied to temperature changes in the seabed, although a 2°C change between seabed surface and 0.2 m depth is used as a guideline in Germany. Conservative calculations undertaken for Viking Link (which crosses German waters) concluded that heating in excess of 2 °C at 20 cm sediment depth will only occur if cables are bundled and buried to less than 0.75 m (National Grid and Energinet 2017). As yet, the full CBRA has not been carried out.). Any temperature changes will be localised to the immediate environment surrounding the cable and undetectable against natural temperature fluctuations in the surrounding sediments and water column. No significant effects are predicted.	OUT – not relevant to decommissioning.

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