



Morven Hawthorn Pit Grid Connection Project

Preliminary Environmental Information Report

Volume 2, Chapter 1: Physical Processes

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Annexes

Annex number	Annex title
1.1	Physical Processes Technical Report
1.2	Model Design, Validation and Results

Glossary

Term	Meaning
Bathymetry	The measurement of water depth in oceans, seas and lakes.
Commitments	Measures (embedded mitigation and secondary) to be adopted during the construction, operation and maintenance, and decommissioning phases of the MHPGC Project.
Cumulative effect	The combined effect of the MHPGC Project in combined with the effects from other proposed developments, on the same receptor or resource.
Cumulative effects assessment	Assessment of the likely effects arising from the MHPGC Project alongside the likely effects arising from other proposed developments on the same receptor or resource.
Development Consent Order (DCO)	An order made under the Planning Act 2008, as amended, granting development consent.
Embedded mitigation	Measures included as part of the project design. Includes both primary and tertiary mitigation.
Environmental Impact Assessment (EIA)	The process of identifying and assessing the significant effects likely to arise from a project. This requires consideration of the likely changes to the environment, where these arise as a consequence of a project, through comparison with the existing and projected future baseline conditions.
Highly Protected Marine Area (HMPA)	Areas of the sea (including the shoreline) that allow the protection and full recovery of marine ecosystems. HPMAs protect all species and habitats and associated ecosystem processes within the site boundary, including the seabed and water column.
Inter-related effects	Effects that may arise from the interactions between different EIA topic effects considered within the project-alone assessment, potentially leading to more significant effects than if they were to be considered in isolation.
Intertidal Area	The area between Mean High Water Springs (MHWS) and Mean Low Water Springs (MLWS).
Landfall	The area in which the offshore export cables make landfall (come onshore) and the transitional area between the offshore cabling and the onshore cabling. This term applies to the entire landfall area between the trenchless technique exit pits and the transition joint bay inclusive of all construction works.
Magnitude of effect	A combination of the spatial extent, duration, frequency and reversibility of an impact.
Marine Conservation Zone (MCZ)	An area designated under the Marine and Coastal Access Act 2009 for the purpose of conserving marine flora, fauna, habitats, or features of geological or geomorphological interest.
Marine Directorate Licensing Operations Team (MD-LOT)	The part of the Scottish Government's Marine Directorate responsible for assessing and administering applications for marine licences for Scottish waters and Section 36 consent (offshore) in Scotland.
Marine Management Organisation (MMO)	The MMO, as a UK government body, is responsible for licensing, regulating and overseeing activities in the marine environment for English waters. For a DCO and deemed marine licence, the MMO acts

Term	Meaning
	as a statutory consultee, advising on marine planning, environmental impacts, habitats and compliance with marine licensing regulations.
Maximum design scenario (MDS)	The realistic worst case scenario, selected on a topic-specific and impact specific basis, from a range of potential parameters for the MHPGC Project.
Mean High Water Springs (MHWS)	The most inshore level location reached by the sea at high tide during mean high water spring tide. This is defined as the average tidal height throughout the year, of two successive high waters, during a 24-hour period in each month when the range of the tide is at its greatest.
Mean Low Water Springs (MLWS)	The average height of the low water levels of each pair of successive low waters during the periods of about 24 hours when the tidal range is at its greatest.
MHPGC Project Scoping Report	A Scoping Report for the MHPGC Project, scoping the likely significant effects of the project on the environment, was submitted and accepted by the Planning Inspectorate (PINS) and submitted to the Scottish Ministers, via MD-LOT in February 2025.
MHPGC Project Scoping Opinions	Separate Scoping Opinions received from PINS (on behalf of the Secretary of State) and MD-LOT (on behalf of the Scottish Ministers) in response to the MHPGC Project Scoping Report. The MHPGC Project Scoping Opinions contain the range of issues that PINS, and MD-LOT in consultation with statutory stakeholders, have identified should be considered within the EIA process.
Morven Hawthorn Pit Grid Connection Project	The MHPGC Project is comprised of the offshore export cables in Scottish and English waters from the Morven North or the Morven South offshore substation platform(s) (OSP), landfall, onshore export cables, the onshore land substation (LSS) and alternating current (AC) connection cables. Also referred to in this report as the MHPGC Project, for ease of reading.
Morven North Offshore Wind Array Project (hereafter 'Morven North')	The Morven North Offshore Wind Array Project, which includes the wind turbines and foundations, offshore substation platforms (OSPs) and foundations, inter-array and inter-connector cables and associated infrastructure located within the Morven North Boundary.
Morven South Offshore Wind Array Project (hereafter 'Morven South')	The Morven South Offshore Wind Array Project, which includes the wind turbines and foundations, offshore substation platforms and foundations, inter-array and inter-connector cables and associated infrastructure located within the Morven South Boundary.
Marine Protected Area (MPA)	Areas within the United Kingdom's seas designated for the protection of marine life and habitats against damage caused by human activities.
Morphology	Term used to describe channel form and its process of change in shape and direction over time.
National Grid Hawthorn Pit Substation	The National Grid substation at Hawthorn Pit, County Durham, which the AC connection cables will connect into from the onshore land substation.
Offshore Export Cable Corridor	The proposed offshore area in which the offshore export cables will be laid, from either the Morven North offshore substation platform

Term	Meaning
	or Morven South offshore substation platform to the transition joint bay at landfall.
Offshore Export Cables	High Voltage Direct Current (HVDC) cables that bring electricity from either the Morven North or Morven South offshore substation platform to the TJB at landfall.
Offshore Substation Platforms (OSP(s))	OSPs comprise the support structure, topside and electrical components used for collecting the electricity generated by the wind turbine generators for the passage or transmission to landfall. These OSPs can be divided into two types: • High Voltage Alternating Current (HVAC) collector substations; • HVDC converter substations.
Operations and maintenance phase (O&M)	The operational and maintenance phase of the MHPGC Project.
Physical Processes	The collective term for the following: hydrodynamics (water levels and currents); winds and waves; stratification and frontal systems; geology and seabed sediments (including sediment transport); seabed geomorphology; and coastal geomorphology.
Planning Inspectorate (PINS)	PINS is an executive agency of the UK Government responsible for administering and examining DCO applications for Nationally Significant Infrastructure Projects (NSIPs) in England. PINS manages the application process, oversees consultation and examination, and makes a recommendation to the relevant Secretary of State on whether consent should be granted.
MHPGC Project Preliminary Environmental Information Report (PEIR)	A report that provides preliminary environmental information in accordance with the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017. This is information that enables consultees to understand the likely significant environmental effects of a project and that helps to inform consultation responses.
Primary mitigation	Measures included as part of the location or design of the MHPGC Project made during the pre-application phase that are an inherent part of the MHPGC Project and do not require additional action to be taken. This includes modifications arising through the iterative design process. These measures will be secured through the consent itself through the description of the MHPGC Project, the parameters and associated commitments secured by the DCO and marine licence, or both.
Residual effects	Effects that continue to exist after mitigation has been applied.
Scour protection	Protective materials installed to avoid sediment being eroded away from the base of the foundations and/or buried subsea cable due to the flow of water.
Special Area of Conservation (SAC)	A site designation specified in the Habitats Directive (Council Directive 92/43/EEC) and protected in the UK under the Conservation (Natural Habitats, &c.) Regulations 1994 (in Scotland), the Conservation of Habitats and Species Regulations 2017 (in England) and Conservation of Offshore Marine Habitats and Species Regulations 2017 (in Scotland and England). Each site is designated for one or more of the habitats and species listed in the Directive.

Term	Meaning
	The Habitats Directive requires the necessary conservation measures to be established involving, if need be, appropriate management plans for each SAC to ensure the favourable conservation status of the habitats or species for which it was designated.
Secondary mitigation	Actions that will require further activity to achieve the anticipated outcome and may be imposed as part of the planning consent, or through inclusion in the ES. These include measures required to reduce the significance of environmental effects and may be secured through an environmental management plan. For secondary mitigation measures both pre-mitigation and residual effects are presented.
Significance	Effect factor that is determined by the magnitude of impact along with the sensitivity of the receptor.
Sites of Special Scientific Interest (SSSI)	Designated areas that feature rare flora or fauna or are host to important features (physiological or geological), which are of scientific interest, designated under the Wildlife and Countryside Act 1981 (as amended).
Special Protection Area (SPA)	Locations within the UK designated to conserve rare, vulnerable, and migratory bird species of European importance, as classified by the Conservation (Natural Habitats, &c.) Regulations 1994 (in Scotland), the Conservation of Habitats and Species Regulations 2017 (in England) and Conservation of Offshore Marine Habitats and Species Regulations 2017 (in Scotland and England).
Spring Tidal Excursion	The distance suspended sediment is transported prior to being carried back on the returning tide.
Tertiary mitigation	Actions that would occur with or without input from the EIA process feeding into the design. These include actions that will be undertaken to meet other existing legislative requirements, or actions that are considered to be standard practices used to manage commonly occurring environmental effects.
Study Area	For each environmental topic, the baseline environment will be characterised, and the potential environmental impacts will be described within a topic-specific Study Area. Specific Study Areas are defined for each topic and are based on the maximum spatial extent across which potential impacts of MHPGC Project may be experienced by the relevant receptors (i.e. Zone of Influence).
Tidal cycle	One high tide plus a successive low tide.
Tidal ellipse	The illustration of the variance of tidal currents in horizontal space.
Transboundary impact	Potential impacts resulting from MHPGC Project and affecting another European Economic Area (EEA) state.
Transboundary effects	Assessment of likely significant effects resulting from MHPGC Project on the interests of another European Economic Area (EEA) state(s).
Trenchless techniques	Construction methods used to install underground or sub-surface infrastructure without the need for continuous open trench excavation, thereby avoiding or minimising disturbance to surface features, habitats and existing land users.

Acronyms

Acronym	Meaning
ABPmer	Associated British Ports Marine Environmental Research Ltd.
AODA	Anglia Offshore Dredging Association
BGS	British Geological Survey
CBRA	Cable Burial Risk Assessment
CEA	Cumulative Effect Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CFE	Controlled Flow Excavator
CMS	Construction Method Statement
CPS	Cable Protection System
CSIP	Cable Specification and Installation Plan
DCC	Durham County Council
DCO	Development Consent Order
DESNZ	Department for Energy Security and Net Zero
EEA	European Economic Area
EGL	Eastern Green Link
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data Network
EMP	Environmental Management Plan
ES	Environmental Statement
EWG	Expert Working Group
HD	Hydrodynamic
HDD	Horizontal Directional Drilling
HPMA	Highly Protected Marine Area
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
HW	High Water
IEMA	Institute of Environmental Management and Assessment
IMarEST	Institute of Marine Engineering Science and Technology
ISEP	Institute of Sustainability and Environmental Professionals
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
LiDAR	Light Detection and Ranging
LSE	Likely Significant Effects

Acronym	Meaning
LW	Low Water
MAREA	Marine Aggregate Regional Environmental Assessment
MBAGC	Morven Brantxton Area Grid Connection Project
MCZ	Marine Conservation Zone
MD-LOT	Marine Directorate – Licensing Operations Team
MDS	Maximum Design Scenario
MD-SEDD	Marine Directorate - Science, Evidence, Data and Digital
MFE	Mass Flow Excavator
MGN	Marine Guidance Note
MHPGC	Morven Hawthorn Pit Grid Connection
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MPA	Marine Protected Area
MPS	Marine Policy Statement
NPPF	National Planning Policy Framework
NPS	National Policy Statements
O&M	Operations and Maintenance
OSP	Offshore Substation Platform
PDE	Project Design Envelope
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PLGR	Pre-Lay Grapple Run
PMF	Priority Marine Feature
POL	Proudman Oceanographic Laboratory
PSA	Particle Size Analysis
PT	Particle Tracking
RCP	Representative Concentration Pathway
SAC	Special Areas of Conservation
SMP	Shoreline Management Plan
SoS	Secretary of State
SPA	Special Protection Area
SSC	Suspended Sediment Concentration
TCE	The Crown Estate
UKHO	United Kingdom Hydrography Office
UXO	Unexploded Ordnance

Acronym	Meaning
ZoI	Zone of Influence

Units

Unit	Meaning
°	Degrees (angle)
%	Percent
cm	Centimetres
kg	Kilograms
kg/s	Kilograms per second
km	Kilometres
m	Metres
m/s	Metres per second
m ²	Square metres
m ³	Cubic metres
m ³ /m/day	Cubic metres per metre per day
mg/l	Milligrams per litre
mm	Millimetres
nm	Nautical mile

1 Physical Processes

1.1 Introduction

- 1.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the preliminary findings of the Environmental Impact Assessment (EIA) work undertaken to date for the Morven Hawthorn Pit Grid Connection Project (hereafter 'MHPGC Project'), as described in **Volume 1, Chapter 2: Project Description, of the PEIR** in respect of Physical Processes.
- 1.1.1.2 The chapter considers the potential impacts and effects on Physical Processes that could result from the construction, operation and maintenance (O&M) and decommissioning phases of the MHPGC Project. Specifically, it relates to the offshore elements of the MHPGC Project from, but not including, the offshore substation platform(s) (OSPs) within Morven North Offshore Wind Array Project or Morven South Offshore Wind Array Project (hereafter 'Morven North and Morven South') located within Scottish offshore waters, transiting through English offshore and inshore waters, to Mean High Water Springs (MHWS) at landfall.
- 1.1.1.3 This chapter describes the methodology, datasets that have informed the preliminary assessment, baseline conditions, including future baseline, mitigation measures and the preliminary residual significant effects on Physical Processes that could result from the MHPGC Project.
- 1.1.1.4 The assessment is informed by the following chapters:
- **Volume 1, Chapter 2: Project Description, of the PEIR;**
 - **Volume 1, Chapter 4: Approach to Environmental Impact Assessment, of the PEIR;**
 - **Volume 1, Chapter 5: Policy and Legislation, of the PEIR;**
- 1.1.1.5 The chapter also draws on information contained within the following annexes:
- **Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR;**
 - **Volume 1, Annex 4.2: Transboundary Screening, of the PEIR;**
 - **Volume 1, Annex 4.3: Cumulative Screening and Location Plan, of the PEIR;**
 - **Volume 2, Annex 1.1: Physical Processes Technical Report;**
 - **Volume 2, Annex 1.2: Model Design, Validation and Results.**
- 1.1.1.6 The assessment informs the following chapters:
- **Volume 2, Chapter 3: Benthic Subtidal and Intertidal Ecology, of the PEIR;**
 - **Volume 2, Chapter 4: Fish and Shellfish Ecology, of the PEIR;**
 - **Volume 2, Chapter 5: Marine Mammals, of the PEIR;**
 - **Volume 2, Chapter 6: Marine Ornithology, of the PEIR;**
 - **Volume 2, Chapter 9: Marine and Intertidal Archaeology, of the PEIR;**
 - **Volume 2, Chapter 10: Infrastructure and Other Sea Users, of the PEIR;**
 - **Volume 4, Chapter 5: Inter-related Effects, of the PEIR.**
- 1.1.1.7 This PEIR will offer a comprehensive overview of the MHPGC Project's preliminary likely significant environmental effects and mitigation measures, presenting essential data to stakeholders for review and feedback. The PEIR will also be informed by the ongoing pre-application consultation process.
- 1.1.1.8 Following statutory consultation, comments will be reviewed and considered, where appropriate, in preparation of the Environmental Statement (ES) that will accompany the application to the Planning Inspectorate (PINS) for development consent and a marine licence application to Marine Directorate Licensing Operations Team (MD-LOT).

1.2 Legislative and policy context

1.2.1 Overview

- 1.2.1.1 The full relevant legislation and policy context for the MHPGC Project has been detailed in **Volume 1, Chapter 5: Policy and Legislation, of the PEIR**. This section sets out the legislation and planning policy that is relevant to the Physical Processes assessment.

1.2.2 Legislation

National legislation

United Kingdom

The Conservation of Habitats and Species Regulations 2017

- 1.2.2.1 The Conservation of Habitats and Species Regulations (2017a) (amended 2019) transpose the Habitats Directive (92/43/EEC) (EU, 1992) and implements provisions from the Birds Directive (2009/147/EC) (EU, 2009), into UK legislation (HM Government, 2017a). These regulations cover the requirements to protect sites that are internationally important for threatened habitats and species out to the 12 nautical mile (nm) limit.

- 1.2.2.2 There are several designated sites within the Physical Processes Study Area. Changes to the physical characteristics of these sites have the potential to impact the habitats they support and, therefore, consideration is given to them in the Physical Processes assessment.

The Conservation of Offshore Marine Habitats and Species Regulations 2017

- 1.2.2.3 The Conservation of Offshore Marine Habitats and Species Regulations (2017) (as amended) cover the requirements to protect sites that are internationally important for marine habitats and species within the UK Offshore Marine Area (beyond the 12nm limit) (HM Government, 2017b).

- 1.2.2.4 There are several designated sites within the Physical Processes Study Area. Changes to the physical characteristics of these sites have the potential to impact the habitats they support and, therefore, consideration is given to them in the Physical Processes assessment.

UK Marine and Coastal Access Act 2009

- 1.2.2.5 The Marine and Coastal Access Act (2009) is the legislation to help ensure clean, healthy, safe, productive and biologically diverse oceans and seas (HM Government, 2009).

- 1.2.2.6 MPAs are designated under the Marine and Coastal Access Act (2009). There are several designated sites within the Physical Processes Study Area. Changes to the physical characteristics of these sites have the potential to impact the habitats they support and, therefore, consideration is given to them in the Physical Processes assessment.

The Conservation (Natural Habitats, &c.) Regulations (1994)

- 1.2.2.7 Defines the species, habitats and types of sites that receive legal protection and described the protection that is afforded.

- 1.2.2.8 There are several designated sites within the Physical Processes Study Area. As stated above, changes to the physical characteristics of these sites have the potential to impact the habitats they support and, therefore, consideration is given to them in the Physical Processes assessment.

Scotland

The Marine (Scotland) Act 2010 (Scotland)

- 1.2.2.9 Marine Protected Areas (MPAs) in Scotland are designated under the Marine (Scotland) Act 2010. The MPA network protects nationally and internationally important marine wildlife, habitats, geology, and underwater landforms.

- 1.2.2.10 There are MPAs within the Physical Processes Study Area. Changes to the physical characteristics of these sites have the potential to impact the habitats they support and, therefore, consideration is given to them in the Physical Processes assessment.

1.2.3 National policy context

National Policy Statements

- 1.2.3.1 National Policy Statements (NPS) set out the primary policy framework for a Development Consent Order (DCO) under which the MHPGC Project will be considered. This framework includes guidelines, requirements and criteria that the MHPGC Project must meet to obtain consent and proceed with development. **Table 1.1** provides details of the NPS relevant to Physical Processes and how and where they are covered in the PEIR:

- NPS for energy (EN-1) (Department for Energy Security and Net Zero (DESNZ), 2025a);
- NPS for renewable energy infrastructure (EN-3) (DESNZ, 2025b);
- NPS for electricity networks infrastructure (EN-5) (DESNZ, 2025c).

Table 1.1: Summary of the NPS provisions relevant to Physical Processes

Summary of relevant NPS provisions	How and where considered in the PEIR
NPS EN-1	
Paragraph 4.5.7: "Applicants are encouraged to approach the marine licensing regulator (Marine Management Organisation (MMO) in England and Natural Resources Wales in Wales) in pre-application, to ensure that they are aware of any needs for additional marine licenses alongside their Development Consent Order application".	Consultation with the MMO was undertaken during the scoping stage and engagement is ongoing through the Evidence Plan process. Relevant engagement is provided in Section 1.3.1 .
Paragraph 4.5.8: "Applicants for a Development Consent Order must take account of any relevant Marine Plans and are expected to complete a Marine Plan assessment as part of their project development, using this information to support an application for development consent".	Relevant Marine Plans are identified in Table 1.3 and considered in Section 1.5 and Section 1.8 .
Paragraph 4.5.9: "Applicants are encouraged to refer to Marine Plans at an early stage, such as in pre-application, to inform project planning, for example to avoid less favourable locations as a result of other uses or environmental constraints".	Relevant Marine Plans are identified in Table 1.3 and considered in Section 1.5 Further detail on the routing is considered in Volume 1, Chapter 3: Site Selection & Consideration of Alternatives, of the PEIR .
Paragraph 4.10.9: "The ES should set out how the proposal will take account of the projected impacts of climate change, using government guidance and industry standard benchmarks such as the Climate Change Allowances for Flood Risk Assessments..."	The Physical Processes baseline has reviewed the impact of climate change on the metocean regime and processes. A full description is given in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR and is summarised in Section 1.4.6 .
Paragraph 5.4.18: "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 and Wales), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats".	Designated sites within the Physical Processes Study Area are summarised in Section 1.4 and described in more detail in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR . An assessment of potential impacts on these designated sites can be found in Section 1.8 .
Paragraph 5.4.20: "The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests".	Relevant commitments identified to conserve and enhance biodiversity are provided in Section 1.7 , with the full list of commitments provided in Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR .
Paragraph 5.4.36: "Applicants should include appropriate avoidance, mitigation, compensation and enhancement measures as an integral part of the proposed development".	Commitments relevant to Physical Processes have been identified and are provided in Section 1.7 , with the full list of commitments provided in Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR .
Paragraph 5.6.9: "Where relevant, applicants should undertake coastal geomorphological and sediment transfer modelling to predict and understand impacts and help identify relevant mitigating or compensatory measures".	Assessment of sediment transport pathways have been undertaken using hydrodynamic (HD) and sediment transport modelling. Assessment of sediment plume advection and deposition has been undertaken using HD and particle tracking (PT) modelling. These results have been used to inform the assessment of impacts in Section 1.8 . A full

Summary of relevant NPS provisions	How and where considered in the PEIR
Paragraph 5.6.10: "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; • 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".	description of modelling methodology and results is provided in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR. The Physical Processes baseline has reviewed the impact of climate change on the metocean regime and coastal processes. A full description is given in Volume 2, Annex 1.1: Physical Processes Baseline Technical Report, of the PEIR and summarised in Section 1.4.6. The landfall is located directly south of Seaham and is covered by The Tyne to Flamborough Head SMP (Royal Haskoning, 2007)). The potential impact of the MHPGC Project on the landfall and coastal processes/geomorphology has been carried out for the construction, O&M and decommissioning phases of the MHPGC Project. This assessment is presented under the impact "Impacts to coastal morphology" in Section 1.8. This assessment considers the nature of ongoing and potential future shoreline change at landfall. The potential for the MHPGC Project to affect flood risk, as well as recreation sites and features is considered in Volume 3, Chapter 2: Water Resources and Flood Risk, of the PEIR, Volume 3, Chapter 8: Land Use, Tourism and Recreation, of the PEIR and Volume 2, Chapter 10: Infrastructure and Other Marine Users, of the PEIR, of the PEIR. The MHPGC Project design will take into consideration the potential for future coastal change throughout its operational life. A full description of coastal processes understanding at the landfall is set out in Volume 2, Annex 1.1: Physical Processes Baseline Technical Report, of the PEIR.
Paragraph 5.6.11: "For any projects involving dredging or deposit of any substance or object into the sea, the applicant should consult the MMO and Historic England or the NRW in Wales. Where a project has the potential to have a major impact in this respect, this is covered in the technology specific NPSs".	The provisions for dredging activities are considered within Volume 1, Chapter 2: Project Description, of the PEIR. An Outline Dredging and Disposal Site Characterisation Plan will also accompany the DCO submission. As part of the commitments adopted as part of the MHPGC Project, best practice techniques will be employed to ensure sediment mobilisation is minimised [see Section 1.7]. Assessment of sediment transport pathways have been undertaken using HD and sediment transport modelling. Assessment of sediment plume, including those arising from dredge spoil disposal, advection and deposition has been undertaken using HD and PT modelling. Empirical equations and expert judgement have been used to assess the persistence and erosion of spoil disposal mounds. These results have been used to inform the assessment of impacts in Section 1.8. A full description of modelling methodology and results is provided in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR.

Summary of relevant NPS provisions	How and where considered in the PEIR
Paragraph 5.6.12: "The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of MPAs. These could include Marine Conservation Zones (MCZs), habitat sites including Special Areas of Conservation and Special Protection Areas with marine features, Ramsar Sites, Sites of Community Importance and Sites of Special Scientific Interest (SSSI) with marine features. Applicants should also identify any effects on the special character of Heritage Coasts".	Designated sites within the Physical Processes Study Area are summarised in Section 1.4 and described in more detail in Volume 2, Annex 1.1: Physical Processes Technical Report of the PEIR. An assessment of the potential morphological impacts on these designated sites can be found in Section 1.8, whilst an assessment of the potential ecological impacts is set out in Volume 2, Chapter 3: Benthic Subtidal and Intertidal Ecology, of the PEIR and Volume 3 Chapter 3 Terrestrial Ecology and Terrestrial and Intertidal Ornithology, of the PEIR. An assessment of impacts on designated sites is available in the HRA [see Chapter 2.2: Report to Inform Appropriate Assessment (RIAA) Part 3: SPA & Ramsar Site Assessments, of the HRA and MCZ/MPA Assessment, which will be submitted with the DCO Application and Marine Licence(s) to the Scottish Ministers.
Paragraph 5.6.14: "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".	Commitments relevant to Physical Processes have been identified and are provided in Section 1.7, with the full list of commitments provided in Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR.
Paragraph 5.6.15: "The Secretary of State should be satisfied that the proposed development will be resilient to coastal erosion and deposition, taking account of climate change, during the project's operational life and any decommissioning period. Proposals that aim to facilitate the relocation of existing energy infrastructure from unsustainable locations which are at risk from coastal change, should be supported where it would result in climate resilient infrastructure".	The Physical Processes baseline has reviewed the impact of climate change on the metocean regime and coastal processes. A full description is given in Volume 2, Annex 1.1: Physical Processes Baseline Technical Report, of the PEIR and summarised in Section 1.4.6. The vulnerability of the MHPGC Project to coastal change is considered in the context of the project design, in Volume 1, Chapter 2: Project Description, of the PEIR.
Paragraph 5.6.16: "The Secretary of State should not normally consent new development in areas of dynamic shorelines where the proposal could inhibit sediment flow or have an adverse impact on coastal processes at other locations. Impacts on coastal processes must be managed to minimise adverse impacts on other parts of the coast. Where such proposals are brought forward, consent should only be granted where the Secretary of State is satisfied that the benefits (including need) of the development outweigh the adverse impacts."	The Physical Processes baseline reviewed the impact of climate change on the metocean regime and coastal processes. A full description is given in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR and is summarised in Section 1.4.6. Assessment of sediment transport pathways and coastal processes have been undertaken using HD and sediment transport modelling. Assessment of sediment plume advection and deposition has been undertaken using HD and PT modelling. These results have been used to inform the assessment of impacts in Section 1.8. A full description of modelling methodology and results is provided in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR.
Paragraph 5.6.17: "...The Secretary of State should ensure that applicants have restoration plans for areas of foreshore disturbed by direct works and will undertake pre- and post-construction coastal	Trenchless techniques will be used for cable installation in the intertidal area. Trenchless cable installation is expected to cause minimal direct disturbance to the existing coastline. Assessment of

Summary of relevant NPS provisions	How and where considered in the PEIR
monitoring arrangements with defined triggers for intervention and restoration”.	impact to coastal morphology and coastal processes in areas of the foreshore have been assessed for the construction, O&M and decommissioning phases of the MHPGC Project in Section 1.8. Commitments relevant to Physical Processes include development and adherence to an Outline Offshore Environmental Management Plan (EMP), an Outline Offshore Construction Method Statement (CMS), an Outline Offshore Operation, Maintenance and Monitoring Plan, and an Offshore Decommissioning Programme [see Section 1.7], which will ensure methods align with good practice, implement agreed mitigation measures and are appropriately managed. Site-specific coastal monitoring is not proposed for the MHPGC Project as the assessment set out within this chapter concluded that the MHPGC Project would not give rise to likely significant effects on Physical Processes, either alone or when considered cumulatively with other plans, projects, or activities.
Paragraph 5.6.18: “The Secretary of State should examine the broader context of coastal protection around the proposed site, and the influence in both directions, i.e. coast on site, and site on coast”.	A review of the stability of the coast, the Shoreline Management Plan recommended actions for coastal protection within the MHPGC Project PEIR Red Line Boundary, and the impacts of the coast on the site is summarised in Section 1.8 and described in more detail in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR. An assessment of impacts of the site on the coast is provided in Section 1.8.
Paragraph 5.6.19: “The Secretary of State should consult the MMO on projects which could impact on coastal change in England, or NRW for projects in Wales, since the MMO or NRW may also be involved in considering other projects which may have related coastal impacts”.	A cumulative effects assessment (CEA) has been completed for Physical Processes. The impacts and projects considered and those scoped out of the CEA are discussed in Section 1.9.
Paragraph 5.6.20: “In addition to this NPS, the Secretary of State must have regard to the appropriate marine policy documents in taking any decision which relates to the exercise of any function capable of affecting any part of the UK marine area”.	Marine policy and legislation relevant to Physical Processes are presented in Section 1.2.
Paragraph 5.6.21: “The Secretary of State should also have regard to any relevant Shoreline Management Plans”.	The landfall is located directly south of Seaham and is covered by The Tyne to Flamborough Head SMP (Royal Haskoning, 2007)). The potential impact of the MHPGC Project on the landfall and coastal processes/geomorphology has been carried out for the construction, O&M and decommissioning phases of the MHPGC Project. This assessment is presented under the impact “Impacts to coastal morphology” in Section 1.8. This assessment considers the nature of ongoing and potential future shoreline change at landfall, as well as present and proposed future management plans.
Paragraph 5.6.22: “Substantial weight should be attached to the risks of flooding and coastal erosion and the Secretary of State should be satisfied that the applicant has taken full account of the policy on assessment and mitigation in paragraphs 4.3.1 to 4.3.9 of	The potential impact of the MHPGC Project on the landfall and coastal processes/geomorphology has been carried out for the construction, O&M and decommissioning phases of the MHPGC Project. This assessment is presented under the impact

Summary of relevant NPS provisions	How and where considered in the PEIR
this NPS, taking account of the potential effects of climate change on these risks”.	“Impacts to coastal morphology” in Section 1.8. This assessment considers the nature of ongoing and potential future shoreline change at landfall, taking account of the potential effects of climate change on these risks. The potential for the MHPGC Project to affect flood risk is considered in Volume 3, Chapter 2: Water Resources and Flood Risk, of the PEIR.
NPS EN-3	
Paragraph 2.4.8: “Whilst offshore wind farms and offshore transmission infrastructure will not be affected by flooding, applicants should demonstrate that any necessary land-side infrastructure (such as cabling and onshore substations) will be appropriately resilient to climate-change induced weather phenomena. Similarly, applicants should particularly set out how the proposal would be resilient to storms”.	The Physical Processes baseline has reviewed the impact of climate change on the metocean regime and coastal processes. A full description is given in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR and summarised in Section 1.4.6. The vulnerability of the MHPGC Project to coastal change and storms is considered in the context of the project design, in Volume 1, Chapter 2: Project Description, of the PEIR.
Paragraph 2.8.94: “Applicants must undertake a detailed assessment of the offshore ecological, biodiversity and physical impacts of their proposed development, for all phases of the lifespan of that development, in accordance with the appropriate policy for offshore wind farm EIAs, HRAs and MCZ assessments”.	A baseline of Physical Processes is provided in Section 1.4 and an assessment of impacts can be found in Section 1.8. An assessment of impacts on designated sites is available in the HRA [see Habitats Regulations Assessment/Habitats Regulations Appraisal Screening Report, prepared to accompany the PEIR, Habitats Regulations Appraisal/Habitats Regulations Assessment RIAA, prepared to accompany the PEIR and Marine Protected Area/Marine Conservation Zone Screening and Stage 1 Assessment Report, which will be submitted with the DCO Application and Marine Licence(s) to the Scottish Ministers.
Paragraph 2.8.97: “Applicants should consult at an early stage of pre-application with relevant statutory consultees and energy not-for profit organisations, as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options which should be undertaken”.	Consultation with the statutory consultees, including the MMO and Natural England, was undertaken during the scoping stage and is ongoing. A summary of the key comments and responses specific to Physical Processes has been provided in Section 1.3, Table 1.5 and Table 1.6.
Paragraph 2.8.105: “...Applicant assessments are expected to include predictions of the physical effects arising from modifications to hydrodynamics (waves and tides), sediments and sediment transport, and seabed morphology that will result from the construction, operation and decommissioning of the required infrastructure”.	Assessment of potential impacts and significance of effects on Physical Processes receptors is provided in Section 1.8. This assessment includes discussion of the potential impacts on tide, waves and sediment transport pathways for all phases of the MHPGC Project (construction, O&M and decommissioning). Assessment of sediment transport pathways and coastal processes have been undertaken using HD and sediment transport modelling. Assessment of sediment plume advection and deposition has been undertaken using HD and PT modelling. A full description of modelling methodology and results is provided in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR.
Paragraph 2.8.106:	The use of cable or scour protection will be implemented through the development of, and adherence to, an Outline Offshore Cable

Summary of relevant NPS provisions	How and where considered in the PEIR
"...Assessments should also include effects such as the scouring that may result from the proposed development and how that might impact sensitive species and habitats".	Specification and Installation Plan (CSIP) and an Outline Offshore Operation, Maintenance and Monitoring Plan, as set out in the in Section 1.7 . (These will be submitted as part of the development consent and marine licence application(s) to the Scottish Ministers. As such, any scour-related impacts will be limited to secondary scour, which due to the nature of scour protection, will be minimal and highly localised, as discussed in Section 1.8 .
Paragraph 2.8.107: "...Applicants should undertake geotechnical investigations as part of the assessment, enabling the design of appropriate construction techniques to minimise any adverse effects".	Geophysical surveys and other site-specific investigations (e.g. metocean deployments) have been undertaken to inform the modelling and assessment, as summarised in Section 1.4.4 .
Paragraph 2.8.112: "...Applicant assessments of the effects of installing offshore transmission infrastructure across the intertidal/coastal zone should demonstrate compliance with mitigation measures in any relevant plan-level HRA or MCZ assessment including those prepared by The Crown Estate as part of its leasing round, and include information, where relevant, about: - Any alternative landfall sites that have been considered by the applicant during the design phase and an explanation for the final choice; - Any alternative cable installation methods that have been considered by the applicant during the design phase and an explanation for the final choice; - Potential loss of habitat; - Disturbance during cable installation, maintenance/repairs and removal (decommissioning); - Increased suspended sediment loads in the intertidal zone during installation and maintenance/repairs; - Potential risk from invasive and non-native species; - Predicted rates at which the intertidal zone might recover from temporary effects, based on existing monitoring data; - Protected sites; and - Impacts on delivery of the Environment Agency's habitat compensation and restoration programme".	A baseline of Physical Processes is provided in Section 1.4 and an assessment of impacts can be found in Section 1.8. An assessment of impacts on designated sites is available in the HRA [see MHPGC Project HRA Screening Report, MHPGC Project, MHPGC Project RIAA] and MCZ/MPA Assessment, which will be submitted with the DCO Application and Marine Licence(s) to the Scottish Ministers .
Paragraph 2.8.116: "...Applicant assessment of the effects on the subtidal environment should include: - loss of habitat due to foundation type including associated seabed preparation, predicted scour, scour protection and altered sedimentary processes, e.g. sandwave/boulder/unexploded ordnance (UXO) clearance; - environmental appraisal of inter-array and other offshore transmission and installation/maintenance methods, including predicted loss of habitat due to predicted scour and scour/cable protection and sandwave/boulder/UXO clearance; - habitat disturbance from construction and maintenance/repair vessels' extendable legs and anchors;	A baseline of Physical Processes is provided in Section 1.4 and an assessment of impacts can be found in Section 1.8. An assessment of impacts on designated sites is available in the HRA [see MHPGC Project HRA Screening Report, MHPGC Project, MHPGC Project RIAA] and MCZ/MPA Assessment which will accompany be submitted with the DCO Application and Marine Licence(s) to the Scottish Ministers .

Summary of relevant NPS provisions	How and where considered in the PEIR
- increased suspended sediment loads during construction and from maintenance/repairs; - predicted rates at which the subtidal zone might recover from temporary effects; - potential impacts from EMF on benthic fauna; - potential impacts upon natural ecosystem functioning; - protected sites; and - potential for invasive/non-native species introduction".	
Paragraph 2.8.172: "...Where a potential offshore wind farm is proposed close to existing operational offshore infrastructure or has the potential to affect activities for which a licence has been issued by government, the applicant should undertake an assessment of the potential effects of the proposed development on such existing or permitted infrastructure or activities. The assessment should be undertaken for all stages of the lifespan of the proposed wind farm in accordance with the appropriate policy and guidance for offshore wind farm EIAs".	A CEA has been completed for Physical Processes in accordance with the appropriate policy and guidance for offshore wind farm EIAs. The impacts and projects considered and those scoped out of the CEA are discussed in Section 1.9.
Paragraph 2.8.196: "...Applicants are expected to have considered the best ecological outcomes in terms of potential mitigation. These might include: - Avoidance of areas sensitive to physical effects; - Consideration of micro-siting of both the array and cables; - Alignment and density of the array; - Design of foundations; - Ensuring that sediment moved is retained as locally as possible; - The burying of cables to a necessary depth; - Using scour protection techniques around offshore structures to prevent scour effects, or designing turbines to withstand scour, so scour protection is not required or is minimised	Mitigation measures to avoid and reduce potential impacts have been incorporated into the MHPGC Project. In the first instance, this has involved cable routing of the offshore export cables in order to avoid areas that would be most susceptible to construction, O&M, and decommissioning activities – [see Volume 1, Chapter 3: Site Selection & Consideration of Alternatives, of the PEIR]. Commitments have been considered [see Section 1.7] and included within the impact assessment [see Section 1.8]. Measures include (but are not limited to) the development and adherence to the Outline Offshore EMP, Outline Offshore Operation, Maintenance and Monitoring Plan and Decommissioning Plan, ensure the MHPGC Project phases align with good practice, implement agreed mitigation measures and are appropriately managed.
Paragraph 2.8.275: "...Where indirect effects are predicted, the Secretary of State should refer to relevant sections of this NPS and EN-1 and must be satisfied that potential impacts on coastal erosion have been minimised".	A commitment has been made to use trenchless techniques for cable installation in the intertidal area at the landfall [see Commitment number CoT13/MM-014 in Table 1.15 and Volume 1, Chapter 2: Project Description, of the PEIR for further details]. Trenchless cable installation is expected to cause minimal direct disturbance to the existing coastline. Assessment of impact to coastal morphology and coastal processes, including indirect effects, have been assessed for the construction, O&M and decommissioning phases of the MHPGC Project in Section 1.8.
Paragraph 2.8.276: "...The Secretary of State must be satisfied that the design of the wind farm, offshore transmission and methods of construction, including use of materials, are such as to reasonably minimise the potential for impact on the physical environment."	The design of the offshore transmission and methods of construction are considered in Volume 1, Chapter 2: Project Description, of the PEIR. Development and adherence to the Outline Offshore EMP, Outline Offshore Operation, Maintenance and Monitoring Plan and Decommissioning Plan [see

Summary of relevant NPS provisions	How and where considered in the PEIR
	Section 1.7] , ensure the MHPGC Project phases align with good practice, implement agreed mitigation measures and are appropriately managed.
Paragraph 2.12.147: "...The Secretary of State should be satisfied that in the development of their proposal, the applicant has made appropriate, and extensive, use of on-site assessments and up-to-date evidence from previous deployments and research results from scientific peer reviewed papers, and, where required, assessed through HRA processes (including the mitigation hierarchy) the impact on any protected species or habitats, as well as having regard to requirements set out in Section 5.4 of EN-1".	A baseline of Physical Processes is provided in Section 1.4 and an assessment of impacts can be found in Section 1.8. This baseline understanding and the associated assessment draw on a combination of site-specific measurements, numerical modelling, empirical analyses, expert judgement and evidence from scientific literature and comparable projects. An assessment of impacts on designated sites is available in the HRA [see MHPGC Project HRA Screening Report, MHPGC Project, MHPGC Project RIAA and MHPGC Project MPA/MCZ Screening and Stage 1 Assessment Report] The MCZ/MPA and HPA Assessment will be submitted as part of the application for development consent and Marine Licence(s) to the Scottish Ministers.
Paragraph 2.12.149: "... Where adverse effects on site integrity/conservation objectives are predicted, the Secretary of State should consider the extent to which the effects are temporary or reversible, and the timescales for recovery".	An assessment of impacts on designated sites is available in the HRA [see Habitats Regulations Assessment/ Habitats Regulations Appraisal Screening Report, prepared to accompany the PEIR, Habitats Regulations Appraisal/Habitats Regulations Assessment RIAA, prepared to accompany the PEIR] and MCZ/MPA Assessment which will be submitted with the DCO Application and Marine Licence(s) to the Scottish Ministers These reports take into consideration the significance of impacts on Physical Processes receptors that have been evaluated in Section 1.8. The assessments consider both the temporal and spatial scale of any predicted impacts, alongside the recoverability and sensitivity of the associated receptor.
NPS EN-5	
Paragraph 2.2.10: "...As well as having duties under Section 9 of the Electricity Act 1989, (in relation to developing and maintaining an economical and efficient network), applicants must take into account Schedule 9 to the Electricity Act 1989, which places a duty on all transmission and distribution licence holders, in formulating proposals for new electricity networks infrastructure, to "have regard to the desirability of preserving natural beauty, of conserving flora, fauna and geological or physiographical features of special interest ... and ...do what [they] reasonably can to mitigate any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, sites, buildings or objects".	Commitments relevant to Physical Processes have been identified and are provided in Section 1.7, with the full list of commitments provided in Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR.
Paragraph 2.3.2(Part): "...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:	The Physical Processes baseline reviewed the impact of climate change on the metocean regime and coastal processes. A full description is given in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR and summarised in Section 1.4.6. The vulnerability of the MHPGC Project to coastal change is considered in Volume 4, Chapter 4: Climate Change, of the PEIR.

Summary of relevant NPS provisions	How and where considered in the PEIR
coastal erosion – for the landfall of offshore transmission cables and their associated substations in the inshore and coastal locations respectively”.	
Paragraph 2.13.21: “The sensitivities of many coastal locations and of the marine environment as well as the potential environmental, community and other impacts in neighbouring onshore areas must be considered in the identification of onshore connection points.”	Landfall design is summarised in Volume 1, Chapter 2: Project Description, of the PEIR whilst site selection/ options appraisal of the landfall sites is set out in Volume 1, Chapter 3: Site Selection & Consideration of Alternatives, of the PEIR. Commitments relevant to Physical Processes have been identified and are provided in Section 1.7, with the full list of commitments provided in Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR.
Paragraph 2.14.2(Part): “In the assessments of their designs, applicants should demonstrate how environmental, community and other impacts have been considered and how adverse impacts have followed the mitigation hierarchy i.e. avoidance, reduction and mitigation of adverse impacts through good design; how the mitigation hierarchy has been followed, in particular to avoid the need for compensatory measures for coastal, inshore and offshore developments affecting SACs SPAs, and Ramsar sites”.	Commitments relevant to Physical Processes have been identified and are provided in Section 1.7, with the full list of commitments provided in Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR.

National Planning Policy Framework

- 1.2.3.2 The National Planning Policy Framework (NPPF) has the potential to be considered important and relevant to the Secretary of State (SoS) consideration of the MHPGC Project (Ministry of Housing, Communities & Local Government, 2025). **Table 1.2** provides details of the elements of the NPPF that are relevant to Physical Processes and how and where they are covered in the PEIR or will be covered within the ES.

Table 1.2: Summary of NPPF requirements relevant to Physical Processes

NPPF section	How and where this is considered in the PEIR
Paragraph 187: “Planning policies and decisions should contribute to and enhance the natural and local environment by [<i>inter alia</i>] ... protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils (in a manner commensurate with their statutory status or identified quality in the development plan); ... [and] recognising the intrinsic character and beauty of the countryside, and the wider benefits from natural capital and ecosystem services; ... [and] minimising impacts on and providing net gains for biodiversity; ...[and] preventing new and existing development from contributing to, being put an unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability”	Features of interest and designated sites within the Physical Processes Study Area are summarised in Section 1.4 and described in more detail in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR. An assessment of impacts on these features and sites can be found in Section 1.8. Relevant designated sites have been further subjected to an HRA and an MCZ/MPA Assessment [see MHPGC Project HRA Screening Report, MHPGC Project, MHPGC Project RIAA and MHPGC Project MPA/MCZ Screening and Stage 1 Assessment Report]. These will be submitted as part of the development consent and marine licence application(s) to the Scottish Ministers .

NPPF section	How and where this is considered in the PEIR
Paragraph 192: “To protect and enhance biodiversity and geodiversity, plans should: Identify, map and safeguard components of local wildlife-rich habitats and wider ecological networks, including the hierarchy of international, national and locally designated sites of importance for biodiversity; wildlife corridors and stepping stones that connect them; and areas identified by national and local partnerships for habitat management, enhancement, restoration or creation; [and] promote the conservation, restoration and enhancement of priority habitats, ecological networks and the protection and recovery of priority species; and identify and pursue opportunities for securing measurable net gains for biodiversity.”	Impacts or effects on geodiversity and biodiversity are considered in Section 1.8, the HRA and the MCZ/MPA Assessment [see Habitats Regulations Assessment/Habitats Regulations Appraisal Screening Report, prepared to accompany the PEIR, Habitats Regulations Appraisal/Habitats Regulations Assessment RIAA, prepared to accompany the PEIR and Marine Protected Area/Marine Conservation Zone Screening and Stage 1 Assessment Report, which will accompany the ES].
Paragraph 194: “The following should be given the same protection as habitats sites: possible Special Areas of Conservation (SAC); [and] listed or proposed Ramsar sites; [and] sites identified, or required, as compensatory measures for adverse effects on habitats sites, potential Special Protection Areas (SPA), possible Special Areas of Conservation, and listed or proposed Ramsar sites.”	No possible/proposed sites have been identified in addition to existing designations. A full list of designated sites relevant to Physical Processes is provided in Section 1.4 and described in more detail in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR. Relevant designated sites have been further subjected to an HRA [see MHPGC Project HRA Screening Report, MHPGC Project, MHPGC Project RIAA] and an MCZ/MPA Assessment which will accompany the ES.

1.2.4 Marine planning policy context

1.2.4.1 The following marine plans are relevant to Physical Processes and have informed the assessment of preliminary effects in this chapter, their relevance to the MHPGC Project is outlined in **Table 1.3**:

- The UK Marine Policy Statement (MPS) (HM Government, 2020);
- Scotland’s National Marine Plan (Marine Directorate, 2015);
- Northeast Inshore and Northeast Offshore Marine Plan (MMO, 2021).

Table 1.3: Marine planning policy relevant to Physical Processes

Marine plan description	How and where considered in the PEIR
UK MPS	
The UK MPS is the framework for preparing Marine Plans and taking decisions affecting the marine environment. The MPS ensures that marine resources are used in a sustainable way by ensuring geodiversity is protected and conserved by using the precautionary principle and relying on sound evidence.	In line with policy objectives in the MPS, this chapter has taken into consideration measures that can be taken to avoid geodiversity and biodiversity loss. Where possible, consideration has been given to conserving and avoiding impacts to Physical Processes through routing, mitigation and consideration of reasonable alternatives – [see Volume 1, Chapter 3: Site Selection & Consideration of Alternatives, of the PEIR]. Potential adverse effects to designated sites and protected features have been avoided where possible. Details of protected sites and species designations are provided in Section 1.4, with an assessment of impacts and in Section 1.8. Commitments relevant to Physical Processes have been identified are provided in Section 1.7, with the full list of commitments provided in Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR.
Scottish National Marine Plan	

Marine plan description	How and where considered in the PEIR
The Scottish National Marine Plan covers the management of both Scottish inshore waters and offshore waters. This National Marine Plan sets out strategic policies for the sustainable development of Scotland's marine resources.	Routeing of the MHPGC Project has been selected to avoid sensitive habitats [see Volume 1, Chapter 2: Project Description, and Volume 1, Chapter 3: Site Selection & Consideration of Alternatives of the PEIR]. The potential for cumulative effects have been assessed, to ensure that changes caused by MHPGC Project activities acting cumulatively with other projects and activities do not combine to adversely impact Physical Processes receptors. A full list of designated sites relevant to Physical Processes is provided in Section 1.4 and described in more detail in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR. An assessment of impacts on these features and sites can be found in Section 1.8. Commitments relevant to Physical Processes have been identified are provided in Section 1.7, with the full list of commitments provided in Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR.
Northeast Inshore and Northeast Offshore Marine Plan	
Northeast Inshore and Northeast Offshore Marine Plan ensures geodiversity is protected and conserved from the Scottish border to Flamborough Head. This marine plan will contribute to the achievement and integration of sectoral activity through specific policies within a framework of economic, social and environmental considerations. The marine plan will reflect the MPS at the sub-national level, considering the social, economic and environmental factors that affect the northeast marine plan areas and the communities that are dependent on, or have an interest in, the northeast marine plan areas.	Routeing of the MHPGC Project has been selected to avoid sensitive habitats [see Volume 1, Chapter 2: Project Description, of the PEIR and Volume 1, Chapter 3: Site Selection & Consideration of Alternatives, of the PEIR]. An ecosystems-based approach has been adopted, and cumulative impacts have been considered, to ensure that effects from MHPGC Project activities do not adversely impact Physical Processes receptors. A full list of designated sites relevant to Physical Processes is provided in Section 1.4 and described in more detail in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR. An assessment of impacts on these features and sites can be found in Section 1.8. Commitments relevant to Physical Processes have been identified are provided in Section 1.7, with the full list of commitments provided in Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR.

1.2.5 Local policy context

- 1.2.5.1 The MHPGC Project lies within the jurisdiction of Durham County Council (DCC). The County Durham Plan (adopted in 2020) is relevant to Physical Processes and has informed the assessment of preliminary effects in this chapter. Its relevance to the MHPGC Project is outlined in **Table 1.4**.

Table 1.4: Local policy relevant to Physical Processes

Policy description	How and where considered in the PEIR
County Durham Plan	
Policy 37: The council will seek to protect and enhance the Durham Heritage Coast and wider Coastal Zone. Development proposals within the Durham Heritage Coast or wider Coastal Zone or that have the potential to individually or cumulatively impact on their setting must:	The Applicant has made a commitment (CoT13/MM-014 of Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR) to install the offshore export cables from the trenchless technique exit pits (situated seaward of MHWS to the TJB at Landfall). Trenchless cable installation is expected to cause minimal direct disturbance to the existing coastline and therefore not increase the risk from

Policy description	How and where considered in the PEIR
• Be appropriate in terms of scale, massing and design; • Not give rise to adverse impacts upon the tranquil or isolated character of the area; • Not increase the risk from climate change, flooding, erosion or land instability; • Demonstrate consistency with the protection, conservation and enhancement of its natural assets and heritage features; • Not be inconsistent with the purposes of the heritage coast and objectives of the heritage coast management plan. Other types of development within, or within the setting of, the Durham Heritage Coast or wider Coastal Zone will only be permitted where they meet criteria above and it can be clearly demonstrated that there are overriding social, environmental and/or economic benefits that will be derived from that particular proposal and that it cannot be accommodated outside of the wider Coastal Zone.	climate change, flooding, erosion or land instability. (This is considered further in Volume 3, Chapter 2: Water Resources and Flood Risk and Volume 4, Chapter 4: Climate Change, of the PEIR). Assessment of potential impacts to coastal morphology and coastal processes, including direct and indirect effects, have been assessed for the construction, O&M and decommissioning phases of the MHPGC Project in Section 1.8. An assessment of the potential for the MHPGC Project to cause adverse impacts upon the tranquil or isolated character of the area is set out in Volume 4, Chapter 1: Landscape and Visual Amenity, of the PEIR.
Policy 41: Proposals for new development will not be permitted if significant harm to biodiversity or geodiversity resulting from the development cannot be avoided, or appropriately mitigated, or, as a last resort, compensated for. Proposals for new development will be expected to minimise impacts on biodiversity by retaining and enhancing existing biodiversity assets and features and providing net gains for biodiversity including by establishing coherent ecological networks. Measures should be appropriate, consistent with the biodiversity of the site and contribute to the resilience and coherence of local ecological networks.	Physical Processes receptors (i.e. designated sites and features) that could be impacted by the MHPGC Project activities are summarised in Section 1.4 and an assessment of potential impacts on these receptors can be found in Section 1.8. No significant harm to geodiversity is predicted to occur. Commitments relevant to Physical Processes are detailed in Section 1.7.
Policy 42: Development that has the potential to have an effect on internationally designated site(s), (including all development within 0.4 kilometres (km) of the sites), either individually or in combination with other plans or projects, will need to be screened in the first instance to determine whether significant effects on the site are likely and, if so, will be subject to an Appropriate Assessment. Development will be refused where it cannot be ascertained, following Appropriate Assessment, that there would be no adverse effects on the integrity of the site, unless the proposal is able to pass the further statutory tests of 'no alternatives' and 'imperative reasons of overriding public interest' as set out in Regulation 64 of the Conservation of Habitats and Species Regulations 2017. In these exceptional circumstances, where these tests are met, appropriate compensation will be required in accordance with Regulation 68.	Consideration has been given to internationally designated sites in the MHPGC Project design. A full list of designated sites relevant to Physical Processes is provided in Section 1.4 and described in more detail in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR. An assessment of impacts on these features and sites can be found in Section 1.8. Relevant designated sites have been further subjected to an HRA [see Habitats Regulations Assessment/ Habitats Regulations Appraisal Screening Report, prepared to accompany the PEIR, Habitats Regulations Appraisal/Habitats Regulations Assessment RIAA, prepared to accompany the PEIR] and an MCZ/MPA Assessment which will accompany the ES].
Policy 43: All development proposals in, or which are likely to adversely impact upon (either individually or in combination with other developments) SSSIs or National Nature Reserves (where not a component of an internationally designated site) will only be permitted where the benefits of development in that location clearly	Consideration has been given to designated sites in the MHPGC Project design [see Volume 1, Chapter 3: Site Selection & Consideration of Alternatives, of the PEIR]. A full list of designated sites relevant to Physical Processes is provided in Section 1.4 and described in more detail in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR.

Policy description	How and where considered in the PEIR
outweigh the impacts on the interest features on the site and any wider impacts on the network of sites. All development proposals in, or which are likely to adversely impact upon, Local Sites (Geology and Wildlife) or Local Nature Reserves will only be permitted when it can be demonstrated that the benefits of development in that location outweigh the impacts on the local nature conservation interest or scientific interest on the site and any wider impacts on the network of sites. In all cases where development impacts adversely on a designated site, mitigation, or as a last resort compensation, must be provided and it must be demonstrated that the proposed mitigation or compensatory measures are appropriate to the designations assigned to the site and deliver clear net gains for the habitats and/or species assemblages the site is designated for. In relation to protected species and their habitats, all development which, alone or in combination, has a likely adverse impact on the ability of species to survive, reproduce and maintain or expand their current distribution will not be permitted unless: • appropriate mitigation, or as a last resort compensation, can be provided, which maintains a viable population and where possible provides opportunities for the population to expand; • where the species is a European protected species, the proposal also meets the licensing criteria of overriding public interest, no satisfactory alternative and favourable conservation status.	An assessment of impacts on these features and sites can be found in Section 1.8. Relevant designated sites have been further subjected to an HRA and an MCZ/MPA Assessment [see MHPGC Project HRA Screening Report, MHPGC Project, MHPGC Project RIAA and MHPGC Project MPA/MCZ Screening and Stage 1 Assessment Report, which will be submitted as part of the application for development consent and marine licence application(s) to MD-LOT]. Commitments relevant to Physical Processes are detailed in Section 1.7.

1.3 Consultation and engagement

1.3.1 Scoping

- 1.3.1.1 A Scoping Report for the MHPGC Project was issued to the PINS and MD-LOT in February 2025 (RPS, 2025). Following consultation with the appropriate statutory bodies, PINS (on behalf of the SoS) and MD-LOT both provided Scoping Opinions in March 2025 (PINS, 2025; MD-LOT, 2025, respectively).
- 1.3.1.2 **Table 1.5** sets out the key comments raised during the scoping process specific to Physical Processes, with details of how these comments have been addressed within the PEIR.

Table 1.5: Summary of scoping responses relevant to Physical Processes

Comment	How and where considered in the PEIR
PINS	
ID 3.1.1 Increased Suspended Sediment Concentrations (SSCs) and associated deposition during the O&M phase should be scoped in.	The potential impact of increased SSCs and associated deposition during the O&M phase has been included in the impact assessment [see Section 1.8.3].
ID 3.1.2 Impact to seabed morphology during decommissioning should be scoped in.	The potential impact on seabed morphology during the decommissioning phase has been included in the impact assessment [see Section 1.8.4].
ID 3.1.3	The potential impact on sediment transport pathways during the construction and decommissioning phases has

Comment	How and where considered in the PEIR
Impact to sediment transport pathways during construction and decommissioning should be scoped in.	been included in the impact assessment [see Section 1.8.2 and Section 1.8.4 , respectively].
ID 3.1.4 Northumbria Coast SPA should be included in the identified designated sites.	Northumbria Coast SPA has been included in the identified designated sites and list of sensitive receptors for impacts to coastal morphology in the impact assessment [see Section 1.8].
ID 3.1.5 The applicant should include impacts on waves and currents in the scope of the assessment.	Impacts on waves and currents due to the blockage effect of MHPGC Project infrastructure on the seabed have been considered under the assessment on "Impacts to sediment transport pathways due to the presence of infrastructure" [see Section 1.8].
MD-LOT	
Paragraph 5.2.1 The extent of the Study Area has been defined as one spring tidal excursion, calculated as 5 to 9km from ABPmer (2017) but given as 5.5 to 13.5km from the interim modelling for Morven North and Morven South. Clarification on this difference would be welcomed.	The extent of the Zone of Influence (Zol) for suspended sediment plumes originating from the MHPGC PEIR Project Red Line Boundary has been defined using a spring tidal excursion buffer of 5km to 9km, as calculated by HD modelling from Associated British Ports Marine Environmental Research Ltd.'s (ABPmer) (2017) and supported by the bespoke, project-specific PT modelling presented in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR. Modelling for Morven North and Morven South (Morven Offshore Wind Farm, 2026) shows similar plume extents of 5km to 9km. The higher value of 13.5km appears to result from conservative upward rounding of these distances or the sum of two tidal excursions (in the flood and ebb directions). For the MHPGC Project, the Physical Processes Study Area has been extended beyond the Zol to include the potential up-drift and down-drift influence of littoral processes at the landfall, as well as several nearby designated coastal and seabed features. As a result, the Physical Processes Study Area used for this assessment [see Section 1.4.2] still encompasses the highly conservative 13.5km tidal excursion distance referenced by Morven Offshore Wind Farm (2026).
Paragraph 5.2.2 Wave and LiDAR buoys were deployed within the Morven North and Morven South scoping boundary in 2022. It is unclear why this data is not being used to characterise the baseline wave regime. Clarification on this would be welcomed.	The use of modelled data provides a comprehensive understanding of the wave regime across the entire Physical Processes Study Area, rather than being limited to the specific locations where measurements were taken. This also enables conditions to be assessed over a much longer time period, allowing both prevailing and extreme wave climates to be characterised. Measured data from the 2022 buoy deployments in Morven North and Morven South has been incorporated into the baseline to validate the wave modelling and to provide insight into shorter-term (seasonal) variability in wave conditions. A summary of the baseline characterisation is provided in Section 1.4.2, with full detail presented in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR.
Paragraph 5.2.4 Advise that "increased SSCs and associated deposition" should be scoped into the operation and maintenance phase for further assessment.	The potential impact of increased SSCs and associated deposition during the O&M phase has been included in the impact assessment [see Section 1.8.3].

Comment	How and where considered in the PEIR
Paragraph 5.2.4 Advise that the potential impact of seabed scour must be scoped in for further assessment.	The effect of secondary seabed scour generated by the presence of cable protection on the seabed has been assessed in Section 1.8.3 .
Paragraph 5.2.5 Advise that impact to seabed morphology and impact to sediment transport pathways be scoped into the decommissioning phase for further assessment.	The potential impact on sediment transport pathways and seabed morphology during the decommissioning phase has been included in the impact assessment [see Section 1.8.4].
Marine Directorate - Science, Evidence, Data and Digital (MD-SEDD)	
MD-SEDD agree with the identified potential impacts on suspended sediment, seabed morphology and sediment transport pathways.	The assessment of impacts to Physical Processes is set out in Section 1.8
Agree with the proposed scope of EIA and with the proposed modelling methodology.	The scope of the Physical Processes PEIR assessment aligns with that set out in scoping report. The scope of the numerical modelling undertaken to support the PEIR assessment is in accordance with that agreed at the EWG held on 18 November, 2025 – [see Table 1.6]. It includes the following numerical modelling, validated using all available data sources, including data from the MHPGC Project specific surveys: • Hydrodynamic (tidal) model to inform baseline conditions; • Sediment transport model to inform baseline conditions; • Wave hindcast model to inform baseline conditions; • Sediment plume model to assess sediment disturbance impacts on SSC and resulting sediment deposition thickness.
Advise that at least one spring neap tidal cycle should be modelled.	Hindcast water-level and tidal-current timeseries from ABPmer SEASTATES HD model (ABPmer, 2017) were first reviewed by the Applicant to identify a representative spring-neap tidal cycle. This cycle was then simulated using bespoke, project-specific HD and PT models to inform the baseline characterisation [see Section 1.4.2] and to assess sediment plume transport and mixing for the impact assessment [see Section 1.8]. Full details of the modelling approach and results are provided in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR .
Natural England	
Advise that quantification of impacts must be presented showing the impacts of the Scottish portion of the cable on English receptors. For example, sediment suspension from Scottish cable laying and the potential for deposition in English waters.	Impacts have been assessed across the wider regional context, covering the full Physical Processes Study Area in both Scottish and English waters, as well as for Scottish and English receptors separately. The modelling domain spans both jurisdictions, meaning that sediment plumes generated by activities in Scottish waters can be transported into English waters (and vice versa), allowing any potential cross-boundary effects to be fully evaluated. This approach has been applied consistently throughout Section 1.8 .
Advise considering the following for the study area: • Underlying geology; • Seabed mobility; • Sediment transport rates and pathways; • Thickness of sediment units;	The Applicant confirms that all of the Physical Processes parameters listed have been taken into consideration in determining the extent of, and characterising the baseline. Full details are presented in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR .

Comment	How and where considered in the PEIR
Surge water levels and currents.	
Advise that the Northumbria Coast SPA and Durham Coast SAC are also included due to potential impact on its supporting habitats.	Coastal morphology within the Northumbria Coast SPA and Durham Coast SAC has been identified as a receptor and considered within the assessment set out in Section 1.8 .
Natural England offers the following advice for the scoped in impacts: - Changes to suspended sediment concentrations needs to include impacts of UXO clearance; - Impacts to the seabed needs to include assessment of scour; - Impacts to sediment transport also needs to include impacts at the offshore export landfall; - Natural England recommends that the following impact is added to the scope of the EIA: impacts on waves and currents.	The Applicant notes that: - Whilst the clearance of UXOs will result in localised sediment disturbance associated with temporary elevated levels of SSC, the volume of displaced material and duration of change will be less than for other seabed disturbance activities (notably sandwave clearance by Mass Flow Excavator (MFE)). Accordingly, the impact of UXO clearance on SSC has not been assessed further in this chapter as it does not represent the Maximum Design Scenario (MDS); - The potential for scour is set out in Section 1.8; - The potential for change to sediment transport at the landfall is set out in Section 1.8; - The assessment of potential change to sediment transport pathways implicitly takes into consideration potential modification of waves and currents. The assess is set out in Section 1.8.
Natural England advises that the applicant uses the following resource when assessing impacts from the project: Brooks, AJ., Whitehead, PA., Lambkin, DO. 2018. Guidance on Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to inform EIA of Major Development Projects.	The guidance set out in Brooks <i>et al.</i> (2018) has been used to inform the assessment [see Section 1.4.3].
Natural England advises detailed commentary is provided in the ES on the introduction of hard substrate as part of the proposed developments to allow further understanding of the potential nature conservation impact and what would need to be included in a CSIP.	At this stage, the exact locations at which hard substrate may be installed is unknown. However, indicative maximum footprints and volumes are known and have been used to assess the significance of potential impacts on benthic habitats - see Volume 2, Chapter 3: Benthic Subtidal and Intertidal Ecology, of the PEIR. The potential for rock protection to impact sediment transport processes is set out in Section 1.8.
As Swallow Sands MCZ is located approximately 20km away from proposed operations, we do not currently anticipate that any associated activity will have an impact on this MPA. However, it remains important to assess all potential operational impact-pathways in combination with the Site Information Centre documents on the Joint Nature Conservation Committee (JNCC) website (JNCC, 2026).	Swallow Sand MCZ could be sensitive to the advection of suspended sediment plumes and/or by the interruption of nearbed sediment transport processes. However, any changes to the above would be restricted to the Zone of Influence, which extends <5km from the MHPGC Project PEIR Red Line Boundary as it passes Swallow Sand MCZ. Accordingly, it has not been considered further within this assessment.
NatureScot	
The extent of the Physical Processes Study Area has been defined as one spring tidal excursion – calculated as 5 to 9km from ABPmer (2017)) but given as 5.5 to 13.5km in the Morven Offshore Wind Array Scoping Report. Clarification on this difference would be welcomed.	The extent of the Zol for suspended sediment plumes originating from the MHPGC Project PEIR Red Line Boundary has been defined using a spring tidal excursion buffer of 5km to 9km, as calculated by HD modelling from ABPmer (2017) and further supported by the bespoke, project-specific PT modelling presented in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR . Modelling for Morven North and Morven South (Morven Offshore Wind Farm, 2026) shows similar plume

Comment	How and where considered in the PEIR
	extents of 5km to 9 km. The higher value of 13.5km appears to result from conservative upward rounding of these distances or the sum of two tidal excursions (in the flood and ebb directions). For the MHPGC Project, the Physical Processes Study Area has been extended to include the potential up-drift and down-drift influence of littoral processes at the landfall, as well as several nearby designated coastal and seabed features. As a result, the Physical Processes Study Area used for this assessment [see Section 1.4.2] still encompasses the highly conservative 13.5km tidal excursion distance referenced by Morven Offshore Wind Farm (2026).
Wave and Light Detection and Ranging (LiDAR) buoys were deployed within the Morven North and Morven South scoping boundary in 2022. It is unclear why this data is not being used to characterise the baseline wave regime. Clarification on this would be welcomed.	The use of modelled data provides a comprehensive understanding of the wave regime across the entire Physical Processes Study Area, rather than being limited to the specific locations where measurements were taken. This also enables conditions to be assessed over a much longer time period, allowing both prevailing and extreme wave climates to be characterised. Measured data from the 2022 buoy deployments in Morven North and Morven South has been incorporated into the baseline to validate the wave modelling and to provide insight into shorter-term (seasonal) variability in wave conditions. A summary of the baseline characterisation is provided in Section 1.4.2, with full detail presented in Volume 2, Annex 1.1: Physical Processes Baseline Technical Report, of the PEIR.
Recommend that as well as the Firth of Forth Banks Complex MPA, consideration should be given to treating areas of undesignated seabed as a receptor.	Potential changes to undesignated areas of seabed are described within Section 1.8. These have not been identified as a receptor within this chapter; however the potential for these physical changes to impact ecological receptors in these areas have been assessed in Volume 2, Chapter 3: Benthic Subtidal and Intertidal Ecology, of the PEIR.
The proposed Physical Processes Study Area overlaps with Offshore Subtidal Sands and Gravels, which are listed as a designated Priority Marine Feature (PMF).	Protected geological and geomorphological features (which includes Offshore Subtidal Sands and Gravels) contained within designated sites overlapping the Zone of Influence are considered within the impact assessment [see Section 1.8]. A full assessment of the potential for impacts to all PMFs including Offshore Subtidal Sands and Gravels is provided in Volume 2, Chapter 3: Benthic Subtidal and Intertidal Ecology, of the PEIR.
Advise that 'increased SSCs and associated deposition' be scoped in for the O&M phase.	The potential impact of increased SSCs and associated deposition during the O&M phase has been included in the impact assessment [see Section 1.8.3].
Advise that seabed scour be assessed.	The effect of seabed scour generated by the presence of cable protection on the seabed has been assessed in Section 1.8.3.
Current policy in Scotland is that all infrastructure associated with offshore renewable energy should be removed during decommissioning.	All scoped in impacts have been assessed for the decommissioning phase of the MHPGC Project [see Section 1.8.4]. The MDS is for all offshore export cable materials to be removed for decommissioning.
We advise that some aspects of modelling could be reduced through semi-quantitative assessment using empirical formulae and scientific judgment.	A combination of modelling and semi-quantitative methods have been used throughout the impact assessment [see Section 1.8]. Full details of the modelling

Comment	How and where considered in the PEIR
	approach and results are provided in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR .
Potential influences from the Ossian Offshore Wind Farm infrastructure should be considered.	Cumulative impacts with the Ossian Offshore Wind Farm have been considered in the CEA [see Section 1.9].
Agree transboundary impacts in relation to Physical Processes can be scoped out.	Comment acknowledged, no action required.
For the MPA screening assessment the Zol for benthic and geodiversity features has been increased to 15km from the modelled 5km to 9km, this should also be applied for the Physical Process assessment.	The extent of the Zol for suspended sediment plumes originating from the MHPGC Project PEIR Red Line Boundary has been defined using a spring tidal excursion buffer of 5km to 9 km, as calculated by HD modelling from ABPmer (2017) and supported by the bespoke, project-specific PT modelling presented in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR. Modelling for Morven North and Morven South (Morven Offshore Wind Farm, 2026) shows similar plume extents of 5km to 9km. The higher value of 13.5km appears to result from conservative upward rounding of these distances or the sum of two tidal excursions (in the flood and ebb directions). For the MHPGC Project, the Physical Processes Study Area has also been extended beyond the Zol to include the potential up-drift and down-drift influence of littoral processes at the landfall, as well as several nearby designated coastal and seabed features. As a result, the Physical Processes Study Area used for this assessment [see Section 1.4.2] still encompasses the highly conservative 13.5km tidal excursion distance referenced by Morven Offshore Wind Farm (2026).
MMO	
Considers scoped in impacts to be acceptable but requests the nearshore and landfall interface is also considered when looking at Physical Processes receptors.	Potential impacts to coastal morphology (encompassing the nearshore and landfall interface) have been assessed for the construction, O&M and decommissioning phases of the MHPGC Project in Section 1.8.2, Section 1.8.3 and Section 1.8.4 , respectively.
Queries why the impact to sediment transport and seabed morphology is not considered during the decommissioning phase. Expect to see the impact assessed.	The impact on sediment transport pathways and seabed morphology during the decommissioning phase has been included in the impact assessment [see Section 1.8.4].
Considers that the desk-based data sources used are appropriate and the proposal of using numerical models is standard practice for assessing Physical Processes.	Comment acknowledged, no action required.

1.3.2 Further consultation and engagement

- 1.3.2.1 As part of the MHPGC Project Evidence Plan Process, additional consultation with Natural England and the MMO has been undertaken via the Physical Processes, Benthic Ecology and Fish and Shellfish Ecology Expert Working Groups (EWG). NatureScot has engaged with the EWGs via email and written feedback where they have been unable to attend. Additional consultation has been summarised in **Table 1.6**.

Table 1.6: Summary of further consultation and engagement

Date	Consultee and response type	Comment	How and where considered in the PEIR
18 November 2025	Natural England, EWG	Agreed to the proposed scope of numerical modelling to support the EIA, to include the following numerical modelling, validated using all available data sources, including data from the MHPGC Project specific surveys: - Hydrodynamic (tidal) model to inform baseline conditions; - Sediment transport model to inform baseline conditions; - Wave hindcast model to inform baseline conditions; - Sediment plume model to assess sediment disturbance impacts on SSC and resulting sediment deposition thickness.	Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR provides a description of baseline environmental conditions relevant to Physical Processes, informed in part by the results of numerical modelling. Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR. provides assessments of Physical Processes, informed in part by the results of numerical modelling.
18 November 2025	Natural England, EWG	Agree in principle that the Physical Processes Study Area should be informed by Physical Processes modelling.	The Physical Processes Study Area has been defined on the basis of: - The distance away from the MHPGC Project that suspended sediment plumes may be advected (and interact with potentially sensitive receptors). This has been defined by a spring tidal excursion ellipse buffer around the MHPGC Project PEIR Red Line Boundary; - The distance up/down drift from the landfall, that littoral processes could theoretically be affected by infrastructure associated with the MHPGC Project. The Physical Processes Study Area is presented in Section 1.4.2.
18 November 2025	Natural England, EWG	Agree with the Applicant's proposed approach to Physical Processes modelling, as presented in the EWG meeting.	Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR. provides assessments of Physical Processes, informed in part by the results of numerical modelling.
18 November 2025	Natural England, EWG	Agrees with use of desktop data and evidence from other sufficiently analogous projects.	Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR provides a description of baseline environmental conditions relevant to Physical Processes, informed in part by the results of numerical modelling, project-specific survey data, and evidence from similar projects.

Date	Consultee and response type	Comment	How and where considered in the PEIR
02 December 2025	Nature Scot, Email correspondence	We understand that the proposed regional-scale modelling will be used only 'to inform the description of baseline conditions', and not for the actual impact assessment. The exception to this is that sediment plume modelling will be used, to inform assessment of changes to suspended sediment concentrations, etc. The assessments to consider how the MHPGC development might cause changes to seabed morphology and changes to sediment transport will instead use desk/spreadsheet-based methods. This is useful clarification, and we confirm that we are content with this approach outlined.	Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR provides a description of baseline environmental conditions relevant to Physical Processes, informed in part by the results of regional-scale numerical modelling. Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR. provides assessments of Physical Processes, informed in part by the results of project-specific plume numerical modelling.
16 July 2026	EWG (Awaiting responses from consultees)	Sought agreement on the approach to the cumulative effects assessment, and the proposed mitigation measures and commitments.	The approach to the cumulative effects assessment is set out in Section 1.9 . Proposed mitigation and commitments are set out in Table 1.15 .

1.4 Baseline Characterisation

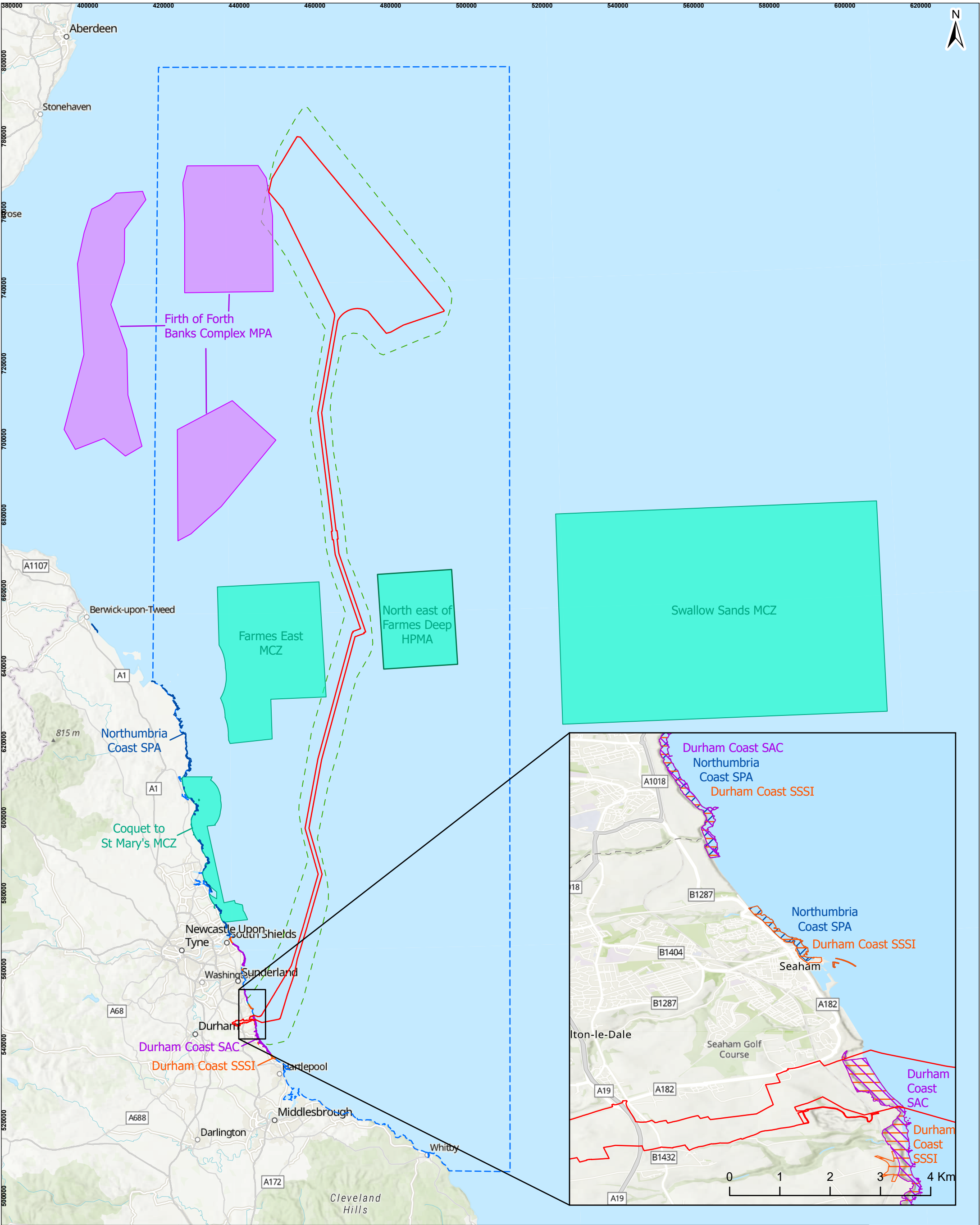
1.4.1 Overview

- 1.4.1.1 **Volume 1, Chapter 2: Project Description, of the PEIR** sets out the description of the MHPGC Project and **Volume 1, Chapter 4: Approach to Environmental Impact Assessment, of the PEIR** sets out the overarching approach that has been used in developing the preliminary environmental information.
- 1.4.1.2 This section describes the methods and data sources used to characterise the baseline for Physical Processes within the Physical Processes Study Area and describes the existing baseline characteristics. A full description of the Physical Processes baseline is provided in **Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR**.

1.4.2 Physical Processes Study Area

- 1.4.2.1 The Physical Processes Study Area is located off the northeast coast of England and southeast coast of Scotland and represents the wider area across which baseline data collation and characterisation has been undertaken for the purposes of informing the Physical Processes assessment (Figure 1-1). The exact limits of the study area boundary are somewhat arbitrary but cover a sufficiently large area to describe the regional-scale Physical Processes, including winds, waves, tides and sediment transport.
- 1.4.2.2 A ZOI has also been defined. This is the area within which the MHPGC project may cause direct or indirect changes to tides, sediments, morphology, and/or the water column. The ZOI has been defined on the basis of:
- The distance away from the MHPGC Project that suspended sediment plumes may be advected (and interact with potentially sensitive receptors). This has been defined by a spring tidal excursion ellipse buffer (of between 5km and 9km) around the MHPGC Project PEIR Red Line Boundary;
 - The distance up/down drift from the landfall, that littoral processes could theoretically be affected by infrastructure associated with the MHPGC Project.

-
- 1.4.2.3 The Physical Processes Study Area is shown on Figure 1-1. The study area is larger than the ZOI and encompasses a nominal wider region within which greater detail of baseline understanding is required to inform assessments of potential indirect changes (e.g.) to sediment transport pathways. The study area does not indicate an expectation of measurable change or impact within this extent.





Project Name:
MORVEN HAWTORN PIT GRID CONNECTION PROJECT

Drawing Title:
FIGURE 1.1: PHYSICAL PROCESSES STUDY AREA

Drawing Number:
MHPGC-ABP-PP-0009

Data Sources:
© Natural England copyright. Contains Ordnance Survey data. © Crown copyright and database right 2024 © NatureScot 2024. OGL V3

Geodetic Information:
World Topographic Map: Esri, HERE, Garmin, FAO, NOAA, USGS
World Hillshade: Esri, Intermap, NGA, NGA, USGS
World Topographic Map: Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community
World Hillshade: Esri, USGS

VER	DATE	DETAILS	BY	CHECK
00	04/12/25	Initial Issue	HMN	HKG
01	09/07/26	Update Issue	ALN	DOL
-	-	-	-	-
-	-	-	-	-

0 5 10 15 20 25 30 35 40 km

Scale@A3:1:900,000

Service Layer Credits:
Datum: OSGB 1936
Projection: British National Grid

LEGEND

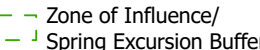
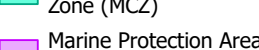


Figure 1-1: Physical Processes Study Area



1.4.3 Relevant guidance

1.4.3.1 The preliminary assessment has been carried out in accordance with the following guidance documents:

- Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards: Phase I: Expectations for pre-application baseline data for designated nature conservation and landscape receptors to support offshore wind applications. (Natural England, 2025);
- Nature conservation considerations and environmental best practice for subsea cables for English Inshore and UK offshore waters. (Natural England and JNCC, 2022);
- Metocean Procedures Guide for Offshore Renewables: Guidance to support metocean characterisation data acquisition and assessments to inform developments (Institute of Marine Engineering Science and Technology (IMarEST, 2024);
- Guidance on Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to Inform EIA of Major Development Projects. Natural Resources Wales Report No 243 (Brooks *et al.*, 2018);
- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Centre for Environment, Fisheries and Aquaculture Science (Cefas), 2012);
- Coastal Process Modelling for Offshore Wind Farm EIA: Best Practice Guide (ABPmer and HR Wallingford, 2009); and
- Guidelines in the use of metocean data through the lifecycle of a marine renewables development (Construction Industry Research and Information Association, 2008).

1.4.3.2 It is noted here that best practice guidance relating to offshore wind farm development in Scottish waters is currently being produced for Scottish Government. This is expected to be published in Q4 2026 but is not available at the time of writing to inform this PEIR chapter.

1.4.4 Baseline Data Sources

Desk study

1.4.4.1 Information on Physical Processes within the Physical Processes Study Area was collected through a detailed desktop review of existing studies; datasets used to inform the analysis are summarised in **Table 1.7**.

1.4.4.2 Both the literature review of the reports and numerical modelling using the datasets were used to characterise the baseline. **Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR** includes full details of the analysis undertaken to develop the Physical Processes baseline.

Table 1.7: Summary of key desktop datasets and reports for the Physical Processes baseline characterisation

Title	Source	Date	Summary	Coverage of the Physical Processes Study Area ¹
ABPmer SEASTATES	ABPmer (2025)	1979 to 2022	Modelled hindcast wave and HD data from across the Physical Processes Study Area (ABPmer, 2025).	Full coverage
British Geological Survey (BGS) offshore geindex	BGS (2025)	Data accessed: 2025	Seabed sediment maps (based on Folk classification) and borehole records from point locations within the Physical Processes Study Area (BGS, 2026).	Partial coverage
European Marine Observation and Data Network	EMODnet (2025)	Data accessed: 2025	EMODnet Map Viewer (EMODnet, 2025).	Full coverage

Title	Source	Date	Summary	Coverage of the Physical Processes Study Area ¹
(EMODnet) Data Layers				
MPA Geodiversity Mapping	(Brooks <i>et al.</i> 2011)	2011	Mapping of geological and geomorphological features within Scottish MPAs, based on publicly available seabed surveys and research.	Partial coverage
Marine Renewables Atlas	ABPmer, Met Office and Proudman Oceanographic Laboratory (POL) (2008)	2008	Modelled hindcast wave and HD data from across the Physical Processes Study Area (ABPmer, Met Office and POL, 2008).	Full coverage
Suspended Particulate Matter mapping	Cefas (2016)	2016	Monthly and seasonal Suspended Particulate Matter maps for the Physical Processes Study Area.	Full coverage
United Kingdom Hydrographic Office (UKHO) Total Tide Data	UKHO (2025)	2025	Tidal water levels from point locations within the Physical Processes Study Area.	Partial coverage
MHPGC Project Seabed Mobility Assessment	Partrac (2024)	2024	Seabed mobility report detailing estimated future seabed level change in relation to the MHPGC project.	Full coverage
MHPGC Project Metocean Reports	Metocean works (2024a)	2024	Metocean reports detailing the representative conditions in relation to the MHPGC project.	Four points within the MHPGC PEIR Red Line Boundary
MHPGC Project Geological Characterisation Report	Norwegian Geotechnical Institute NGI) (2024)	2024	Integrated geological, geophysical and geotechnical characterisation of soil and rock units encountered in relation to the MHPGC project	Full coverage
(Key publications)	-	[various]	Public and grey literature considering coastal morphology and behaviour at sensitive coastal locations within the Physical Processes Study Area e.g. Pitman <i>et al.</i> (2024) and Royal Haskoning (2014).	Full to partial coverage

¹ See **Figure 3.1: Site-specific survey data locations in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR** for coverage

Site specific surveys

- 1.4.4.3 A summary of the surveys undertaken to inform the Physical Processes baseline is outlined in **Table 1.8** below.

Table 1.8: Summary of site-specific surveys undertaken for the Physical Processes baseline characterisation

Survey Type	Scope of survey	Coverage of the Physical Processes Study Area ¹
Offshore export cable corridor geophysical and environmental survey (XOCEAN Ltd., 2023) Year of survey: 2023	Multibeam Echosounder and sub bottom profiler on offshore export cable corridor and four landfall options.	Partial coverage
Benthic sample survey (Gardline Ltd., 2023) Year of survey: 2023	128 of the grab samples that underwent Particle Size Analysis (PSA) analysis	Nearly full coverage of offshore export cable corridor
Offshore export cable corridor geotechnical survey (Gardline Ltd., 2024a) Year of survey: 2023	Geotechnical Core Penetration Tests (CPT) (English/Scottish waters) and Vicrocore (Scottish waters only) sampling	Partial coverage
Benthic sample survey (Gardline Ltd., 2024) Year of Survey: 2024	42 grab samples that underwent PSA analysis	Partial coverage
Floating LiDAR (EOLOS, 2025) Deployed: Oct 2022 Recovered: 2024	Two floating LiDAR deployments to measure metocean parameters	Partial coverage
Offshore export cable corridor geophysical and environmental survey (XOCEAN Ltd., 2025) Year of survey: 2024 & 2025	Multibeam Echosounder, side scan sonar, magnetometer and sub bottom profiler on offshore export cable route and four landfall options	Full coverage
¹ See Figure 3.1: Site-specific survey data locations in Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR for coverage		

Data limitations and assumptions

- 1.4.4.4 Uncertainty exists regarding the characterisation of the future baseline with respect to global climate change. Key areas of uncertainty include actual future rates of sea level rise and the extent to which future changes in the wave regime may occur. There is also related uncertainty regarding how the coastline may respond to a future wave climate acting in combination with higher than present sea levels. More detail on the future baseline is provided in **Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR**.

1.4.5 Overview of baseline environment

- 1.4.5.1 An overview of the Physical Processes baseline environment is provided in this section. A full description of the Physical Processes baseline is provided in **Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR**.

Scottish waters

- 1.4.5.2 The Physical Processes Study Area is located within a semi-diurnal tidal environment. The furthest northern extent of the MHPGC Project PEIR Red Line Boundary, in Scottish waters, has a spring tidal range of ~2.5m.
- 1.4.5.3 Current speed is relatively uniform in space across the MHPGC Project PEIR Red Line Boundary, with Scottish and English regions of the MHPGC Project PEIR Red Line Boundary showing similar current speed values. Tidal currents are relatively weak, with depth-averaged mean spring peak current speeds typically less than 0.6m/s. During peak flows coinciding with (close to) low water, current direction is approximately northwards in Scottish waters. During peak flows coinciding with (close to) high water, flow directions are reversed.

- 1.4.5.4 Waves in the Scottish waters of the Physical Processes Study Area predominantly come from the north. Mean and extreme significant wave height values are greatest in Scottish waters; mean significant wave height is 1.9m.
- 1.4.5.5 Seabed sediments within the Physical Processes Study Area vary with distance offshore. Further offshore, seabed sediments tend to comprise sands, gravelly sands and muddy sands, with the sand component originating from Holocene deposits. The thickness of the surficial Holocene veneer within the Physical Processes Study Area is typically thin (<2m). These surficial units are underlain by various sequences of Pleistocene age (the period between approximately 2.6 million years ago and 11,700 years ago).
- 1.4.5.6 The MHPGC Project-specific geophysical survey data shows that water depths within the MHPGC Project PEIR Red Line Boundary that overlaps with Scottish waters range between approximately ~72m Lowest Astronomical Tide (LAT) and ~60m LAT. The average gradients within the Scottish waters of the Physical Processes Study Area are gentle (<1°) (XOCEAN Ltd., 2025).
- 1.4.5.7 Regional scale patterns of potential sediment transport have been inferred using sediment transport modelling undertaken for the MHPGC Project (see **Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR** and **Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR** for further details). The predominant direction of net sediment transport across the Physical Processes Study Area is towards the north, driven by tidal currents. Over much of the Scottish waters Physical Processes Study Area, water depths are too great for waves to cause sediment mobility on a regular basis.
- 1.4.5.8 Potential net sediment transport rates are generally lower across the MHPGC Project PEIR Red Line Boundary in Scottish waters. This is primarily due to naturally weaker tidal currents that are insufficient to frequently or strongly mobilise or transport sand.

English waters

- 1.4.5.9 The spring tidal range increases as the cable runs southward, into English waters and to the landfall. Near the central point of the MHPGC Project PEIR Red Line Boundary, in English waters, the spring tidal range is ~3.3m. At the landfall the spring tidal range further increases to ~4.3m (ABPmer *et al.*, 2008).
- 1.4.5.10 Tidal currents are relatively weak, with depth-averaged mean spring peak current speeds typically less than 0.6m/s. During peak flows coinciding with (close to) LW, current direction is approximately north-northwesterly in English waters. During peak flows coinciding with (close to) HW, flow directions are reversed.
- 1.4.5.11 Waves in the English waters of the Physical Processes Study Area predominantly come from the north-north east closer to the landfall, with a northward rotation further offshore in English waters. Mean and extreme significant wave height values reduce towards the landfall, with generally lower values in English waters compared to further northwards and offshore Scottish waters. For the closest point to the landfall in English waters, the mean significant wave height is 0.9m.
- 1.4.5.12 In offshore English waters seabed sediments tend to comprise sands, and muddy sands. Closer to the landfall, seabed sediments mainly comprise fine silty sand, with the occasional isolated regions of more gravelly sand, boulder fields and exposed bedrock close to the coast. The thickness of the surficial Holocene veneer within the Physical Processes Study Area is typically thin (<2m). These surficial units are underlain by various sequences of Pleistocene age (the period between approximately 2.6 million years ago and 11,700 years ago).
- 1.4.5.13 The MHPGC Project-specific geophysical survey data shows that water depths within the MHPGC Project PEIR Red Line Boundary that overlaps with English waters range between approximately ~107m LAT and ~0m LAT at the landfall. The steepest gradients within the Physical Processes Study Area (~50°) are associated with a boulder field close to the coast.
- 1.4.5.14 Over much of the English waters Physical Processes Study Area, water depths are too great for waves to cause sediment mobility on a regular basis. However, occasional additional seabed sediment disturbance might be expected due to larger storm waves in relatively shallower water depths (i.e. close to the coastline).

- 1.4.5.15 Sediment transport rates increase closer to the coast, in English waters, where current speeds are typically higher due to flow acceleration around the Northumberland coastline. Generally, the predominant direction of net sediment transport is towards the north. Comparison between the MHPGC Project bathymetric survey and an earlier UKHO survey from 2004 (UKHO, 2004) indicates that bed features have migrated northwards at rates of up to approximately 4m per year.
- 1.4.5.16 The coastline in the Physical Processes Study Area extends from Bamburgh to Whitby, much of the coastline is natural with cliffs, beaches and dunes present. The offshore export cables are expected to make landfall directly south of Seaham to then join up to the National Grid at the Hawthorn Pit. The landfall site extends from Dolostone cliffs, through a platform of natural soil and colliery waste, to a beach of gravelly sands. The available evidence indicates a relatively stable beach extent and cliff location. LiDAR data shows that material is transported southwards as the southern end of the beach has accreted material while the northern end has eroded. The 2007 Shoreline Management Plan 2 (SMP2) recommends “No Active Intervention” across all time periods (to 2025, to 2055 and to 2105) within the MHPGC Project PEIR Red Line Boundary (Royal Haskoning, 2007). Consequently, it is unlikely that coastal defences will be implemented and the coast will erode naturally.

Designated sites and priority marine features

- 1.4.5.17 The Physical Processes Study Area [see Figure 1-1] contains several nationally and internationally designated sites.
- 1.4.5.18 Designated sites within the Physical Processes Study Area located in Scottish waters are as follows, with distances from the MHPGC PEIR Red Line Boundary at the closest point, provided:
- Firth of Forth Banks Complex MPA (33km away).
- 1.4.5.19 Designated sites within the Physical Processes Study Area located in English waters are:
- Farnes East MCZ (2km away);
 - North East of Farnes Deep MCZ and Highly Protected Marine Area (HPMA) (4km away);
 - Durham Coast SAC (overlap with the MHPGC PEIR Red Line Boundary);
 - Durham Coast SSSI (overlap with the MHPGC PEIR Red Line Boundary);
 - Northumbria Coast SPA (2km away);
 - Coquet to St. Mary’s MCZ (15km away).
- 1.4.5.20 The sites are designated for the habitats they contain as well as (in some instances) for the presence of geological and geomorphological features. These are described in more detail in **Section 1.5.1**.

1.4.6 Future baseline conditions

- 1.4.6.1 During the 35 year operational lifetime of the MHPGC Project, the Physical Processes baseline can be expected to evolve both on a natural basis and in response to global trends such as climate change and other anthropogenic activities. The Infrastructure Planning (EIA) Regulations 2017, the Marine Works (Environmental Impact Assessment) Regulations 2007 and the Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 require that “an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge” is included. Therefore, an assessment of future baseline conditions, in the absence of the MHPGC Project, has been undertaken and is described within this section.
- 1.4.6.2 An overview of the Physical Processes future baseline environment is provided in this section. A full description of the Physical Processes future baseline is provided in **Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR**.
- 1.4.6.3 Information on the rate and magnitude of anticipated relative sea level change during the 21st Century is available from United Kingdom Climate Projections (UKCP18) (Palmer *et al.*, 2018). By 2075, relative sea level is predicted to have risen by approximately 0.6m above present day (2025) levels (Representative Concentration Pathway (RCP) 8.5, 95th percentile) at the landfall, with rates of change increasing over time.

- 1.4.6.4 Sea level rise may result in the loss of intertidal habitat through the process of 'coastal squeeze', caused by the presence of coastal defences preventing natural roll back, and future equilibrium position of coastal features (Environment Agency, 2021).
- 1.4.6.5 UKCP18 provides projections of changes to storm surge magnitude in the future as a result of climate change. These projections of change in extreme coastal water levels are dominated by the increase in mean sea level with only a minor (<10%) additional contribution due to atmospheric storminess changes over the 21st Century (Palmer *et al.*, 2018).
- 1.4.6.6 These changes are unlikely to significantly alter tidal patterns and sediment transport regimes offshore in the MHPGC Project PEIR Red Line Boundary. However, a rise in sea level may allow larger waves, and therefore more wave energy, to reach the coast in certain conditions and consequently result in an increase in local rates or patterns of erosion and the equilibrium position of coastal features. However, there is substantial uncertainty in projecting future changes of wave climates within the North Sea.

1.5 Impact assessment methodology

1.5.1 Overview

- 1.5.1.1 **Volume 1, Chapter 4: Approach to Environmental Impact Assessment, of the PEIR** sets out the overarching approach that has been used in developing the preliminary environmental information. This section describes the technical methods used to determine the sensitivity of the receptors and magnitude of impacts and sets out the significance criteria that have been used for the Physical Processes assessment. The methodologies for assessing sensitivity, magnitude and significance for Physical Processes are described in more detail below.
- 1.5.1.2 In order to assess the potential changes to Physical Processes, relative to the existing baseline, a combination of analytical methods have been used. These methods are discussed with respect to each of the potential impacts, and pathways of effects, in the assessment sections, but can be summarised as:
- Semi-quantitative assessments of sediment transport blockages from the MHPGC Project infrastructure, also with reference to spatial maps of baseline sediment transport pathways from a high-resolution numerical sand transport model;
 - Numerical modelling of sediment plumes produced from installation activities, giving associated changes in SSC and bed level;
 - Spreadsheet based tools for extent and concentration of sediment plumes produced from installation activities and associated changes in bed level;
 - Analytical assessments of MHPGC Project-specific data;
 - Evidence from analogous projects including other offshore wind farms and subsea cables.
- 1.5.1.3 For the most part, Physical Processes are not in themselves receptors but are instead 'pathways'. However, changes to Physical Processes have the potential to indirectly impact other environmental receptors (e.g. Brooks *et al.* 2018; ABPmer and HR Wallingford, 2009). For instance, the creation of sediment plumes (the potential for which is considered in the Physical Processes assessment) may lead to the settling of material onto benthic habitats. The potential significance of this particular change is assessed in **Volume 2, Chapter 3: Benthic Subtidal and Intertidal Ecology, of the PEIR**.
- 1.5.1.4 Whilst Physical Processes can largely be considered as pathways, a small number of potentially sensitive Physical Processes receptors have been identified within (or in proximity to) the Zol. These are:
- The seabed morphology and sediment characteristics of designated areas of seabed:
 - Firth of Forth Banks Complex MPA (which contains the following protected geomorphological and sediment features):
 - Moraines;
 - Shelf Banks & Mounds;
 - Offshore subtidal sands and gravels;

- Farnes East MPA (which contains the following protected geomorphological and sediment features):
 - Moderate energy circalittoral rock;
 - Subtidal coarse sediment;
 - Subtidal sand;
 - Subtidal mud;
 - Subtidal mixed sediments;
- North East of Farnes Deep MCZ and HPMA (which contains the following protected geomorphological and sediment features):
 - Subtidal coarse sediment;
 - Subtidal sand;
 - Subtidal mud;
 - Subtidal mixed sediments.
- The morphology of designated coastlines
 - Durham Coast SAC (which contains the following protected geomorphological features):
 - Vegetated sea cliffs;
 - Northumbria Coast SPA
 - Designated for internationally important bird species whose presence directly relates to the coastal geological and geomorphological characteristics (namely rocky shores, bedrock reefs, and cobble beaches, interspersed with small sandy bays.);
 - Durham Coast SSSI (which contains the following protected geomorphological features):
 - Vegetated sea cliffs.
- Non designated coastlines:
 - Including cliffs, inter-tidal and nearshore sub-tidal areas.

1.5.1.5 Where these receptors have the potential to be affected by changes to Physical Processes as a result of the MHPGC project, a full impact assessment (i.e. assigning sensitivity, magnitude and significance) has been carried out.

1.5.2 Receptor sensitivity

1.5.2.1 When defining sensitivity, reference has been made to the criteria levels set out in **Volume 1, Chapter 4: Approach to Environmental Impact Assessment, of the PEIR**. To determine sensitivity of the receptor, the vulnerability of the receptor to the specific impact and its ability to recover and adapt were also considered [see **Table 1.9**].

Table 1.9: Definition of terms relating to the sensitivity of the receptor

Sensitivity	Definition
Very high	No capacity to accommodate the proposed form of change and/ or receptor designated and/or of international level importance. Receptor very unlikely to be able to recover from impact. Likely to be rare with minimal potential for substitution. May also be of very high socioeconomic importance.
High	Very low capacity to accommodate the proposed form of change and/ or receptor designated and/or of international level importance. Receptor unlikely to be able to recover from impact. Likely to be rare with minimal potential for substitution. May also be of very high socioeconomic importance.
Medium	Moderate to low capacity to accommodate the proposed form of change and/or receptor designated and/ or of regional level importance. Receptor has some potential to recover from impact. Likely to be relatively rare. May also be of moderate socioeconomic importance.
Low	Moderate to high capacity to accommodate the proposed form of change and/or receptor not designated but of district level importance. Receptor likely to be able to recover from impact.
Negligible	High capacity to accommodate the proposed form of change and/or receptor not designated and only of local level importance. Receptor very likely to be able to recover from impact.

1.5.3 Magnitude of impact

- 1.5.3.1 The magnitude of an impact that could affect Physical Processes is influenced by several key factors, including the scale of the change, the spatial extent the impact is likely to occur within and the duration and frequency of the impact. When defining the magnitude of the impact, criteria detailed in **Volume 1, Chapter 4: Approach to Environmental Impact Assessment, of the PEIR** has been followed [see **Table 1.10**].

Table 1.10: Definition of terms relating to the magnitude of an impact

Magnitude	Definition
High	Permanent adverse change/deterioration across the near- and large parts of the far-field to key characteristics or features of the particular environmental aspect's character or distinctiveness. Impact likely irreversible (Adverse).
	Permanent beneficial change/improvement across the near- and large parts of the far-field to key characteristics or features of the particular environmental aspect's character or distinctiveness (Beneficial).
Medium	Semi-permanent adverse change/deterioration, over the near- and parts of the far-field, to key characteristics or features of the particular environmental aspect's character or distinctiveness. Impact likely to be partially reversible (Adverse)
	Semi-permanent beneficial change/improvement over the near- and parts of the far-field to key characteristics or features of the particular environmental aspect's character or distinctiveness (Beneficial).
Low	Noticeable, temporary (for part of the Proposed Development duration) adverse change restricted to the near-field and immediately adjacent far-field areas, to key characteristics or features of the particular environmental aspect's character or distinctiveness. Impact likely to be reversible (Adverse).
	Noticeable, temporary (for part of the Proposed Development duration) beneficial change restricted to the near-field and immediately adjacent far-field areas, to key characteristics or features of the particular environmental aspect's character or distinctiveness (Beneficial).
Negligible	Adverse changes that are barely discernible from background conditions. Impact will be reversible (Adverse).
	Beneficial changes that are barely discernible from background conditions (Beneficial).
No change	Adverse/Beneficial changes that are not discernible from background conditions. Impact will be reversible.

1.5.4 Significance of effect

- 1.5.4.1 The significance of the effect upon Physical Processes is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The method employed for this assessment is presented in **Table 1.11**.

Table 1.11: Matrix used for the assessment of the significance of the effect

Sensitivity of receptor	Magnitude of impact			
	Negligible	Low	Medium	High
Negligible	Negligible	Negligible or minor	Negligible or minor	Minor
Low	Negligible or minor	Negligible or minor	Minor	Minor or moderate
Medium	Negligible or minor	Minor	Moderate	Moderate or major
High	Minor	Minor or moderate	Moderate or major	Major
Very high	Minor	Moderate or major	Major	Major

- 1.5.4.2 Following the classification of an effect using this methodology, a clear statement will then be made as to whether that effect is significant or not significant. Major and moderate effects are considered to be significant, whilst minor and negligible effects are considered to be not significant. However, professional judgement will also be applied in reaching conclusions as to the significance of effects. Typical definitions for the classification of effects are shown in **Table 1.12**.

Table 1.12: Significance definitions

Significance classification	Definition	Significant effect
Major	A large and detrimental change to a valuable/sensitive receptor, likely exceeding an accepted threshold. A large and beneficial change, resulting in enhancements in baseline conditions, transitioning from previously poor conditions to new legal compliance, or making a major contribution to national goals. These effects may represent key factors in the decision-making process. Potentially associated with sites and features of national importance or likely to be important considerations at a regional scale. Major effects may relate to features that are unique and irreplaceable.	Significant
Moderate	A medium scale change albeit one that is not beyond an accepted threshold. If adverse, these effects are likely to be important at a regional or local scale and on their own could influence on decision making. A positive moderate effect is a medium scale change that improves baseline conditions sufficiently to contribute to guideline targets.	Significant
Minor	A minor adverse change that remains within legal and planning policy limits. Minor positive change that is unlikely to significantly impact the overall balance of considerations. These effects might be raised as local issues and could be relevant to the detailed design of a project, but they are unlikely to be critical in the decision-making process.	Not significant
Negligible	A very small change that is so inconsequential it can be considered acceptable to disregard. These effects fall below perceptible limits, lie within normal variations, or fall within the margin of forecasting error. They are unlikely to influence decision-making.	Not significant

1.5.5 Assumptions and limitations of the assessment

- 1.5.5.1 The assessments have included the development and use of numerical HD and sediment models. These models are robust tools but are subject to a number of assumptions. These include the input parameters (e.g. using a representative sediment grain size for sediment transport, for example), scenario assumptions (e.g. the volume and location of pre-ley trenching released under different release scenarios) as well as uncertainty in the underpinning datasets (e.g. HD data and bathymetry data). Such uncertainty is managed through conservatism in the design of the modelling study and the interpretation of the model results in the context of the baseline and using expert judgement. Discussion relating to the performance of the models developed to support the assessment is also set out in **Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR**.
- 1.5.5.2 It is recognised that all data (including survey data) is subject to varying levels of uncertainty. The datasets have been reviewed and levels of accuracy considered in the assessment process along with the application of appropriate assessment methods and the use of multiple datasets where available.

1.6 Key parameters for assessment

1.6.1 Scope of the assessment

- 1.6.1.1 The approach to assessment was presented in the MHPGC Project Scoping Report and has been refined in consultation with relevant statutory and non-statutory consultees as detailed in **Section 1.3** and through the MHPGC Project Scoping Opinions received from the PINS and MD-LOT.
- 1.6.1.2 **Table 1.13** summarises the impacts considered as part of the assessment. At this stage, there are no potential impacts proposed to be scoped out of the assessment.

Table 1.13: Impacts scoped into the assessment

Impact	Phase			Potential effects scoped into the assessment
	C	O&M	D	
Changes to SSCs and associated deposition	✓	✓	✓	There is potential for increased SSCs, and associated deposition could occur during all phases where activities are occurring on the seabed. These include seabed preparation and cable installation in the construction phase, cable repair and reburial in the O&M phase and cable removal in the decommissioning phase.
Changes to sediment transport pathways due to the presence of infrastructure	✓	✓	✓	During the construction phase, the formation of exit and floatation pits have the potential to change sediment transport pathways through alteration of the nearshore sediment transport and wave regime. The presence of infrastructure on the seabed, primarily in shallow regions, could alter the wave and tidal regime and impact sediment transport pathways as a result, which may affect Physical Processes receptors. During the decommissioning phase, the partial removal of seabed infrastructure and therefore the presence of remaining infrastructure can affect sediment transport pathways through the same mechanisms as that described for the O&M phase. However, for partially removed of cable protection these effects will be no greater than that set out for the O&M phase.
Impacts to seabed morphology	✓	✓	✓	During the construction phase, seabed preparation has the potential to alter the seabed morphology directly through sandwave clearance and dredged spoil release creating disposal mounds. The presence of infrastructure during the O&M phase causes direct changes to the seabed morphology. Following installation, the seabed morphology can evolve to a new equilibrium state including the influence and presence of infrastructure. Removal of structures, which have been in place for a long time, during the decommissioning phase could lead to changes in morphodynamics.
Impacts to coastal morphology	✓	✓	✓	During the construction phase, cable installation has the potential to alter the coastal morphology directly through the construction of exit and floatation pits, as well as nearshore seabed preparation activities. The presence of nearshore infrastructure during the O&M phase may cause direct changes to the coastal morphology. Following installation, the coastal morphology can evolve to a new equilibrium state including the influence and presence of infrastructure. Removal of structures, which have been in place for a long time, during the decommissioning phase could lead to changes in coastal processes and morphodynamics.

C = construction; O&M = operations and maintenance; D = decommissioning

1.6.2 Maximum design scenario

- 1.6.2.1 The MDS for each impact identified in **Section 1.6.1** has been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The MDS presented in **Table 1.14.** have been selected from the parameters provided in **Volume 1, Chapter 2: Project Description, of the PEIR** and methodology outlined in **Volume 1, Chapter 4: Approach to Environmental Impact Assessment, of the PEIR.**

Table 1.14: MDS relevant for the assessment of potential impacts on Physical Processes

Impact	Maximum Design Scenario	Explanation
Note: The cable length measurements are for the maximum distance between the Offshore Substation Platform (OSP) and trenchless technique exit pit unless otherwise stated. For clarity one trench length is as follows: - OSP to exit pit – up to 324.67 km; - OSP to MHWS – up to 326.00 km; - Scottish waters (OSP – Scottish-English offshore waters boundary) – up to 98.00 km; - English waters (English offshore waters boundary – exit pit) – up to 226.67 km; and - English waters (English offshore waters boundary – MHWS) – up to 228.00 km.		
Construction		
Changes to SSCs and associated deposition	Construction duration: up to four years. Sandwave clearance: - Sandwave clearance activities undertaken using MFE over an approximate four month duration; - Sediment disturbance rate is 1000kg/s - Surface width of up to 28m per trench and base width of up to 20m per trench; <u>Per trench = 1,484,000m²</u> - Scottish waters: 31km length × 28m width = 868,000m² - English waters: 22km length × 28m width = 616,000m² <u>Total (up to two trenches) = 2,968,000m²</u> - Scottish waters: 1,736,000m² - English waters: 1,232,000m² Cable installation (trenching): - Installation via trenching of up to 324.67km of cable, with a trench width of up to 2.1m and a depth of up to 3m; - Trenching rate is 400 m/hr. <u>Per trench = 2,045,421m³</u>	The MDS is defined by the maximum spatial extent of seabed disturbance from cable installation, route preparation, sandwave clearance and landfall works. Landfall works and vessel interactions are defined by the maximum footprint of exit pits, floatation pits, anchor spreads and jack-up activities. The MDS is inherently precautionary, assuming all maximum parameters occur concurrently with no reduction for overlapping disturbance footprints. Site preparation: - Sandwave clearance activities may be undertaken using a range of techniques (plough and MFE), over an approximate four-month duration in both Scottish and English waters. Releases via both are modelled; - A conservative MFE near-bed sediment release rate of 1000 kg/s conservatively estimated based on the MDS trench cross section dimensions, the speed of progress of the tool and the bulk density of the local sediment type;

Impact	Maximum Design Scenario	Explanation
	- Scottish waters: 98km length × 2.1m width × 3m depth = 617,400m³ - English waters: 226.67km length × 2.1m width × 3m depth = 1,428,021m³ <u>Total (up to two trenches) = 4,090,842m³</u> - Scottish waters: 1,234,800m³ - English waters: 2,856,042m³ Trenchless techniques (landfall) (English waters): - Up to four boreholes. Trenchless installation via Horizontal Directional Drilling (HDD), (conduit diameter of 1.6m, conduit length of 2,000m). Drilling fluid discharge up to 180m³ each and up to 1,083m³ total. - Trenchless drill punchout will be up to approximately 1660m offshore of MHWS in water depths up to 20m LAT. - Up to four exit pits (140m long × 50m wide × m deep). Area up to 7,000m² each; 28,000m² total. Volume up to 18,667m³ each; 74,668m³ total. - Up to two floatation pits (240m long × 55m wide × 5m deep). Area up to 13,200m² each; 26,400m² total. Volume up to 39,167m³ each; 78,334m³ total.	- Dredge spoil release is simulated as an instantaneous release at the water surface. 10% of 11,000m³ is assumed to form the passive phase of the plume; - Other seabed preparation such as sandwave clearance plough, boulder clearance and PLGR may be used but do not represent the MDS in terms of potential increases in SSC and associated deposition. Cable installation: - Trenching may be carried out by mechanical cutting, jet trenching, ploughing or CFE. Jet trenching is anticipated to generate the highest suspended sediment concentrations (SSC) and has therefore been assumed as the MDS; - Suspension of 100% of material from the trench cross section will give the MDS for sediment disturbance; - Conservatively assumes 100% fluidisation of material expelled from a U-shaped trench. In reality trenching will move a proportion of material rather than bringing it fully into suspension; - Cable routes cross a variety of seabed materials, and burial depth may be up to 3 m in some areas. The assessment therefore considers this upper bound to define the MDS in terms of sediment disturbance; - Trenching rate will be up to 400 m/hr. Trenchless techniques (landfall): - Trenchless installation methods include HDD and Direct Pipe; - HDD represents the maximum MDS for sediment disturbance due to the potential for drilling fluid release (frac-out); - The MDS for sediment disturbance by trenchless installation is given by applying a conservative Bentonite concentration of 100 kg/m³ in drilling mud, the volume of spoil released is equal to the maximum volume of the bore;

Impact	Maximum Design Scenario	Explanation
		- Other stages of drilling (pilot hole drilling and stages of reaming) may result in smaller release events separated in time. But the MDS is considered as a release of drilling mud from a single conduit; - Two drills could be operational at one time; however, the timing of drilling will be staggered meaning there will not be an occasion where punch-out occurs simultaneously (or within 6 hours of each other). - Trenchless drill punchout will be up to approximately 1,660 m offshore of MHWS in water depths up to -20 m LAT.
Impact to seabed morphology	Sandwave clearance: - Sandwave clearance activities undertaken over an approximate four-month duration; - Surface width of up to 28m per trench and base width of up to 20m per trench; <u>Per trench = 1,484,000m²</u> - Scottish waters: 31km length × 28m width = 868,000m² - English waters: 22km length × 28m width = 616,000m² <u>Total (up to two trenches) = 2,968,000m²</u> - Scottish waters: 1,736,000m² - English waters: 1,232,000m² Boulder clearance: <u>Per trench = 1,380,000m²</u> - Scottish waters: 31km length × 20m width = 620,000m² - English waters: 38km length × 20m width = 760,000m² <u>Total (up to two trenches) = 2,760,000m²</u> - Scottish waters: 1,240,000m² - English waters: 1,520,000m² Pre-Lay Grapnel Run (PLGR):	Sandwave clearance: - Direct changes to the seabed through sandwave clearance. Areas estimated based on geophysical interpretation of sandwaves; - Sandwave clearance activities may be undertaken using a range of techniques – MFE, sandwave clearance plough and suction hopper dredging. - Dredged spoil release creates disposal mounds through the active phase of the plume, assumed to be 90% of the material released. Boulder clearance: - Direct changes to the seabed through boulder clearance, boulder grab and pre-lay grapnel run; - Length requiring clearance estimated based on length of cable within designated boulder areas. Pre-lay grapnel run: - Direct changes to the seabed through boulder clearance, boulder grab and pre-lay grapnel run, for the full length of the cable from the landfall exit pit to the OSP.

Impact	Maximum Design Scenario	Explanation
	<u>Per trench = 3,246,700m²</u> - Scottish waters: 98km length × 10m width = 980,00 m² - English waters: 226.67km length × 10m width = 2,266,700m² <u>Total (up to two trenches) = 6,493,400m²</u> - Scottish waters: 1,960,000m² - English waters: 4,533,400m² Vessel interactions (English waters): - Up to 127,456 m² anchor seabed disturbance per vessel movement × 40 full anchor spread movements = 5,098,230m² - Up to six jack-up events (2 m diameter spud legs × 4), 3.14m² per events, total disturbance = 18.85m².	Vessel interactions Direct changes to the seabed through contact with anchors and wires used by vessels involved in nearshore cable landfall activities.
Impact to coastal morphology	Landfall works (English waters): - Trenchless drill punchout will be up to approximately 1660m offshore of MHWS in water depths up to 20m LAT. - Up to four exit pits (140m long × 50m wide × 5m deep). Area up to 7,000m² each; 28,000m² total. Volume up to 18,667m³ each; 74,668m³ total. - Up to two floatation pits (240m long × 55m wide × 5m deep). Area up to 13,200m² each; 26,400m² total. Volume up to 39,167m³ each; 78,334m³ total. - Trenchless drill exit pit protection: backfill, rock placement and mattress protection will be implemented. Maximum height above seabed of 0.35m with intention to restore to original seabed level.	Landfall works (English waters): Duration – individual pits (floatation or exit) are likely to remain open for up to a few months.
Changes to sediment transport pathways due to the presence of infrastructure (including secondary scour assessment)	Landfall works (English waters): - Trenchless drill punchout will be up to approximately 1660m offshore of MHWS in water depths up to 20m LAT. - Up to four exit pits (140m long × 50m wide × 5m deep). Area up to 7,000m² each; 28,000m² total. Volume up to 18,667m³ each; 74,668m³ total.	Landfall works (English waters):

Impact	Maximum Design Scenario	Explanation
	Up to two floatation pits (240m long × 55m wide × 5m deep). Area up to 13,200m² each; 26,400m² total. Volume up to 39,167m³ each; 78,334m³ total.	- Exit and floatation pits have the potential to change sediment transport pathways through alteration of the nearshore sediment transport and wave regime. However, these pits will be temporary and eventually backfilled; - The MDS for changes to sediment transport associated with partially installed cable protection will be no greater than that set out for the operation and maintenance phase.
Operation and Maintenance		
Changes to SSCs and associated deposition	- Operational life of 35 years; Cable repairs (English and Scottish waters): - Up to 41 export cable repairs, each with a length of up to km and a 20m width. Up to 40,000m² of temporary disturbance each; 1,640,000m² total; - Up to 4% of the cable route length, up to 13km, may require remediation per year. Remediation may occur in different locations and for varying lengths but it is anticipated that up to 13km of export cable length per year per trench will require remediation with a maximum width of 20m. Up to 522,240m² of temporary disturbance per year; total 18,278,400m².	Cable repairs (English and Scottish waters): - The greatest foreseeable number of cable reburial and repair events is considered to be the MDS for sediment dispersion; - The majority of cable repairs are anticipated to be c.500-1000 m. The MDS utilises the area of disturbance by repair which provides a highly conservative area; - The repair of cables may be undertaken using similar techniques to those employed during installation, therefore the potential increases in SSC and deposition would be in-line with the construction phase.
Impact to seabed morphology	Cable protection (English and Scottish waters): - Offshore export cable: up to 8.3% (equivalent to 27km) of the total route length within Scottish and English waters may require external protection using rock installation. Rock installation may be up to 14m wide and 2m high and side slope of 1:3. <u>Area per trench = 378,980m²</u> <u>Total area (up to two trenches) = 757,960m²</u> <u>Volume per trench = 433,120m³</u> <u>Total volume (up to two trenches) = 866,240m³</u> - Export cable crossing: Up to 16 crossings using either rock installation or concrete mattresses within Scottish and	Cable protection (English and Scottish waters): - Direct changes to seabed morphology through the presence of cable protection. - Several cable protection materials may be used including – rock installation or concrete mattresses/rock bags and Cable Protection Systems (CPS). Rock installation provides the MDS for changes to seabed morphology.

Impact	Maximum Design Scenario	Explanation
	English waters. Each crossing will be up to 200m (length) x 18m (wide) x 2m (height). <u>Per crossing = 3,600m²</u> <u>Total (up to 16 crossings) = 57,600 m²</u>	
Impact to coastal morphology	Cable protection (English and Scottish waters): - Offshore export cable: Total of up to 8.3% (equivalent to 27km) of the total route length within Scottish and English waters may require external protection using rock installation. Rock installation may be up to 14m wide and 2m high and side slope of 1:3. <u>Area per trench = 378,980m²</u> <u>Total area (up to two trenches) = 757,960m²</u> <u>Volume per trench = 433,120m³</u> <u>Total volume (up to two trenches) = 866,240m³</u> - Export cable crossing: Up to 16 crossings using either rock installation or concrete mattresses within Scottish and English waters. Each crossing will be up to 200m (length) x 18m (wide) x 2m (height). <u>Per crossing = 3,600m²</u> <u>Total (up to 16 crossings) = 57,600m²</u>	Cable protection (English and Scottish waters): - Direct changes to seabed morphology through the presence of cable protection. - Several cable protection materials may be used including – rock installation or concrete mattresses/rock bags and CPS. Rock installation provides the MDS for changes to seabed morphology.
Changes to sediment transport pathways due to the presence of infrastructure (including secondary scour assessment)	Cable protection (English and Scottish waters): - Offshore export cable: Total of up to 8.3% (equivalent to 27km) of the total route length within Scottish and English waters may require external protection using rock berm installation. Rock berms may be up to 14m wide and 2m high and side slope of 1:3. <u>Area per trench = 378,980m²</u> <u>Total area (up to two trenches) = 757,960m²</u> <u>Volume per trench = 433,120m³</u> <u>Total volume (up to two trenches) = 866,240m³</u> - Offshore export cable: Total of up to 8km of the total route length within Scottish and English waters may require	Cable protection (English and Scottish waters): - Cable protection has the potential to change sediment transport pathways through alteration of the tidal and wave regimes. - Rock berms present the potentially larger local obstacle above the seabed. - CPS is typically an articulated circular cladding installed around the cables to provide additional protection against movement, impact or abrasion. The CPS might be buried in the seabed or surface laid.

Impact	Maximum Design Scenario	Explanation
	external protection using a CPS. CPS may be up to 0.8m wide and 0.8m high. <u>Area per trench = 6,400m²</u> <u>Total area (up to two trenches) = 12,800m²</u> Export cable crossing: Up to 16 crossings using either rock installation or concrete mattresses within Scottish and English waters. Each crossing will be up to 200m (length) x 18m (wide) x 2m (height). <u>Per crossing = 3,600m²</u> <u>Total (up to 16 crossings) = 57,600m²</u>	
Decommissioning		
Changes to SSCs and associated deposition	Cables and cable protection (English and Scottish waters): All export cables and cable protection will be removed.	Cables and cable protection (English and Scottish waters): - The removal of cables may be undertaken using similar techniques to those employed during installation, therefore the potential increases in SSC and deposition would be in-line with the construction phase. - Whilst the MDS is for all export cable materials to be removed for decommissioning, in many cases it may be less environmentally impactful to leave assets in place. The decommissioning approach will be reviewed at the time of decommissioning following the most up to date and best available guidance.
Impact to seabed morphology	Cables and cable protection (English and Scottish waters): All export cables and cable protection will be removed.	Cables and cable protection (English and Scottish waters): - The coastal and seabed morphology could evolve to a new equilibrium state including the influence and presence of infrastructure. Removal of structures which have been in place for a long time could lead to changes in morphodynamics. - Whilst the MDS is for all infrastructure to be removed for decommissioning, in many cases it may be less environmentally impactful to leave assets in place. The decommissioning approach will be reviewed at the time of decommissioning following the most up to date and best available guidance.
Impact to coastal morphology	Cables and cable protection (English and Scottish waters):	Cables and cable protection (English and Scottish waters):

Impact	Maximum Design Scenario	Explanation
	All export cables and cable protection will be removed.	- The coastal and seabed morphology could evolve to a new equilibrium state including the influence and presence of infrastructure. Removal of structures which have been in place for a long time could lead to changes in morphodynamics. - Whilst the MDS is for all infrastructure to be removed for decommissioning, in many cases it may be less environmentally impactful to leave assets in place. The decommissioning approach will be reviewed at the time of decommissioning following the most up to date and best available guidance.
Changes to sediment transport pathways due to the presence of infrastructure (including secondary scour assessment)	Cables and cable protection (English and Scottish waters): All export cables and cable protection will be removed.	Cables and cable protection (English and Scottish waters): The MDS for changes to sediment transport associated with partially removed cable protection will be no greater than that set out for the operation and maintenance phase.

1.7 Commitments adopted as part of the MHPGC Project

- 1.7.1.1 As set out in **Volume 1, Chapter 4: Approach to Environmental Impact Assessment, of the PEIR** and **Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR**, several measures have been adopted as part of the MHPGC Project to reduce the potential for effects on Physical Processes.
- 1.7.1.2 Embedded mitigation includes the following measures as identified in the Institute of Environmental Management and Assessment (IEMA) (recently renamed in 2025 as the Institute of Sustainability and Environmental Professionals (ISEP)) Guide to Shaping Quality Development (IEMA, 2015):
- Primary mitigation - measures included as part of the project design. IEMA describes these as “modifications to the location or design of the development made during the pre-application phase that are an inherent part of the project and do not require additional action to be taken”. This includes modifications arising through the iterative design process. These measures will be secured through the consent itself through the description of the project and the parameters secured in the DCO and marine licence, or both;
 - Tertiary mitigation - IEMA describes these as “actions that would occur with or without input from the EIA feeding into the design process. These include actions that will be undertaken to meet other existing legislative requirements, or actions that are considered to be standard practices used to manage commonly occurring environmental effects”.
- 1.7.1.3 Embedded mitigation measures that will form part of the final design (and are established legislative requirements/good practice, or both) have been taken into account as part of the initial assessment presented in **Section 1.8** (i.e., the initial determination of impact magnitude and significance of effects assumes implementation of these measures). This ensures that the measures that the Applicant is committed to are considered in the assessment of effects.
- 1.7.1.4 Where an assessment identifies likely significant adverse effects, secondary mitigation measures may be applied. These are measures that could further prevent, reduce and, where possible, offset these effects. They are defined by IEMA as “actions that will require further activity to achieve the anticipated outcome” and may be imposed as part of the planning consent, or through inclusion in the ES. These include measures required to reduce the significance of environmental effects and may be secured through an EMP. For secondary mitigation measures, both pre-mitigation and residual effects are presented.
- 1.7.1.5 The measures relevant to Physical Processes are outlined in **Table 1.15**. As there is a secured commitment to implementing these measures, they are considered inherently part of the design of the MHPGC Project and have therefore been considered in the assessment presented in **Section 1.8**.

Table 1.15: Embedded commitments relevant to Physical Processes implemented as part of the MHPGC Project

Commitment number	Measure adopted	How the measure will be secured
CoT06/MM-006	An Outline Offshore Environmental Management Plan (OEMP) will be prepared and submitted with the application for development consent. A Detailed OEMP will be developed in accordance with the Outline OEMP. The Outline Offshore EMP will include: • An Outline Marine Biosecurity Plan; • An Outline Marine Pollution Contingency Plan; • An Outline Marine Mammal Mitigation Protocol; • An Outline Vessel Traffic Management Plan; • An Outline Navigational Safety Plan; • A chemical risk assessment that includes information such as how chemicals will be used, stored, and transported, in line with recognised best-practice guidance; • A dropped-object protocol will be established to cover the reporting and recovery of any items lost overboard that could endanger other sea users; • A Marine Emergency Action Card outlining the steps to be followed in the case of a marine emergency; • Provisions for the handling and disposal of waste.	Proposed to be secured as a requirement of the DCO and Scottish Marine Licence(s) submitted to the Scottish Ministers.
CoT07/MM-007	An Outline Offshore O&M Plan will be prepared and submitted as part of the application for development consent. Detailed Offshore O&M Plan(s) will be produced prior to entering the operation and maintenance phase.	Proposed to be secured as a requirement of the DCO and Scottish Marine Licence(s) submitted to the Scottish Ministers.
CoT08/MM-010	An Outline Offshore CSIP will be prepared and submitted with the application for development consent. It will include cable burial to be the preferred option for cable protection, where practicable. A Detailed CSIP will be developed prior to construction in accordance with the Outline CSIP. • The Outline CSIP will include (but is not limited to): A Cable Burial Risk Assessment (CBRA), which will define burial depths and safeguards, based on seabed conditions and external aggression and climate change hazards, to keep the offshore export cables protected and compliant through all project phases while upholding navigational and environmental safety; • The implementation, management and monitoring of cable protection.	Proposed to be secured as a requirement of the DCO and Scottish Marine Licence(s) submitted to the Scottish Ministers.
CoT13/MM-014	The Project Description (Volume 1, Chapter 3 of the Environmental Statement) sets out that the installation of the offshore export cables under Durham Coast SSSI and SAC will be undertaken by trenchless technologies. The trenchless technique exit pits associated with the trenchless technologies installation will be at least 100 m seaward of the eastern boundary of the Durham Coast SSSI and SAC.	Proposed to be secured as a requirement of the DCO.

Commitment number	Measure adopted	How the measure will be secured
CoT14/MM-022	An Offshore Construction Method Statement (CMS) will be produced and implemented prior to construction.	Proposed to be secured as a requirement of the DCO and Scottish Marine Licence(s) submitted to the Scottish Ministers.
CoT32/MM-086	An Advisory Safety Statement to define advisory safe passing distance and use of guard vessels, will be submitted as part of the application for development consent.	Proposed to be secured as a requirement of the DCO and Scottish Marine Licence(s) submitted to the Scottish Ministers.
CoT44	An Offshore Decommissioning Programme will be developed prior to decommissioning and will be adhered to. It will be in line with the latest relevant legislation and available guidance at the time of production, as far as reasonably practicable.	Proposed to be secured as a requirement of the DCO and Scottish Marine Licence(s) submitted to the Scottish Ministers.

1.8 Assessment of impacts

1.8.1 Overview

- 1.8.1.1 This section includes the assessment of the impacts to Physical Processes arising from the construction, O&M and decommissioning phases of the MHPGC Project. A summary of the effects is presented in **Table 1.29**.
- 1.8.1.2 As stated in **Section 1.5.1** onwards, for the most part, Physical Processes (such as sediment transport) are not themselves receptors but are instead pathways. The only potentially sensitive receptors are the coast and protected geological and geomorphological seabed features and habitats contained within designated sites. This distinction between assessments of pathways and receptors is summarised in **Table 1.16**, for each of the potential impacts/changes identified in **Table 1.13**.

Table 1.16: Summary of potential impacts/ changes considered in the Physical Processes assessment.

Potential impact/change	Pathway/ receptor
Changes to SSCs and associated deposition	Pathway
Changes to sediment transport pathways due to the presence of infrastructure	Pathway
Impacts to seabed morphology	Receptor
Impacts to coastal morphology	Receptor

- 1.8.1.3 In this section and for each project phase, the assessment of change to marine Physical Processes pathways is presented first, followed by an assessment of the significance of effects to marine processes receptors. The potential significance of impacts to ecological and socio-economic receptor groups arising from changes to (i) SSC and associated deposition; and (ii) sediment transport has been assessed in other chapters, in particular:
- **Volume 2, Chapter 3: Benthic Subtidal and Intertidal Ecology, of the PEIR;**
 - **Volume 2, Chapter 4: Fish and Shellfish Ecology, of the PEIR;**
 - **Volume 2, Chapter 5: Marine Mammals, of the PEIR;**
 - **Volume 2, Chapter 6: Marine Ornithology, of the PEIR;**
 - **Volume 2, Chapter 9: Marine and Intertidal Archaeology, of the PEIR;**
 - **Volume 2, Chapter 10: Infrastructure and Other Sea Users, of the PEIR; and**
 - **Volume 3 Chapter 3 Terrestrial Ecology and Terrestrial and Intertidal Ornithology, of the PEIR.**
- 1.8.1.4 Outputs from the assessment have also been used to inform the **Habitats Regulations Assessment/Habitats Regulations Appraisal Screening Report, prepared to accompany the PEIR** and the **Habitats Regulations Appraisal/Habitats Regulations Assessment RIAA, prepared to accompany the PEIR**.

1.8.2 Construction phase

Construction phase: changes to pathways

Changes to SSCs and associated deposition

Overview

- 1.8.2.1 During the construction phase of the MHPGC Project, sediment will be disturbed and released into the water column. This will give rise to suspended sediment plumes and localised changes in bed levels as material settles out of suspension. The following embedded commitments have been made which will help reduce the potential for adverse impacts associated with changes to SSCs:

- The embedded commitments CoT14/MM-022 and CoT06/MM-006 means a CMS and OEMP will be produced as part of the MHPGC Project, ensuring construction methods align with good practice, implement agreed mitigation measures and are appropriately managed.
- The embedded commitment CoT32/MM-086 will define advisory safe passing distances between vessels. Although this commitment is made to ensure safety of navigation, it will also serve to minimise the potential for sediment plume interaction associated with bed disturbance activities.

1.8.2.2 Further details are provided in **Table 1.15**.

1.8.2.3 The main activities resulting in disturbance of seabed sediments during construction are:

- Pre-lay cable trenching using a jet trenching tool at the seabed;
- Sandwave clearance using an MFE tool at the seabed;
- Release of dredged material at the water surface related to seabed preparation for cables (including sandwave clearance);
- Drilling fluid discharge associated with trenchless cable installation techniques.

1.8.2.4 Details of the MDS for sediment disturbance events are set out in **Table 1.14**. These sediment release events have subsequently been considered using numerical modelling, at various locations across the MHPGC Project PEIR Red Line Boundary within offshore Scottish waters, and offshore and nearshore English waters occurring (separately) on and around representative spring and neap tidal periods. A total of 19 release events for the MHPGC Project have been considered which together, capture the full range of sediment disturbance activities as defined under the MDS, across Scottish and English waters.

1.8.2.5 The modelled sediment release events have been designed to capture the MDS, and full range of the Project Design Envelope (PDE), in terms of:

- Maximum plume concentrations;
- Maximum plume extent;
- Maximum vertical change in bed level;
- Maximum spatial extent of change in bed level.

1.8.2.6 The above will be governed by a range of factors including:

- The rate at which material is disturbed;
- The total mass of material disturbed;
- The characteristics of material that is disturbed (e.g. Coarse, fine, consolidated etc.);
- The height within the water column the material is released;
- Whether the sediment disturbance occurs in a fixed location or moves over time.

1.8.2.7 A full description and discussion of each event and details of the sediment plume model design are provided in **Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR**.

1.8.2.8 The wider range of results can be summarised broadly in terms of four main zones of effect, based on the distance along the tidal axis from the activity causing sediment disturbance.

- 0m to 50m:
 - Zone of highest SSC increase and greatest likely thickness of deposition. All gravel sized sediment likely deposited in this zone. Also a large proportion of sands that are not resuspended high into the water column, and also most or all dredge spoil in the 'active phase' – which relates to the initial rapid descent of sediment from the dredger to the bed as a result of the sediment/water mixture being of higher density than the surrounding water. Plume dimensions and SSC, and deposit extent and thickness, are primarily controlled by the volume of sediment released and the manner in which the deposit settles:
 - At the time of active disturbance: very high SSC increase (tens to hundreds of thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following end of disturbance; sands and gravels may deposit in local thicknesses of tens of centimetres to several metres; fine sediment is unlikely to deposit in measurable thickness;

- More than one hour after the end of active disturbance: SSC is <50mg/l; no measurable ongoing deposition.
- 50m to 500m:
 - Zone of measurable SSC increase and measurable, but lesser thickness of deposition. Mainly sands that are released or resuspended higher in the water column and resettling to the seabed whilst being advected by ambient tidal currents. Plume dimensions and SSC, and deposit extent and thickness, are primarily controlled by the volume of sediment released, the height of resuspension or release above the seabed, and the ambient current speed and direction at the time:
 - At the time of active disturbance: high SSC increase (hundreds to thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following end of disturbance; sands and gravels may deposit in local thicknesses of up to tens of centimetres; fine sediment is unlikely to deposit in measurable thickness;
 - More than one hour after end of active disturbance: SSC is <10mg/l; fine sediment is unlikely to deposit in measurable thickness;
 - Deposition thicknesses of 5cm or more may occur (will be limited to) up to approximately 100m from activities causing sediment disturbance;
 - Deposition thicknesses of 1cm or more may occur (will be limited to) up to approximately 200m from activities causing sediment disturbance;
 - Measurably higher SSC of hundreds mg/l or more may occur (will be limited to) up to approximately 200m from activities causing sediment disturbance (the distance within which most sand and gravel will have resettled and only finer sediment remains in suspension).
- 500m to a maximum distance of the edge of the tidal excursion buffer around the MHPGC Project PEIR Red Line Boundary [see **Figure 1-1**]:
 - Zone of lesser but measurable SSC increase and no measurable thickness of deposition. Mainly fines that are maintained in suspension for more than one tidal cycle and are advected by ambient tidal currents. Plume dimensions and SSC are primarily controlled by the volume of sediment released, the patterns of current speed and direction at the place and time of release and where the plume moves to, over the following 24 hours:
 - At the time of active disturbance: low to intermediate SSC increase (tens to low hundreds of mg/l) as a result of any remaining fines in suspension, only within a narrow plume (tens to a few hundreds of metres wide, SSC decreasing rapidly by dispersion to ambient values within one day after the end of active disturbance; fine sediment is unlikely to deposit in measurable thickness;
 - One to six hours after end of active disturbance: decreasing to low SSC increase (tens of mg/l); fine sediment is unlikely to deposit in measurable thickness;
 - Six to 24 hours after end of active disturbance: decreasing gradually through dispersion to background SSC (no measurable local increase); fine sediment is unlikely to deposit in measurable thickness. No measurable change from baseline SSC after 24 hours to 48 hours following cessation of activities.
- Beyond the tidal excursion buffer distance (or anywhere not tidally aligned to the active sediment disturbance activity) following one flood-ebb tidal cycle:
 - Elevated levels of SSC will be very low (<5mg/l) and not measurable in practice. Any sediment deposition will also be extremely limited and not measurable in practice;
 - Tidal excursion distances have been determined based on the observed advection of the plume features in the sediment plume model results.
- In offshore Scottish waters:
 - On neap tides, the tidal excursion distance is approximately 3km to 4km.
 - On spring tides, the tidal excursion distance is approximately 5km to 6km.
- In offshore English waters:

- On neap tides, the tidal excursion distance is approximately 3km to 4km.
- On spring tides, the tidal excursion distance is approximately 5km to 6km.
- In nearshore English waters:
 - On neap tides, the tidal excursion distance is approximately 5km to 6km.
 - On spring tides, the tidal excursion distance is approximately 8km to 9km.

Suspended sediment concentrations of plumes from longer duration disturbance (moving and static point sources over multiple flood/ebb cycles)

1.8.2.9 For both Scottish and English waters, the following activities are associated with longer duration disturbance:

- Pre-lay cable trenching using jet trenching;
- Sandwave clearance using a MFE.

1.8.2.10 For these release scenarios, in general it is found that:

- The sediment releases associated with these activities result in a long, relatively thin plume extending along the tidal axis and to the limit of the tidal excursion distance from the point of active disturbance [see **Figure 1-2**];
- Where the source is moving, the path of active disturbance in the simulation period is visible in the results images as a line of higher maximum instantaneous SSC, with elevated SSC regions extending from this aligned with the tidal axis [see **Figure 1-3**];
- During spring tidal conditions, the disturbed sediment is carried away from the working area at a faster rate, dispersing the sediment mass over a larger area and water volume, and so the resulting SSC in the plume is relatively lower than on a comparable neap tide;
- During slack water (on both neap and spring tides), water is not moving sediment away from the area of disturbance, resulting in suspended sediment accumulating in a local area of relatively higher SSC. This local area of higher SSC is subsequently advected by the tide and may take longer to reduce to background levels than other parts of the plume generated during non-slack water conditions;
- The limited footprint of the plume feature means that specific locations will only be affected by the increase in SSC for the limited duration it takes for the plume to be advected past by the tide;
- The path followed by the tidal ellipse is not the same on every tide, so it is unlikely that the same area of seabed will be affected by higher SSC within the localised plume for more than one or two consecutive tides.

Scottish waters

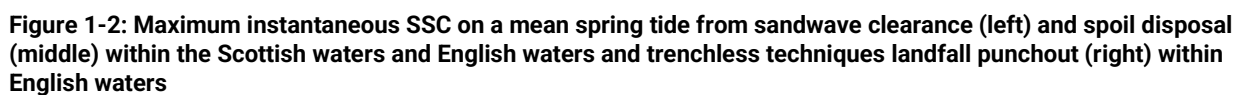
1.8.2.11 For the release scenarios in Scottish waters, it is found that:

- Sediment release associated with these activities along the western extent of the MHPGC Project PEIR Red Line in Scottish waters has the potential to reach northeastern region of the Firth of Forth Banks Complex MPA [see **Figure 1-2**].
 - The MPA lies very close to the MHPGC Project PEIR Red Line Boundary (<100m), so high SSC values (>500mg/l) are predicted within this designated site;
 - The region of most intense maximum instantaneous SSC is small, and SSC reduces quickly with distance into the MPA from the release location;
 - Very high SSC values are only present during the active release and for a very short time afterwards;
 - Several hours after the release has ended maximum SSC concentration within the MPA reduces to <20mg/l. One day after the release has ended plume concentrations have reduced to less the 5mg/l within the MPA (as well as throughout the wider Physical Processes Study Area).
- Plumes generated by these activities within the MHPGC Project PEIR Red Line Boundary for the length of offshore export cable corridor in Scottish waters do not reach, or directly effect, any designated sites.

English waters

1.8.2.12 For the release scenarios in English waters, it is found that:

- Sediment released by these activities within the MHPGC Project PEIR Red Line Boundary in English waters has the potential to reach the Farnes East MCZ, when the release location is at the closest point in the MHPGC Project PEIR Red Line Boundary aligned with the tidal axis to this designated site.
 - The MCZ lies approximately 4.5km northwest from the nearest point of the MHPGC Project PEIR Red Line Boundary (approximately KP82), so SSC will have significantly reduced due to sediment resettlement before reaching the area [see **Figure 1-2** and **Figure 1-3**];
 - The maximum predicted instantaneous SSC within the MCZ is less than 100mg/l during pre-lay trenching and less than 30mg/l during sandwave clearance;
 - One day after disposal ends, the plume will have dispersed, and no elevated SSC is expected within the designated site.
- The North East of Farnes Deep MCZ and HPMA lies to the east/southeast and just outside the mean spring tidal excursion ellipse, so any plume overlap is predicted to be minimal and short-lived, occurring only during large spring tides, extending only slightly into the designated site and with very low SSC (less than 5mg/l) [see **Figure 1-3**].



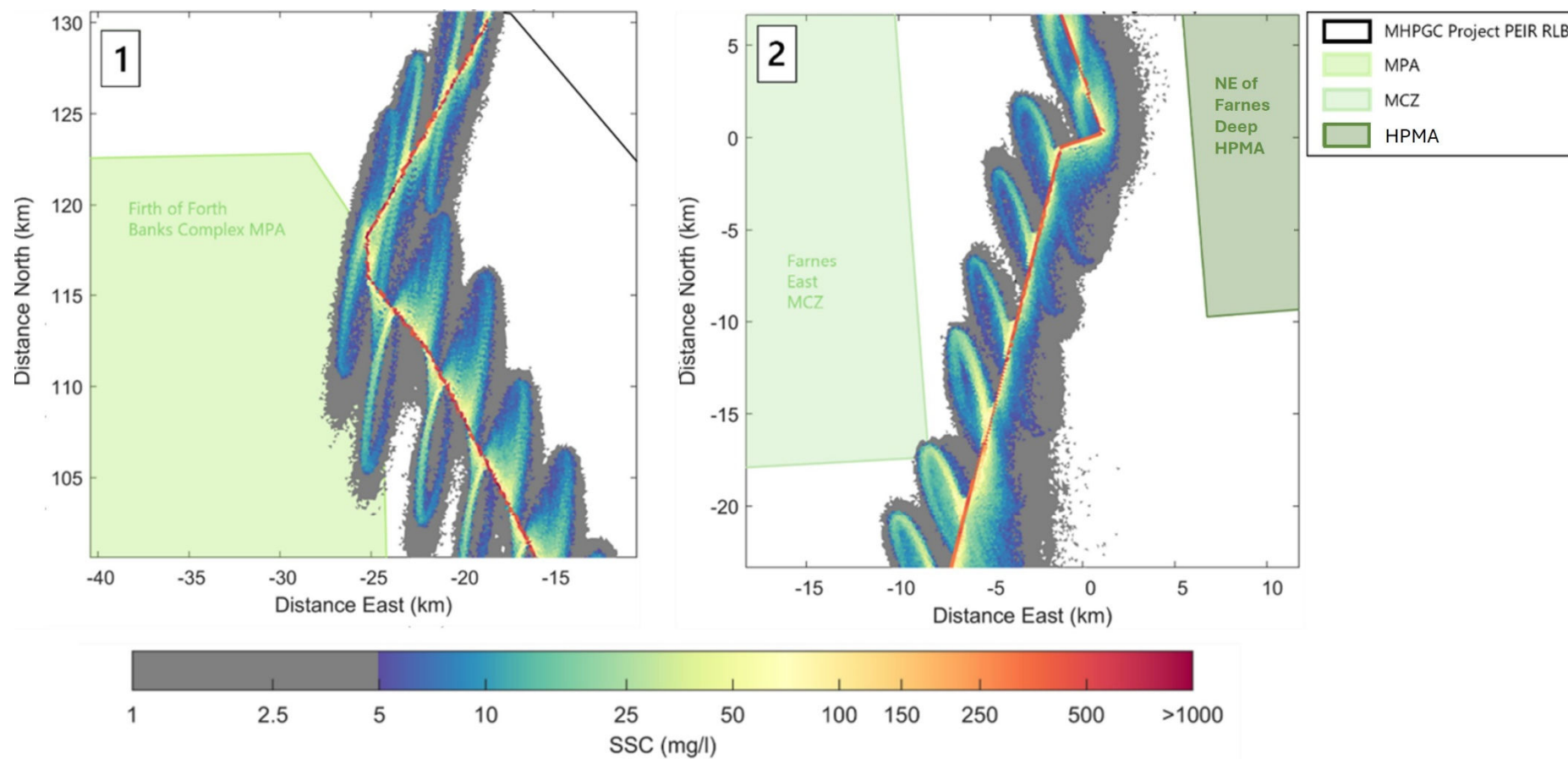


Figure 1-3: Maximum instantaneous SSC from pre-lay trenching within Scottish waters (left) and English waters (right)

Suspended sediment concentrations of plumes from releases of dredged sediment

1.8.2.13 In both Scottish and English waters, seabed preparation via the use of a Trail Suction Hopper Dredger (TSHD) may be required in some locations. The release of the dredged sediment back to the seabed will take place within the MHPGC Project PEIR Red Line Boundary.

1.8.2.14 The following summary provides a general description of the resultant plumes:

- During releases of dredged sediment, the TSHD opens large doors on the bottom of the hull, and the full volume of dredged material is released into the water column near to the water surface in a relatively short time. It is assumed 90% of the total volume will descend rapidly and directly to the seabed as a single mass under gravity, forming the 'active phase' of the plume (ABPmer, 2011). The remaining 10% of material will enter suspension in the water column, settling out more slowly at the rate of the individual sediment grains, forming the 'passive phase' of the plume (ABPmer, 2011);
- The active and passive phases will contain a similar representative distribution of all grain sizes present in the originally dredged sediments. The active phase is almost solid sediment and is rapidly deposited to the seabed, so is not assessed in terms of SSC. The following assessment mainly describes the SSC associated with the passive phase of the plume;
- Gravels and sands will settle relatively rapidly towards the seabed. From the maximum expected height of initial suspension (approximately 105m above the bed), these sediments are likely to resettle on the seabed, ceasing to increase SSC, within approximately three to 180 minutes;
- At a representative higher current speed of 0.6m/s during spring tides, these sediments will settle to the bed within approximately 126m for gravel, 630m for coarse sand, 2,100m for medium sand, and 6,300m for finer sands from the release point. This distance will be proportionally shorter during periods of lower current speed, such as outside peak flow times and generally around neap tides;
- Fine sand and silt sized sediments persist in suspension for longer than relatively coarser sediment grain sizes (i.e. medium sand, coarse sand and gravels) and so control most of the effect on SSC beyond the above durations/distances;
- The level of SSC associated with the active and passive phases during the initial release is realistically expected to be locally very high at the location of the spoil release (millions of mg/l within 5m of the activity, i.e. more sediment than water in the local plume);
- Due to ongoing dispersion and the settlement of non-silt sediment to the seabed during the first half tidal cycle, the level of SSC within the spoil plume reduces rapidly with time to less than 25mg/l after one day, and to less than 5mg/l after three days;
- For all release locations, the plume remains spatially constrained, with only a limited footprint that effects designated sites. Consequently, only a small part of the designated site is likely to be affected, and only for a short duration. The tidal ellipse path varies between tides, making it unlikely that the same seabed area will experience elevated SSC for more than one or two consecutive tides [see **Figure 1-2**].

Scottish waters

1.8.2.15 For the release scenarios in Scottish waters, it is found that:

- Sediment released by spoil disposal activities along the western extent of the MHPGC Project PEIR Red Line Boundary in Scottish waters has the potential to reach northeastern region of the Firth of Forth Banks Complex MPA:
 - The MPA is very close to the MHPGC Project PEIR Red Line Boundary (<100m), and high SSC values (>500mg/l) are predicted within the designated site [see **Figure 1-2**];
 - The region of most intense maximum instantaneous SSC is small, and SSC reduces quickly with distance into the MPA from the release location;
 - Very high SSC values are only present during the active release and for a very short time afterwards;
 - Several hours after the release has ended maximum SSC concentration within the MPA reduce to <50 mg/l, and one day after the release has ended plume concentrations have reduced to less the 5mg/l within the MPA and throughout the wider Physical Processes Study Area;

- Plumes generated by spoil disposal activities within the MHPGC Project PEIR Red Line Boundary for the length of offshore export cable corridor in Scottish waters do not reach, or directly effect, any designated sites.

English waters

1.8.2.16 For the release scenarios impacts in English waters, it is found that:

- Sediment released by spoil disposal activities within the MHPGC Project PEIR Red Line Boundary for the length of offshore export cable corridor in English waters has the potential to reach the Farnes East MCZ, when the release location is at the closest point in the MHPGC Project PEIR Red Line Boundary aligned with the tidal axis to the designated site:
 - The MCZ lies approximately 4.5km northwest from the nearest point of the MHPGC Project PEIR Red Line Boundary (approximately KP82) aligned with the tidal axis, so SSC will have significantly reduced due to sediment resettlement before reaching the MCZ [see **Figure 1-2**];
 - The maximum predicted instantaneous SSC within the MCZ is less than 50mg/l;
 - One day after disposal ends, the plume will have dispersed, and no elevated SSC is expected within the designated site.
- The North East Farnes Deep MCZ and HPMA could potentially be affected by spoil disposal activities within English waters if the release point aligns with the closest location along the tidal axis in the MHPGC Project PEIR Red Line Boundary (approximately KP113) and the timing coincides with large spring tides;
- The North East Farnes Deep MCZ and HPMA lies just (c. 2.5km) outside the mean spring tidal excursion ellipse, so any plume overlap is expected to be minimal, extending only a relatively small distance (<1km) into the designated site and with very low SSC of less than 5mg/l.

Suspended sediment concentrations of plumes from drilling fluid discharge

English waters

1.8.2.17 A trenchless technique, such as HDD, is the installation method for bringing the offshore export cables ashore (in English waters) through the intertidal to the TJB where the offshore export cables will be jointed to the onshore export cables. The release of drilling fluid into the coastal waters at the punch-out location could create a sediment plume in the nearshore area. Drilling fluid release is only modelled for English waters as this is where the MHPGC Project PEIR Red Line Boundary makes landfall.

1.8.2.18 The following summary provides a general description of the resultant plumes:

- The release of drilling fluids (which typically contain a lubricating natural clay mineral such as bentonite) along with drill cuttings from the planned trenchless technique operations will result in a localised and temporary plume of elevated SSC;
- The majority of the plume will be advected in the direction of the ambient tidal currents, which are broadly aligned to the coast. The direction of transport (either to the north or south) will depend on the state of the tide (flood or ebb) at the time of the release [see **Figure 1-2**];
- The plume is dispersed to relatively low concentrations within hours of release and to background concentrations within a few tidal cycles;
- The drilling fluid is expected to remain in suspension for at least hours or days and will be widely dispersed before settling. Therefore, it is not expected to accumulate anywhere in measurable thicknesses, other than in the immediate vicinity of the trenchless technique exit pit. However, any such locally accumulated material is expected to be subsequently reworked and redistributed to not measurable concentrations and thicknesses over time by wave and tidal action;
- Lubricating clay in the drilling fluid (typically bentonite or similar) normally has an overall density and viscosity similar to seawater and so is expected to behave (advection, mix and disperse) in a similar manner. If the drilling fluid behaves as a slightly denser fluid, it may either (temporarily) accumulate in the trenchless technique exit pit or move over the adjacent seabed downslope under gravity, i.e. in an offshore direction and away from nearshore areas;
- The bentonite plume does not reach, or directly affect, any designated sites;
- Settlement thickness resulting from plumes from MFE.

1.8.2.19 In both Scottish and English waters, following disturbance of the seabed by MFE, it is found that:

- The coarser sand and gravel fractions at each site settle to the seabed within a limited time of release (from seconds up to five minutes, i.e. within the ten minute timestep of the sediment plume model) and so tend to be deposited within a relatively small footprint (from metres up to 100m), resulting in a relatively greater local average thickness of <100mm;
- The predicted thickness of settlement for only the finer sediments is very limited, in the order of <2mm for all release locations;
- Sediment accumulation of <1mm would not cause a measurable change in bed level or sediment type in practice. Fine sediments that do settle are also likely to be subject to further erosion and dispersion during subsequent tides;
- Maximum average sediment deposit thickness for a range of realistic downstream dispersion distances for coarse-grained material is set out in **Table 1.17**.

Table 1.17: Maximum average sediment deposit thickness for a 6.3m³ trench for a range of realistic downstream dispersion distances

Distance of displacement (m)	Average thickness of deposit (mm) for trench cross section area
	6.3m ²
5	1,260
10	630
25	252
50	126
100	63
150	42
200	32
250	25
300	21
400	16
500	13

Scottish waters

1.8.2.20 For the release scenarios in Scottish waters, it is found that:

- For MFE releases along the western extent of the MHPGC Project PEIR Red Line Boundary in Scottish waters, some deposition within the Firth of Forth Bank Complex MPA is possible:
 - The deposition footprint is small, aligned with the tidal axis, and extends approximately 100m either side of the release location for deposits greater than 50mm, and around 500m either side for deposits greater than 10mm;
 - During spring tides, higher current speeds result in a slightly larger spatial footprint (extending 20% further from the release location during springs than neaps), although overall thickness values are lower (P95 during springs is 192mm, compared to 301mm during neaps) compared to equivalent activity at the same location during neap tides as the same amount of material is being spread over a greater area;
 - There is no deposition due to MFE activities predicted in any designated sites for release originating from within the MHPGC Project PEIR Red Line Boundary in Scottish waters.

English waters

1.8.2.21 For the release scenarios in English waters, it is found that:

- There is no deposition due to MFE activities predicted within any of the surrounding designated sites for releases originating from the MHPGC Project PEIR Red Line Boundary where it overlaps with English waters.

Settlement thickness resulting from plumes from releases of dredged sediment

1.8.2.22 In both Scottish and English waters, the actual shape and thickness of the seabed deposit resulting from the release of dredged material at the water surface cannot be predicted accurately in advance and in any case is likely to vary. A range of possible configurations of area and thickness are presented in **Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR**. From this range, the following examples represent a relatively widely spread deposit, which is the MDS for the area of seabed affected (by a nominal average thickness of 50mm). In practice, the deposit may comprise several individual releases from multiple dredging cycles and the deposits are likely to be relatively thicker (actual thickness dependant on the local thickness of each of the deposits in the area of overlap, which cannot be predicted in advance), with a correspondingly smaller area of effect:

- If up to 11,000m³ of material is released from a representative large hopper, an area measuring up to 220,000m² (nominally 469m x 469m) could potentially be covered by an average thickness of 50mm;
- A greater average thickness of material would lead to a smaller area of impact and vice versa. For example, a 100mm average thickness deposit would affect an area half that described above (for an average deposition thickness of 50mm);
- Deposits resulting from fine sediment that is much more widely dispersed in the passive phase of the plume will have an average thickness <2mm and therefore would not be measurable in practice. Furthermore, this material would be readily re-mobilised and dispersed further away from the release location, in the direction of the ambient tidal flow.

Scottish waters

1.8.2.23 For the release scenarios in Scottish waters, it is found that:

- Spoil disposal in the MHPGC Project PEIR Red Line Boundary that overlaps with the western extent of Morven North and Morven South, some deposition within the Firth of Forth Bank Complex MPA is possible;
- The deposition footprint is small, aligned with the tidal axis, and extends approximately 200m either side of the release location for deposits greater than 10mm, and around 3km for deposits less than 5mm.

English waters

1.8.2.24 For the release scenarios in English waters, it is found that:

- There is no deposition due to spoil disposal release predicted within any of the surrounding designated sites for releases within the MHPGC Project PEIR Red Line Boundary that overlaps with English offshore and nearshore waters.

Persistence of spoil mounds

1.8.2.25 In both Scottish and English waters, the causes and dimensions of potential seabed deposits forming spoil mounds on the seabed is described in **Paragraph 1.8.2.22**. The persistence and evolution of these spoil mounds will be dependent upon a range of factors, principally:

- The type of material in the mound;
- The size/shape of the mound;
- The level of bed shear stress exerted on the mound by tidal currents and waves (water depth being a key determinant of the latter).

1.8.2.26 The type of material in the mound is one of the most important factors determining the persistence and evolution of a spoil mound. It can reasonably be expected that spoil mounds in the MHPGC Project PEIR Red Line Boundary will comprise entirely (or almost entirely) of sand. This is because any dredging will be associated with sandwave levelling/clearance.

- 1.8.2.27 On the basis of the estimates set out in **Table 1.18**, mounds comprising of sand may persist for a period of a few months to a decade, depending upon location. Where net sediment transport rates are typically higher ($\sim 0.25 \text{ m}^3/\text{m}/\text{day}$) in the region of MHPGC Project PEIR Red Line Boundary that overlaps with the central region of the offshore export cable corridor in offshore English waters, spoil mounds will persist for less time (~ 0.8 years). Within the region of the MHPGC Project PEIR Red Line Boundary that overlaps with Morven North and Morven South (in Scottish waters), net sediment transport rates are lower, typically $< 0.025 \text{ m}^3/\text{m}/\text{day}$ towards the northeast corner and $< 0.01 \text{ m}^3/\text{m}/\text{day}$ towards the southwest, resulting in an estimated displacement time of spoil mounds from ~ 7.3 years to ~ 18.1 years.

Table 1.18: Indicative estimates for the persistence of spoil mounds comprising sand, based on modelled rates of net tidally driven sediment transport

Net rate of sediment transport ($\text{m}^3/\text{m}/\text{day}$)*	Time to displace mound †		
	Expressed in days	Expressed in months	Expressed in years
10	6.6	0.2	0.01
5	13.2	0.4	0.03
1	66	2.2	0.2
0.5	132	4.3	0.4
0.25	264	8.6	0.8
0.1	660	21.7	1.8
0.05	1,320	44	3.7
0.025	2,640	87	7.3
0.01	6,600	217	18.1

* Does not account for influence of waves, which may reduce the likely time required to displace the mound.

† Based on a spoil mound of $\sim 0.5 \text{ m}$ height with a nominal footprint of 150 m by 150 m .

- 1.8.2.28 It is noted that the lowest rates of net (tidally driven) sediment transport are encountered further north, within the MHPGC PEIR Project Red Line Boundary that overlaps with Morven North and Morven South in Scottish waters, and very close to landfall, within shallow waters in England. Whilst net rates of tidally driven sediment transport may be low close to landfall, waves will also frequently stir the seabed and contribute to sediment mobility, especially during winter months where material contained within the mounds may be dispersed rapidly during storm events.

Multiple disturbance activities

- 1.8.2.29 In both Scottish and English waters, if multiple activities causing sediment disturbance (such as dredging or cable installation) are undertaken simultaneously at two or more locations that are aligned in relation to the ambient tidal streams, then there is potential for overlap between the areas of change in SSC and sediment deposition. The change in SSC in areas of overlap will be additive if the downstream activity occurs within the area of effect from upstream (i.e. sediment is disturbed within the sediment plume from the upstream location). The change in SSC will not be additive (i.e. the effects will be as described for single occurrences only) if the areas of effect only meet or overlap downstream following advection or dispersion of the effects. Effects on sediment deposition will be additive if and where the footprints of the deposits overlap.

Changes to sediment transport pathways due to the presence of infrastructure

Overview

- 1.8.2.30 During the construction phase of the MHPGC Project, modification of existing sediment transport pathways could occur in response to:

- Changes in the wave and tidal regimes resulting from the presence of cable protection being installed;
- Direct (albeit very localised and limited volume) blockage to sediment transport; and/or
- The presence of the trenchless technique exit pit (associated with the installation of the offshore export cable at landfall) and floatation pits.

- 1.8.2.31 The above changes could potentially occur over a range of timescales, depending on location and the specific infrastructure that is interacting with the sediment transport regime.
- 1.8.2.32 The MDS with respect to the potential for changes to the sediment transport regime is set out in **Table 1.14**.
- 1.8.2.33 The following embedded commitments have been made which will help reduce the potential for adverse impacts associated with changes to sediment transport pathways:
- The embedded commitments CoT14/MM-022 and CoT06/MM-006 means a CMS and OEMP will be produced as part of the MHPGC Project, ensuring construction methods align with good practice, implement agreed mitigation measures and are appropriately managed.
- 1.8.2.34 Further details are provided in **Table 1.15**.
- 1.8.2.35 For both Scottish and English waters, the installation of cable protection has the potential to result in a localised blockage of waves, tides and sediment transport. This blockage will commence when construction begins, increasing incrementally up to the MDS (i.e. up to 27 km of rock protection), which is represented by the fully operational MHPGC Project.
- 1.8.2.36 All changes to sediment transport systems due to direct blockage and/or modification of the wave and current climate will be no greater than that identified for the operational phase below [**Paragraph 1.8.3.1 et seq.**] and, therefore, is not considered further here. The potential for floatation pits to modify sediment transport pathways is discussed in **Paragraph 1.8.2.82** in the context of potential impacts to coastal morphology.

Construction phase: impacts to receptors

Impacts to seabed morphology

Overview

- 1.8.2.37 During the construction phase of the MHPGC Project, impacts to seabed morphology could occur in response to:
- The installation of MHPGC Project infrastructure (cables and cable protection) on the seabed;
 - Direct change through seabed preparation (i.e., sandwave levelling, boulder clearance and pre-lay grapnel run);
 - Direct change through the creation of dredged disposal mounds; and
 - Direct changes to the seabed through contact with anchors and wires used by vessels.
- 1.8.2.38 Details of the MDS for impacts to seabed morphology are set out in **Table 1.14**.
- 1.8.2.39 Some levelling of sandwaves may be necessary during the construction phase, which has the potential to directly alter the local seabed morphology within the MHPGC Project PEIR Red Line Boundary. This would be achieved by MFE or dredging, although it is noted that any sediment removed from the seabed would, preferentially, be deposited in close proximity to the dredge location. The potential extent of change and likely timescales over which sandwave feature recovery may occur is considered further in this section.
- 1.8.2.40 Where dredging is required, material will be disposed of nearby on the seabed, within the MHPGC PEIR Red Line Boundary. These disposal events may leave mounds, which locally change the morphology of the seabed and (depending on the nature of the material and local HD setting) may persist in time. The persistence and evolution of these mounds is considered in this section.
- 1.8.2.41 The following embedded commitments have been made which will help reduce the potential for adverse impacts to seabed morphology:

- The embedded commitments CoT14/MM-022 and CoT06/MM-006 means a CMS and OEMP will be produced as part of the MHPGC Project, ensuring construction methods align with good practice, implement agreed mitigation measures and are appropriately managed.
- The embedded commitment CoT08/MM-010 means an Outline Offshore CSIP will be prepared and submitted as part of the MHPGC Project, ensuring routing, installation and monitoring methods align with good practice.

1.8.2.42 Further details are provided in **Table 1.15**.

Receptor sensitivity

Scottish waters

1.8.2.43 The only identified receptor within the Zol in Scottish Waters is the seabed morphology and sediment characteristics of the Firth of Forth Banks Complex MPA (**Figure 1-1**).

1.8.2.44 The MHPGC Project PEIR Red Line Boundary does not directly intersect the Firth of Forth Banks Complex MPA, but it does pass very close (c. 40m) to its boundary. As set out in **Section 1.5.1**, this site contains designated moraines, shelf banks and mounds, and subtidal sands and gravels that are of high value/importance. The designated moraines, shelf banks and mounds are relict, with no ability to recover from impact. Therefore, the receptor sensitivity is considered to be **very high**.

English waters

1.8.2.45 The only identified receptor within the Zol in English Waters is the seabed morphology and sediment characteristics of the Farnes East MCZ although it should be noted that the MHPGC Project PEIR Red Line Boundary does not directly pass through this MCZ. The North East of Farnes Deep MCZ and HPMA is located very close (<2km) to the Zol so the seabed morphology and sediment characteristics of this designated site are also included here as a receptor (**Figure 1-1**).

1.8.2.46 Both designated sites contain protected sedimentary features (notably subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments). These are considered to be of high value/importance. Their ability to recover from impact is both spatial and temporarily variable although in most instances are likely to have at least some ability to recover from impact. Overall, the receptor sensitivity is considered to be **high to very high**.

Magnitude of impact

Cable and cable protection installation

1.8.2.47 In both Scottish and English waters, cable installation, and subsequent presence of cable protection measures, has the potential to impact seabed morphology through the modification of HD/wave regimes and in turn sediment transport. This potential impact will commence when construction begins, increasing incrementally up to the MDS (i.e. up to 27 km of rock protection), which is represented by the fully operational MHPGC Project. Morphological change arising from the presence of the cables/cable protection will be no greater than that identified for the O&M phase and, therefore, is discussed in **Section 1.8.3.27**.

1.8.2.48 Cables may be buried into surficial sediments or more consolidated Quaternary material. Once buried, the cables will not have any potential to impact seabed morphology unless exposed. Should this occur, the maximum depth of scour will be between one and three times the cable diameter (i.e. up to ~1m) and the maximum horizontal extent of any scour effect will be up to 50 times the cable diameter (i.e. up to about 20m). The MHPGC Project PEIR Red Line Boundary does not pass directly through any designated sites in either Scottish or English waters and therefore the seabed morphology and sediment characteristics in these designated areas of seabed will be entirely unaffected by any scour.

1.8.2.49 Given the highly localised nature of any physical changes associated with cable or cable-protection infrastructure installation, the overall magnitude of impact on seabed morphology and sediment characteristics within designated seabed areas during the construction phase is assessed as **negligible**, for both Scottish and English waters.

Sandwave levelling

1.8.2.50 Within the MHPGC PEIR Red Line Boundary up to 1,736,000m² of seabed could be impacted by sandwave clearance in Scottish waters, and up to 1,232,000m² in English waters. The volume of material to be displaced from individual sandwaves will vary according to the local dimensions of

the sandwave (height, length and shape) and the level to which the sandwave must be reduced (also accounting for stable sediment slope angles and the capabilities and requirements of the cable burial tool being used).

- 1.8.2.51 The sediments comprising the sandwave features will be predominantly sand, although a small proportion of fines and gravel may, potentially, also be present. Individual sandwaves will require removal via MFE or by multiple dredging cycles to complete the required corridor. If dredging is undertaken, the preference is for the dredge spoil to be returned to the seabed in the vicinity of the dredged area. Maintaining the local total sediment volume will enable levelled sandwaves to reach a new equilibrium, which is as similar as possible to the pre-levelled feature. The equilibrium position should also be reached more quickly than if the material was removed from the system.
- 1.8.2.52 The tidal current regime (peak current speeds on a mean spring tide of 0.6m/s) is sufficiently strong to cause mobility of sand on a regular basis. The tidal current regime will not measurably change as a result of the localised levelling, or as a result of any other aspect of the MHPGC Project. The volume of sediment available in each local system will be locally redistributed by the local levelling (via MFE) and/or dredging, and disposal of removed material back into the water column nearby but will not change in an overall net sense. As the controlling factors will also not change, the levelled areas and sandwave features will recover in time to a new (dynamically evolving) natural state.
- 1.8.2.53 The levelled area is considered to be 'recovered' in terms of form and function once the local crest level has re-established to a form that is within the range of natural variability observed in the other similarly sized surrounding bedforms, which may be of different dimensions and location than the original feature pre-levelling.
- 1.8.2.54 The rate and timescale of recovery will vary in proportion to the rate of sediment transport/accumulation and the amount of material removed (width of dredge corridor and height/wavelength of dredged features). Faster infill and recovery rates will be associated with periods of higher local flow speeds and more frequent wave influence at the seabed.
- 1.8.2.55 A shorter estimated timescale is obtained when considering the instantaneous rate of transport during higher flow periods. As shown by the detailed sand transport modelling presented in **Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR**, instantaneous transport rates (increasing with proximity to the coast) of between approximately 0.05 to 3.5m³/m/hr may be active up to four times per day (peak flood and ebb) for a few days either side of the peak of spring tides, and are relatively uniform across the MHPGC Project PEIR Red Line Boundary, so apply to both Scottish and English waters. At a representative rate of 0.5m³/m/hr, and assuming a representative 50m wide corridor and a nominal volume of 15,000m³ sediment displaced for an individual sandwave, it could take in the order of (15,000m³/0.5m³/m/hr x 50m x 4hr/day x 4 days) 37.5 spring tidal cycles (~1.5 years) to move the displaced volume of sediment back into the levelled area. The overall rate of recovery would also vary in proportion to the volume displaced (relative to the representative value of 15,000m³).
- 1.8.2.56 The recovery may be gradual or episodic. Rates of sandwave bedform recovery are likely to be relatively faster closer to the coast (higher current speeds and shallower depths lead to greater and/or more frequent sediment mobility). Varying states of partial recovery will be achieved in a shorter timescale. As the recovery is due to natural processes of sediment transport, the nature of the seabed surface sediments in the recovering area will not be measurably different to that on the surrounding seabed and adjacent sections of undisturbed sandwave. In all locations, surficial sediments will continue to be mobilised at the natural ambient rate and direction under sufficiently energetic current and wave conditions, with the associated development and migration of smaller (e.g. ripple and megaripple) bedforms.
- 1.8.2.57 The final shape of the bedform following recovery may be similar to its original condition (e.g. rebuilding a single crest feature, although likely displaced in the direction of natural migration) or it might change (e.g. a single crest feature might bifurcate or merge with another nearby bedform). All such possible outcomes are consistent with the natural processes and bedform configurations that are already present in the Physical Processes Study Area and would not adversely affect the onward form and function of the individual bedform features.
- 1.8.2.58 The levelled areas are not considered likely to create a barrier to onward sediment transport. Evidence from aggregate dredging activities indicates that if any changes occur to the flow

conditions or wave regime, these are localised in close proximity to the dredge pocket (with widths and lengths of several kilometres) (e.g. Anglia Offshore Dredging Association (AODA), 2011; TEDA, 2012). The proposed works will be at a much smaller scale and footprint, with trench widths expected to be in the order of up to a few tens of metres. This means there is likely to be little to no influence on the flow or wave regime in the surrounding area which, in turn, means little to no change to the regional scale sediment transport processes across the MHPGC Project PEIR Red Line Boundary.

Scottish waters

- 1.8.2.59 There will be no impact from any sandwave levelling on the seabed morphology and sediment characteristics of the Firth of Forth Banks Complex MPA, notably the protected designated moraines, shelf banks and mounds, and subtidal sands and gravels. This is because no seabed preparation activities will occur directly within the Firth of Forth Banks Complex MPA and these activities will not alter regional sediment transport processes or the character of the seabed sediments away from the immediate location of the preparation activity.
- 1.8.2.60 Therefore, the magnitude of impact to seabed morphology for these designated areas of seabed from sandwave levelling, during the construction phase is considered to be **negligible**.

English waters

- 1.8.2.61 Designated areas of seabed within (or nearby to) the Physical Processes Study Area that lie in English waters include the Farnes East MCZ (protected features: subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments) and the North East of Farnes Deep MCZ and HPMA (protected features: subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments) [see
- 1.8.2.62 **Figure 1-1**]. No seabed preparation activities are planned within the designated sites themselves, and the impact of any works occurring nearby would be confined to a very limited footprint. As such, they would not influence broader sediment transport pathways or modify the prevailing seabed sediment characteristics. Accordingly, any sandwave levelling activity is not considered to pose a risk to the seabed morphology and sediment characteristics of these designated areas.
- 1.8.2.63 On the basis of the above, the magnitude of impact to seabed morphology and sediment characteristics from sandwave levelling during the construction phase within these two designated areas of seabed is considered to be **negligible**.

Boulder clearance and pre-lay grapnel run

- 1.8.2.64 Prior to the installation of MHPGC Project infrastructure, site preparation activities will be required. These include boulder clearance and PLGR to prepare the seabed for cable installation. The MHPGC Project geophysical survey has found the presence of boulder fields within the MHPGC Project PEIR Red Line Boundary, specifically within 15km of the coast and the northern extent of the MHPGC Project PEIR Red Line Boundary in English and Scottish waters (XOCEAN Ltd., 2025); see **Figure 4.12** within **Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR**. These boulders will be cleared by plough or by grab with preference given to micro-siting to avoid boulders where possible. The consequence for marine Physical Processes is a low level of direct mechanical disturbance of the seabed for the duration of the operation and an increased density of boulders to the adjacent seabed. This could lead to a slight increase in bed roughness. In total an area of up to 11,100,000m² (Scottish and English waters combined) could be disturbed by boulder clearance activities.
- 1.8.2.65 A PLGR operation will also be executed prior to the installation of the offshore export cable to clear the seabed of surface debris. PLGR operations are normally carried out along the proposed cable route centre line to provide 100% coverage of the centre-line route, with the exception of in-service cable and pipeline exclusion zones. Additional passes will be completed in any area where anomalies and/or debris are expected or located. In total an area of up to 6,493,400m² (Scottish and English waters combined) could be disturbed by PLGR activities.
- 1.8.2.66 The MHPGC Project PEIR Red Line Boundary does not intersect any designated sites. Consequently, these preparation activities will not occur directly within designated areas, and any disturbance arising from nearby works would remain highly localised and confined to a limited footprint. Therefore, the magnitude of impact to seabed morphology and sediment characteristics from

boulder clearance and PLGR, during the construction phase within designated seabed areas is considered to be **negligible**, for both Scottish and English waters.

Disposal mounds

- 1.8.2.67 In both Scottish and English waters, levelling of sandwaves via dredging could be associated with the formation of disposal mounds adjacent to dredged areas, following the release of material from the dredge hopper. The persistence and evolution of these spoil mounds will be dependent upon a range of factors. These are discussed in detail in **Paragraph 1.8.2.22 et seq.** and **Paragraph 1.8.2.25 et seq.**, therefore are not discussed again here.
- 1.8.2.68 The magnitude of impact to seabed morphology and sediment characteristics from dredge disposal mounds within designated seabed areas during the construction phase is considered to be **negligible**, for both Scottish and English waters. This is because the deposition of dredged spoil will not occur in any designated areas and any associated changes to HDs, waves and sediment transport will be highly localised to the mounds themselves.

Vessel interactions with the seabed

- 1.8.2.69 A total seabed area of (up to) 5,098,230m² may be disturbed by vessel anchoring, whilst a total seabed area of (up to) 18.85m² may be impacted by jack-up spud legs. These disturbance events could occur in both Scottish and English Waters.
- 1.8.2.70 The magnitude of impact to seabed morphology and sediment characteristics from vessel interactions within designated seabed areas during the construction phase is considered to be **negligible**, for both Scottish and English waters. None of these activities will occur in any designated areas and any associated changes to HDs, waves and sediment transport will be highly localised.

Significance of effect

- 1.8.2.71 The receptors under consideration in this assessment are seabed morphology and sediment characteristics within the following designated areas of seabed:
- Firth of Forth Banks Complex MPA (notably Moraines shelf Banks & mounds and offshore subtidal sands and gravels);
 - Farnes East MCZ (notably moderate energy circalittoral rock, subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments);
 - North East of Farnes Deep MCZ and HPMa (notably moderate energy circalittoral rock, subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments).

- 1.8.2.72 For all of the above receptors, the sensitivity is **high** or **very high** and the magnitude of all identified impacts is assessed as **negligible**. Therefore, the impact to seabed morphology and sediment characteristics within these designated seabed areas during the construction phase, is considered to be **minor adverse**, which is not significant in EIA terms.

Secondary mitigation and residual effect

- 1.8.2.73 Because the significance of effect is **minor adverse** and therefore not significant in EIA terms, no secondary mitigation is required.

Impacts to coastal morphology

Overview

- 1.8.2.74 The offshore export cables will make landfall directly south of Seaham, England, connecting to the National Grid at the Hawthorn Pit Substation. During the construction phase of the MHPGC Project impacts to coastal morphology could occur due to trenchless installation techniques. Details of the MDS for impacts to coastal morphology are set out in **Table 1.14**.
- 1.8.2.75 The following embedded commitments have been made which will help reduce the potential for adverse impacts to coastal morphology:
- The embedded commitment CoT13/MM-014 means that the installation of the offshore export cables under Durham Coast SSSI and SAC will be undertaken by trenchless technologies. The trenchless technique exit pits associated with the trenchless technologies installation will be at least 100 m seaward of the eastern boundary of the Durham Coast SSSI and SAC.

- The embedded commitments CoT14/MM-022 and CoT06/MM-006 means a CMS and OEMP will be produced as part of the MHPGC Project, ensuring construction methods align with good practice, implement agreed mitigation measures and are appropriately managed.
- The embedded commitment CoT08/MM-010 means an Outline Offshore CSIP will be prepared and submitted as part of the MHPGC Project, ensuring routing, installation and monitoring methods align with good practice.

1.8.2.76 Further details are provided in **Table 1.15**.

Receptor sensitivity

1.8.2.77 The following receptors are located within the Zol at the landfall (which is in English waters) – see Figure 1-1 for locations:

- Designated morphological features within the Durham Coast SAC (notably vegetated sea cliffs);
- Designated morphological features within the Durham Coast SSSI (notably vegetated sea cliffs);
- Morphological characteristics of the Durham Coast SPA (notably rocky shores, bedrock reefs, and cobble beaches, interspersed with small sandy bays);
- Morphological characteristics of non-designated coastline (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed).

1.8.2.78 The coastline within the Physical Processes Study Area may be considered to be of high value within internationally designated sites (Durham Coast SAC and Durham Coast SPA) and moderate/high value elsewhere (Durham Coast SSSI or along undesignated sections of coastline). It is typically a dynamic environment that is subject to natural change under baseline conditions. However, the degree to which it may recover from disturbance and accommodate change will be highly location specific, with (for instance) geological features such as cliffs unable to recover from disturbance than dynamic sedimentary features such as a sandy beach. Taking all of the above into account, the overall sensitivity of coastal morphological features located within the Zol at the landfall is considered to be no greater than **high**.

Magnitude of impact

Trenchless installation techniques

1.8.2.79 The coastline at the landfall is characterised by the presence of a gravelly beach backed by a man-made platform of colliery waste ground and dolostone cliffs. The man-made platform is (up to) several 10s of metres wide and runs north to south throughout much of the landfall area. The available evidence presented in **Volume 2, Annex 1.1: Physical Processes Technical Report, of the PEIR** suggests that the coastline is stable (beach extent and cliff location) with only very modest erosion anticipated over the lifetime of the MHPGC Project in response to climate change and sea level rise.

1.8.2.80 Trenchless cable installation will cause minimal direct disturbance to the existing coastline because it will not interact directly with, or leave any infrastructure exposed in, the active parts of the beach between the entry and exit points of the drill, and so will not impact upon littoral processes. Provided that the cable remains buried beyond the exit point, there is no possibility for it to interact with, or have any effect on, nearshore beach processes or morphology. The design of the trenchless operations will take into account the potential for natural morphological change to occur throughout the lifetime of the MHPGC Project. Accordingly, even where the MHPGC Project overlaps with the Durham Coast SAC/SSSI there is not expected to be an interruption to coastal processes including changes to sediment transfer as a result of trenchless installation techniques.

1.8.2.81 Cable installation at the landfall is predicted to cause a **negligible** impact on coastal morphological characteristics. This holds true both for the designated vegetated sea cliffs within the Durham Coast SAC and Durham Coast SSSI (which are located within the MHPGC Project PEIR Red Line Boundary at the landfall), as well as other coastal features (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed) in nearby areas including the Durham Coast SPA. This is because trenchless cable installation techniques will be used, meaning that there will be no interaction with the beach and associated littoral transport processes.

Construction of trenchless technique exit pits and floatation pits

- 1.8.2.82 As the trenchless installation is carried out between a start and end point (both within England/English waters), entry and trenchless technique exit pits must be excavated at either end of the drill: in the landfall compound (entry) and offshore (exit). Floatation pits at the trenchless technique exit pit may also be required to provide sufficient water depth for working vessels.
- 1.8.2.83 Up to four trenchless technique exit pits may be required, with maximum individual trenchless technique exit pit dimensions of 140m (length) x 50m (width) x 5m (depth). Up to 2 floatation pits may be constructed, with a maximum individual floatation pit dimensions of 240m (length) x 55m (width) x 5m (depth). All exit and floatation pits will be constructed in English waters.
- 1.8.2.84 Exit/floatation pits will be excavated or dredged to the required depth, and side-cast material for backfilling will be stored adjacent to the exit/floatation pit. Once installation is complete, the exit/floatation pits will either be backfilled using side-cast material or left to naturally backfill.
- 1.8.2.85 The potential mechanisms by which the presence of the exit/floatation pits could theoretically impact the coast at landfall are principally via the modification of waves and interception of sediment. Potential changes to the wave regime resulting from the presence of exit/floatation pits in shallow subtidal areas are summarised as follows:
- Changes to short period, low amplitude wind waves will be largely immeasurable at all states of the tide as the likely depth and footprint dimensions of the temporary changes to water depths will be insufficient to measurably alter short wave characteristics;
 - Longer period, higher amplitude storm waves could theoretically be more affected by the presence of the exit/floatation pits, possibly resulting in some wave refraction. However, the dimensions of the exit/floatation pits will be very small relative to the wavelengths of storm waves, greatly limiting the potential for measurable refraction. Any change to the wave regime will also diminish with increasing distance away from the trenchless technique exit pits and at higher states of the tide when water depths are greater;
 - The presence of the exit/floatation pits could potentially enable wave energy associated with storm waves to propagate slightly further inshore/ up the beach than would have been the case, as larger waves will shoal less, enabling them to remain marginally higher immediately in the lee of the exit/floatation pits. However as larger waves travel inshore from the exit/floatation pits, the shoreline gradient/water depths will increasingly become the limiting condition on wave form.
- 1.8.2.86 However, even with the possibility of some (highly localised) wave refraction, it is probable that only some of the waves reaching the beach will have passed across the footprint of the exit/floatation pits.
- 1.8.2.87 The trenchless technique exit pits are expected to be located within the theoretical active shore profile, as defined by the 'Depth of Closure'. This means that during storm events, material removed from the beach may be transported across the location of the trenchless technique exit pits. Given the likely high gradient (1:4) of the pit side-slopes, it is probable that any local material entering the pits could become trapped. This material would then not be available to replenish the beach during calmer conditions (when waves are generally constructive rather than destructive in nature).
- 1.8.2.88 The extent to which a very small section of beach morphology could potentially be altered by trapping of sediment will be dependent upon the frequency and magnitude of storms during the operational period of the exit/floatation pits, and their dimensions. If either an exit or floatation pit were to be entirely infilled, this would represent up to 18,667m³ or 39,167m³ of material temporarily 'lost' from the local subtidal sedimentary system and beach, respectively. However, this is unlikely to happen given the relatively short duration of time that the exit/floatation pits will be open and operational, and their distance from the beach.
- 1.8.2.89 Given that winter storms may occur during the operational period of the exit/floatation pits, it is theoretically possible that some maintenance dredging may be required prior to further access. Should this be required, any dredged material is likely to be deposited in reasonably close proximity to the exit/floatation pits. Accordingly, no mobile beach material will be lost from the local system but will instead remain available for beach resupply.

- 1.8.2.90 The potential impact of the exit and/or floatation pits on coastal morphological characteristics will be of a magnitude no greater than **low**. This is because whilst highly localised morphological change could theoretically occur to the seabed and beach immediately adjacent to the pits, any change would be temporary. Away from these areas, any impact would be negligible. This holds true both for the designated vegetated sea cliffs within the Durham Coast SAC and Durham Coast SSSI (which are located within the MHPGC Project PEIR Red Line Boundary at the landfall), as well as other coastal features (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed) in nearby areas including the Durham Coast SPA, located 2km to the north of the landfall.

Significance of effect

- 1.8.2.91 The receptors under consideration in this assessment are:
- Designated morphological features within the Durham Coast SAC (notably vegetated sea cliffs);
 - Designated morphological features within the Durham Coast SSSI (notably vegetated sea cliffs);
 - Morphological characteristics of the Durham Coast SPA (notably rocky shores, bedrock reefs, and cobble beaches, interspersed with small sandy bays);
 - Morphological characteristics of non-designated coastline (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed).
- 1.8.2.92 For all of the above receptors, the sensitivity is no greater than **high** and the magnitude of all identified impacts is assessed as being no greater than **low**. Therefore, the impact to these receptors during the construction phase, is considered to be no greater than **minor adverse**, which is not significant in EIA terms. (On the basis of **Table 1.11**, the combination of high sensitivity and low magnitude can result in either minor or moderate impacts. A professional judgement of minor has been made here, principally because of the commitment to trenchless installation techniques and because any changes would be highly localised and temporary).

Secondary mitigation and residual effect

- 1.8.2.93 The significance of effect is **minor adverse** and not significant in EIA terms, therefore no secondary mitigation is required.

1.8.3 O&M phase

O&M phase: changes to pathways

Changes to SSCs and associated deposition

Overview

- 1.8.3.1 During the O&M phase of the MHPGC Project, sediment could be disturbed and released into the water column. This will give rise to suspended sediment plumes and localised changes in bed levels as material settles out of suspension.
- 1.8.3.2 The main activity resulting in disturbance of seabed sediments during the O&M phase is remedial works to installed offshore export cables. Details of the MDS for sediment disturbance events are set out in **Table 1.14**.
- 1.8.3.3 The embedded commitments CoT07/MM-007 and CoT06/MM-006 means an Outline Offshore O&M Plan and OEMP will be produced as part of the MHPGC Project, ensuring O&M methods align with good practice, implement agreed mitigation measures and are appropriately managed (**Table 1.15**).
- Repairs and Remedial works to installed cables
- 1.8.3.4 The repair and remedial work events for cables during the O&M phase is expected to result in some localised seabed disturbance accompanied by temporary increases in SSC. The MDS is for up to 41 offshore export cable repairs over the 35 year operational lifetime. Up to 4% of the cable route (13km) may require remediation per year. These O&M activities will use similar methods as those for cable installation activities.
- 1.8.3.5 Each repair event will have a maximum length of 2km, with the majority of cable repairs anticipated to be 500m to 1,000m maximum. Therefore, the scale of change is expected to be far less than those identified for the construction phase [see **Paragraph 01.8.2.1 et seq.**].

Changes to sediment transport pathways due to the presence of infrastructure (including secondary scour assessment)

Overview

1.8.3.6 During the O&M phase of the MHPGC Project, modification of existing sediment transport pathways could occur in response to:

- Changes in the wave and tidal regimes resulting from the presence of cable protection;
- Direct (albeit very localised and limited volume) blockage to sediment transport from the presence of cable protection;
- Secondary scour.

1.8.3.7 The above changes could potentially occur over a range of timescales, depending on location and the specific infrastructure that is interacting with the sediment transport regime.

1.8.3.8 The MDS with respect to the potential for changes to the sediment transport regime is set out in **Table 1.14**.

1.8.3.9 The embedded commitments CoT07/MM-007 and CoT06/MM-006 means an Outline Offshore O&M Plan and OEMP will be produced as part of the MHPGC Project, ensuring O&M methods align with good practice, implement agreed mitigation measures and are appropriately managed (**Table 1.15**).

Change to the wave and tidal regimes

Scottish and English waters

1.8.3.10 Sediment transport is driven by the combination of waves and tides, and the relative contribution of these driving processes will vary spatially and temporally in response to, amongst other things, variation in water depth, tidal strength and meteorological events. This assessment considers the potential for modification of sediment transport pathways arising from changes to HD/wave regimes.

1.8.3.11 Cable protection (in the form of concrete mattresses/rock bags/rock installation or a CPS) may be installed along parts of the MHPGC project offshore export cable, covering a maximum of up to 8.3% (equivalent to 27km) of the cable length within Scottish and English waters. Rock installation for protection represents the MDS (in terms of the largest local blockage) and may be up to 2m high and 14m wide, with a side slope of 1:3. There will be up to 16 cable/pipeline crossing that may also require protection (in the form of rock installation or concrete mattresses). Each crossing will be up to 200m (length) x 18m (width) x 2m (height).

1.8.3.12 Water depths are between approximately 80m LAT and 107m LAT along the MHPGC Project PEIR Red Line Boundary, seaward of 12nm. On the few occasions, during large storm events, when waves are sufficiently large to interact at all with the cable protection, it is very unlikely that the cable protection will present a sufficient obstacle to cause changes to their size or direction.

1.8.3.13 The long axis of any potential cable protection may be aligned to, or perpendicular to, the main tidal current axis, depending on exact location within MHPGC Project PEIR Red Line Boundary. However, the cable protection height (maximum 2m) is a very small proportion of the total water depth and so, together with the sloped sides of the berm, will present a minimal obstruction to tidal currents (no measurable effect more than a few tens of metres from the berm and restricted only to the near-bed).

1.8.3.14 Consistent with the very limited scale of change predicted in tidal currents and wave regime, no measurable change in sediment transport rates or directions is predicted.

English nearshore waters

1.8.3.15 The MHPGC Project has committed to using trenchless technologies – see Commitment CoT13/MM-014 in **Table 1.15**. This will cause minimal direct disturbance to the existing coastline because it will not interact directly with, or leave any infrastructure exposed in, the active parts of the beach (between the entry and exit points of the drill) and so will not impact upon littoral processes in these areas during the O&M phase. Provided that the cable remains buried beyond the exit point, there is no possibility for it to interact with, or have any effect on, nearshore sediment transport processes.

- 1.8.3.16 The trenchless technique exit pit will be protected by backfill, rock placement and mattress protection. The maximum height above the seabed of the protection will be 0.35m (although the intention will be to restore the original seabed level). There is no possibility for a localised change in seabed elevation of this scale to interact with, or have any effect on, nearshore sediment transport processes.

Direct blockages to sediment transport

Scottish and English waters

- 1.8.3.17 Installation of cable protection could result in a local increase in the elevation of the seabed, up to 2m. Cable protection would be placed onto the seabed surface above the cable and therefore could directly trap sediment, locally impacting down drift locations.
- 1.8.3.18 The monitoring data reviewed in The Crown Estate (TCE, 2019) presented little or no information on the effects of cable protection either on the seabed or on associated benthic ecology communities (e.g. colonisation of installed protection measures). However, research initiatives are currently underway that should help address this data gap.
- 1.8.3.19 Following installation and under favourable conditions, an initial period of sediment accumulation would be expected to occur against cable protection measures, which could have a height of up to 2m above the bed. This accumulation would likely create a smooth slope against the cable protection. The process of wedge formation may take place over a period of a few weeks to months, depending on rates of sediment transport.
- 1.8.3.20 Sandy sediments are transported in two modes: bedload and saltation. Saltation is the process by which sands are moved up into the water column. These suspended sands would be expected to move relatively freely over the top of the protection although to begin with would regularly be deposited upon it, filling void spaces. Once any void spaces have been infilled, saltation is expected to be largely unaffected by the presence of the cable protection such that existing transport process (including bed form migration) will remain unaffected.
- 1.8.3.21 The process of void infilling is expected to occur relatively quickly (in the order of a few months). This is due to saltation as well as the anticipated higher rates of transport in areas of mobile seabed (which is where much of the cable protection is anticipated).
- 1.8.3.22 Bedload is the process by which sands move while still in contact with the seabed. The slope of the protection (1:3) already provides an approximate 18° slope angle, which is within the range of naturally stable bed slopes (<32° for sands). Bedload will be temporarily affected up until such time that the protection is covered by sand and the slope gradient either side has been reduced in response to the accumulation of a sediment wedge with stable slope angles (approximately 30°). Following this, bedload will continue over the protection at the natural ambient rate and direction because the slope angle presented by sections of protected cable would be within the natural range of bed slope angles associated with bed forms mapped within the MHPGC Project PEIR Red Line Boundary.
- 1.8.3.23 Accordingly, for all areas in which cable protection is used, in Scottish and English waters (including where sandwaves are present), it is not expected that the presence of the cable protection will continuously affect patterns of sediment transport following the initial period of accumulation. It follows that any changes on seabed morphology away from the cable protection will also be very small. No measurable change to the seabed is expected more than a few metres from the updrift edge of the protection. The extent of the cable protection measures does not constitute a continuous blockage along the offshore export cable corridor, therefore no measurable change to wider seabed morphology will be observed as the supply of sediment will be broadly maintained.

English nearshore waters

- 1.8.3.24 The MHPGC Project has committed to using trenchless technologies – see Commitment CoT13/MM-014 in **Table 1.15**. This will cause minimal direct disturbance to the existing coastline because it will not interact directly with, or leave any infrastructure exposed in, the active parts of the beach (between the entry and exit points of the drill) and so will not impact upon littoral processes in these areas. Provided that the cable remains buried beyond the exit point, there is no possibility for it to interact with, or have any effect on, nearshore sediment transport processes.

Secondary scour

- 1.8.3.25 The purpose of cable protection is to provide protection to the offshore export cables and remove risk to local sea users. It is also designed to prevent sediment scour. Where protection is applied, no scour will be caused by the protected cable itself. However, where surficial sediment is present, a small amount of localised secondary scour may form at the edges of the protection, in proportion to the overall protection dimensions and the clast size used.
- 1.8.3.26 The patterns and dimensions of sediment accumulation or scour may vary over the operational lifetime of the berm, due to natural fluctuations in sediment supply and transport rates and directions. Changes may be seasonal or episodic in nature (e.g. during or following larger storms, then gradually returning to another state associated with purely tidal conditions). However, the nature of the seabed (sediment type and texture) around the berm, including within any areas of local accretion or scour, is not expected to be measurably very different to the surrounding seabed.

O&M phase: changes to receptors

Impacts to seabed morphology

Overview

- 1.8.3.27 During the O&M phase of the MHPGC Project, impacts to seabed morphology could occur in response to the presence of MHPGC Project infrastructure (cables and cable protection) on the seabed. These could cause change to the tidal/wave regime, which in turn could change the sediment transport regime [discussed in more detail in **Paragraph 1.8.3.1 et seq.**].
- 1.8.3.28 Details of the MDS for impacts to seabed morphology are set out in **Table 1.14**.
- 1.8.3.29 The embedded commitments CoT07/MM-007 and CoT06/MM-006 means an Outline Offshore O&M Plan and OEMP will be produced as part of the MHPGC Project, ensuring O&M methods align with good practice, implement agreed mitigation measures and are appropriately managed (**Table 1.15**).

Receptor sensitivity

Scottish waters

- 1.8.3.30 The only identified receptor within the Zol in Scottish Waters is the seabed morphology and sediment characteristics of the Firth of Forth Banks Complex MPA (**Figure 1-1**). It should be noted that the MHPGC Project PEIR Red Line Boundary does not directly pass through this MPA.
- 1.8.3.31 This site contains designated moraines, shelf banks and mounds, and subtidal sands and gravels that are of high value/importance. The designated moraines, shelf banks and mounds are relict with no ability to recover from impact. Therefore, (and as previously stated in **Section 1.8.2** for the construction phase) the receptor sensitivity is considered to be **very high**.

English waters

- 1.8.3.32 The only identified receptor within the Zol in English Waters is the seabed morphology and sediment characteristics of the Farnes East MCZ although it should be noted that the MHPGC Project PEIR Red Line Boundary does not directly pass through this MCZ. The North East of Farnes Deep MCZ and HPMA is located very close (<2km) the Zol so the seabed morphology and sediment characteristics of this designated site is also included here as a receptor (**Figure 1-1**).
- 1.8.3.33 Both designated sites contain protected sedimentary features (notably subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments). These are considered to be of high value/importance. Their ability to recover from impact is both spatial and temporarily variable although in most instances are likely to have at least some ability to recover from impact. Overall, the receptor sensitivity is considered to be **high to very high**.

Magnitude of impact

- 1.8.3.34 The presence of cable protection during the O&M phase has the potential to cause changes to the local seabed level as a result of local flow interaction between the body and surface of the berm, and any near-bed current and wave action. The potential for cable protection to cause larger scale changes to the tidal, wave or sediment transport regimes is very limited. As discussed in detail in **Paragraph 1.8.3.1 et seq.**

- 1.8.3.35 Changes to the tidal regime may indirectly impact seabed morphology (including bedforms) in several ways. There exists a close relationship between flow speed and bedform type (Belderson *et al.*, 1982) and thus any changes to flows have the potential to alter seabed morphology over the lifetime of the MHPGC Project.
- 1.8.3.36 Where the wave climate is important to local processes and is persistently modified, these changes may potentially alter the frequency or pattern of sediment transport and therefore seabed morphology in affected offshore areas.
- 1.8.3.37 The maximum cable protection dimensions (19m width x 2m height) result in relatively low angle slopes and a low overall height relative to the water depth in the offshore region of the MHPGC Project PEIR Red Line Boundary, which limits the potential for changes to tidal currents and wave characteristics, even when flows and waves are perpendicular to the berm and the potential for scour effects [discussed in **Paragraph 1.8.3.1 et seq.**].
- 1.8.3.38 Given the highly localised nature of any physical changes associated with the presence of either exposed cables or cable-protection infrastructure, the overall magnitude of impact on seabed morphology and sediment characteristics within designated seabed areas during the operation phase is assessed as **negligible**, for both Scottish and English waters..

Significance of effect

- 1.8.3.39 The receptors under consideration in this assessment are seabed morphology and sediment characteristics within the following designated areas of seabed:
- Firth of Forth Banks Complex MPA (notably Moraines shelf Banks & mounds and offshore subtidal sands and gravels);
 - Farnes East MCZ (notably moderate energy circalittoral rock, subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments);
 - North East of Farnes Deep MCZ and HPMa (notably moderate energy circalittoral rock, subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments).

- 1.8.3.40 For all of the above receptors, the sensitivity is **high to very high** and the magnitude of all identified impacts is assessed as **negligible**. Therefore, the impact to seabed morphology and sediment characteristics within these designated seabed areas during the construction phase, is considered to be **minor adverse**, which is not significant in EIA terms.

Secondary mitigation and residual effect

- 1.8.3.41 The significance of effect is **minor adverse** and therefore not significant in EIA terms, therefore no secondary mitigation is required.

Impacts to coastal morphology

Overview

- 1.8.3.42 The MHPGC Project offshore export cable is expected to make landfall directly south of Seaham . During the O&M phase of the MHPGC Project, impacts to coastal morphology could occur in response to the presence of MHPGC Project infrastructure (exposed cables and cable protection) on the seabed. These could cause change to the tidal/wave regime, which in turn could change the sediment transport regime [discussed in more detail in **Paragraph 1.8.3.1 et seq.**].
- 1.8.3.43 Details of the MDS for impacts to seabed morphology are set out in **Table 1.14**.
- 1.8.3.44 The embedded commitments CoT07/MM-007 and CoT06/MM-006 means an Outline Offshore O&M Plan and OEMP will be produced as part of the MHPGC Project, ensuring O&M methods align with good practice, implement agreed mitigation measures and are appropriately managed (**Table 1.15**).
- 1.8.3.45 The embedded commitment CoT13/MM-014 means that the installation of the offshore export cables under Durham Coast SSSI and SAC will be undertaken by trenchless technologies. The trenchless technique exit pits associated with the trenchless technologies installation will be at least 100 m seaward of the eastern boundary of the Durham Coast SSSI and SAC. This means that there will be no MHPGC Project infrastructure in the inter-tidal zone which could cause long-term change to coastal morphology.

Receptor sensitivity

1.8.3.46 The following receptors are located within the Zol at landfall (in English waters)- see Figure 1-1 for locations:

- Designated morphological features within the Durham Coast SAC (notably vegetated sea cliffs);
- Designated morphological features within the Durham Coast SSSI (notably vegetated sea cliffs);
- Morphological characteristics of the Durham Coast SPA (notably rocky shores, bedrock reefs, and cobble beaches, interspersed with small sandy bays);
- Morphological characteristics of non-designated coastline (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed).

1.8.3.47 The coastline within the Physical Processes Study Area may be considered to be of high value within internationally designated sites (Durham Coast SAC and Durham Coast SPA) and moderate/high value elsewhere (Durham Coast SSSI or along undesignated sections of coastline). It is typically a dynamic environment that is subject to natural change under baseline conditions. However, the degree to which it may recover from disturbance and accommodate change will be highly location specific, with (for instance) geological features such as cliffs unable to recover from disturbance than dynamic sedimentary features such as a sandy beach. Taking all of the above into account, the overall sensitivity of coastal morphological features located within the Zol at the landfall is considered to be no greater than **high**.

Magnitude of impact

Exposure of cables

1.8.3.48 The Applicant has made a commitment (CoT08/MM-010 of **Volume 1, Annex 4.1: Draft Commitments Register, of the PEIR**) that an Outline Offshore CSIP will be prepared and submitted with the application for development consent and as part of the marine licence application(s) to the Scottish Ministers. The Outline CSIP will include (but is not limited to) a Cable Burial Risk Assessment (CBRA). Detailed plans will be developed substantially in accordance with the outline CSIP, and as approved by the discharging. The CBRA will be undertaken to ensure that all cables will be buried to an appropriate depth (or surface laid and protected along up to 8.3% of the total route length) to minimise the chance of exposure during the lifetime of the MHPGC Project. If exposure does occur, cables will be re-buried. However, no protection of greater dimensions (outside that already outlined as the MDS in **Table 1.14**, and used as the basis for the assessment) will be applied. (This means that any installed rock protection will be no larger than 14m wide and 2m high.) Where cable protection has been employed during the construction phase, this may be replenished during the operational phase, as necessary.

1.8.3.49 Once the offshore export cables are buried in the (nearshore) seabed, in English waters, there is no potential for cable related scour to occur. If and where the offshore export cables become exposed due to natural seabed erosion, then a small, localised, area of additional scour may occur, as a result of currents interacting with the exposed part of the cable. The exact dimensions of the scour will depend on the height of the offshore export cables relative to the seabed but will be in proportion to the relatively small diameter of the cable (up to a few hundred mm diameter) and no more than described for the cable protection [see **Paragraph 1.8.3.1**], namely that scour could be up to a few tens of centimetres deep and up to a few metres from the cable protection).

1.8.3.50 Based on the above, cable exposure at the landfall zone is predicted to cause a **negligible** impact on coastal morphological characteristics. This holds true both for the designated vegetated sea cliffs within the Durham Coast SAC and Durham Coast SSSI (which are located within the MHPGC Project PEIR Red Line Boundary at the landfall), as well as other coastal features (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed) in nearby areas including the Durham Coast SPA. This is because any scouring will be highly localised and temporary, and will stop once the cable is reburied.

Cable protection

1.8.3.51 In nearshore subtidal areas, cable protection could potentially be used to protect the offshore export cables. The exact location of cable protection and orientation relative to the beach is presently unknown. However, given the route of the offshore export cable corridor, it is probable that the long

axis of the rock berms will be orientated generally across the main tidal current axis but broadly aligned with the direction of waves as they approach the coast.

- 1.8.3.52 Cable protection in shallow areas could, theoretically, work in a similar way to a submerged offshore breakwater, affecting wave transformation processes closer to shore. This, in turn, could potentially alter the wave approach to the shore, leading to wave focusing on areas of the beach not presently eroding. This could result in long-term lowering in areas where surficial mobile material is present whilst localised accretion may also occur in other areas, as material is redistributed. If and where exposed bedrock platforms are present, the presence of any cable protection is not expected to lead to enhanced erosion.
- 1.8.3.53 The structures themselves could also locally intercept sediment being transported by wave and tidal driven currents. However, whilst it can reasonably be expected that there will be some localised change to waves and HDs in the immediate vicinity of the rock berms, the potential for wider morphological change at the coast at landfall, especially to the upper beach and adjacent cliffs, is considered to be very limited. This is primarily due to the fact that any rock berms would be relatively distant from the upper beach and have a relative low profile (<2m), meaning the ability to trap sediment and modify waves would be limited.
- 1.8.3.54 Based on the above, the impact of cable protection in nearshore areas on coastal morphological characteristics will be no greater than **low**. This is because whilst morphological change could theoretically occur to the seabed immediately adjacent to the protection, any change would be highly localised. Away from these areas, any impact would be negligible. This holds true both for the designated vegetated sea cliffs within the Durham Coast SAC and Durham Coast SSSI (which are located within the MHPGC Project PEIR Red Line Boundary at the landfall), as well as other coastal features (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed) in nearby areas including the Durham Coast SPA, located 2km to the north of the landfall.

Significance of effect

- 1.8.3.55 The receptors under consideration in this assessment are:
- Designated morphological features within the Durham Coast SAC (notably vegetated sea cliffs);
 - Designated morphological features within the Durham Coast SSSI (notably vegetated sea cliffs);
 - Morphological characteristics of the Durham Coast SPA (notably rocky shores, bedrock reefs, and cobble beaches, interspersed with small sandy bays);
 - Morphological characteristics of non-designated coastline (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed).
- 1.8.3.56 For all of the above receptors, the sensitivity is no greater than **high** and the magnitude of all identified impacts is assessed as being no greater than **low**. Therefore, the impact to these receptors during the construction phase, is considered to be no greater than **minor adverse**, which is not significant in EIA terms. (On the basis of **Table 1.11**, the combination of high sensitivity and low magnitude can result in either minor or moderate impacts. A professional judgement of minor has been made here principally because of the commitment to trenchless installation techniques and because any changes would be highly localised).

Secondary mitigation and residual effect

- 1.8.3.57 The significance of effect is **minor adverse** and therefore not significant in EIA terms, therefore no secondary mitigation is required.

1.8.4 Decommissioning phase

Decommissioning phase: changes to pathways

Changes to SSCs and associated deposition

Overview

- 1.8.4.1 During the decommissioning phase of the MHPGC Project, sediment will be disturbed and released into the water column. This will give rise to suspended sediment plumes and localised changes in

bed levels as material settles out of suspension. The main activity resulting in disturbance of seabed sediments during the decommissioning phase is the removal of offshore export cables and cable protection.

1.8.4.2 Details of the MDS for sediment disturbance events are set out in **Table 1.14**.

The embedded commitment CoT44 means a decommissioning plan will be produced as part of the MHPGC Project, ensuring decommissioning methods align with good practice, implement agreed mitigation measures and are appropriately managed (**Table 1.15**).

1.8.4.3 The MDS for decommissioning is the removal of all cables and protection installed during the construction phase. Therefore, the nature of the plume and area of seabed impacted will be similar to that described for construction. The changes in SSC and accompanying changes to bed levels associated with decommissioning activities are therefore expected to be less than or the same as that associated with construction [see **Paragraph 01.8.2.1 et seq.**].

Changes to sediment transport pathways due to the presence of infrastructure (including secondary scour assessment)

Overview

1.8.4.4 During the decommissioning phase of the MHPGC Project, modification of existing sediment transport pathways could occur in response to:

- changes in the wave and tidal regimes resulting from partially removed cable protection;
- direct (albeit very localised and limited volume) blockage to sediment transport by partially removed cable protection.

1.8.4.5 The above changes could potentially occur over a range of timescales, depending on location and the specific infrastructure that is interacting with the sediment transport regime.

1.8.4.6 The MDS with respect to the potential for changes to the sediment transport regime is set out in **Table 1.14**.

1.8.4.7 The embedded commitment CoT44 means a decommissioning plan will be produced as part of the MHPGC Project, ensuring decommissioning methods align with good practice, implement agreed mitigation measures and are appropriately managed (**Table 1.15**).

1.8.4.8 Where some or all cable protection is left during or following the decommissioning process, the potential for changes to local (and regional) sediment transport are the same as described and assessed for the presence of cable protection during the O&M phase [see **Paragraph 1.8.3.1 et seq.**].

1.8.4.9 Any impression left following the removal of infrastructure from the seabed, will be no larger than the original infrastructure and scour footprint. Depressions will become infilled and high points (comprising mobile sediment) will be levelled out by ambient sediment transport over time. The seabed sediment type will either remain or return to the ambient baseline condition within a similar or shorter time period as new sediment is deposited or underlying (previously undisturbed) sediments are exposed.

Decommissioning phase: changes to receptors

Impacts to seabed morphology

Overview

1.8.4.10 During the decommissioning phase of the MHPGC Project, impacts to seabed morphology could occur in response to the removal of infrastructure. However, these would be highly localised. The potential for wider morphological change to designated seabed areas arising from these activities would be very limited and no greater than that identified for the construction and O&M phases.

1.8.4.11 Details of the MDS for impacts to seabed morphology are set out in **Table 1.14**.

1.8.4.12 The embedded commitment CoT44 means a decommissioning plan will be produced as part of the MHPGC Project, ensuring decommissioning methods align with good practice, implement agreed mitigation measures and are appropriately managed (**Table 1.15**).

Receptor sensitivity

Scottish waters

- 1.8.4.13 The only identified receptor within the Zol in Scottish Waters is the seabed morphology and sediment characteristics of the Firth of Forth Banks Complex MPA (**Figure 1-1**).
- 1.8.4.14 The MHPGC Project PEIR Red Line Boundary does not directly intersect the Firth of Forth Banks Complex MPA, but it does pass very close to its boundary (within <100 m). This site contains designated moraines, shelf banks and mounds, and subtidal sands and gravels that are of high value/importance. The designated moraines, shelf banks and mounds are relict (with no ability to recover from impact). Therefore, the receptor sensitivity is considered to be **very high**.

English waters

- 1.8.4.15 The only identified receptor within the Zol in English Waters is the seabed morphology and sediment characteristics of the Farnes East MCZ although it should be noted that the MHPGC Project PEIR Red Line Boundary does not directly pass through this MCZ. The North East of Farnes Deep MCZ and HPMA is located very close (<2km) the Zol so the seabed morphology and sediment characteristics of this designated site is also included here as a receptor (**Figure 1-1**).
- 1.8.4.16 Both designated sites contain protected sedimentary features (notably subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments). These are considered to be of high value/importance. Their ability to recover from impact is both spatial and temporarily variable although in most instances are likely to have at least some ability to recover from impact. Overall, the receptor sensitivity is considered to be **high to very high**.

Magnitude of impact

- 1.8.4.17 Where some or all cable protection may be left during or following the decommissioning process, the potential for changes to local seabed morphology, as well as regionally, within designated areas of seabed within the Physical Processes Study Area is the same as described and assessed for the presence of cable protection during the O&M phase [**Paragraph 1.8.3.34 et seq.**].
- 1.8.4.18 Any impression left following the removal of infrastructure from the seabed, will be no larger than the original infrastructure and scour footprint. Depressions will become infilled and high points (comprising mobile sediment) will be levelled out by ambient sediment transport over time. The seabed sediment type will either remain or return to the ambient baseline condition within a similar or shorter time period as new sediment is deposited or underlying (previously undisturbed) sediments are exposed.
- 1.8.4.19 The MHPGC Project offshore export cable corridor does not intersect any designated sites; therefore seabed morphology and sediment characteristics will not be impacted within these areas.
- 1.8.4.20 Given the highly localised nature of any physical changes associated with cable or cable-protection infrastructure installation, the overall magnitude of impact on seabed morphology and sediment characteristics within designated seabed areas during the construction phase is assessed as **negligible**, for both Scottish and English waters.

Significance of effect

- 1.8.4.21 The receptors under consideration in this assessment are seabed morphology and sediment characteristics within the following designated areas of seabed:
- Firth of Forth Banks Complex MPA (notably Moraines shelf Banks & mounds and offshore subtidal sands and gravels);
 - Farnes East MCZ (notably moderate energy circalittoral rock, subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments);
 - North East of Farnes Deep MCZ and HPMA (notably moderate energy circalittoral rock, subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments).
- 1.8.4.22 For all of the above receptors, the sensitivity is **very high** and the magnitude of all identified impacts is assessed as **negligible**. Therefore, the impact to seabed morphology and sediment characteristics within these designated seabed areas during the construction phase, is considered to be **minor adverse**, which is not significant in EIA terms.

Secondary mitigation and residual effect

- 1.8.4.23 The significance of effect is **minor adverse** and therefore not significant in EIA terms, therefore no secondary mitigation is required.

Impacts to coastal morphology

Overview

- 1.8.4.24 The MHPGC Project offshore export cables are expected to make landfall directly south of Seaham connecting to the National Grid at Hawthorn Pit. During the decommissioning phase of the MHPGC Project, impacts to coastal morphology could occur in response to the removal of infrastructure.
- 1.8.4.25 Details of the MDS for impacts to seabed morphology are set out in **Table 1.14**.
- 1.8.4.26 The embedded commitment CoT44 means a decommissioning plan will be produced as part of the MHPGC Project, ensuring decommissioning methods align with good practice, implement agreed mitigation measures and are appropriately managed (**Table 1.15**).

Receptor sensitivity

- 1.8.4.27 The following receptors are located within the ZOI at the landfall (which is in English waters) – see Figure 1-1 for locations:
- Designated morphological features within the Durham Coast SAC (notably vegetated sea cliffs);
 - Designated morphological features within the Durham Coast SSSI (notably vegetated sea cliffs);
 - Morphological characteristics of the Durham Coast SPA (notably rocky shores, bedrock reefs, and cobble beaches, interspersed with small sandy bays);
 - Morphological characteristics of non-designated coastline (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed).

- 1.8.4.28 The coastline within the Physical Processes Study Area may be considered to be of high value within internationally designated sites (Durham Coast SAC and Durham Coast SPA) and moderate/high value elsewhere (Durham Coast SSSI or along undesignated sections of coastline). It is typically a dynamic environment that is subject to natural change under baseline conditions. However, the degree to which it may recover from disturbance and accommodate change will be highly location specific, with (for instance) geological features such as cliffs unable to recover from disturbance than dynamic sedimentary features such as a sandy beach. Taking all of the above into account, the overall sensitivity of coastal morphological features located within the ZOI at the landfall is considered to be no greater than **high**.

Magnitude of impact

- 1.8.4.29 The removal of structures (especially rock protection) that have been in place for a long time could in theory, lead to much longer-term effects on morphodynamics. This is because the coastal and seabed morphology could have evolved to a new equilibrium state including the influence and presence of that structure. However, it is not expected that the removal of any cable protection from shallow subtidal areas would lead to substantive morphological change. This is because the presence of any cable protection measures is not expected to result in widespread change to the beach at landfall in the first instance.
- 1.8.4.30 Should cables require removal at the end of its operational life, it will be removed through the same sediments and sub-strata disturbed during installation. This process could result in short term elevations in SSC and localised changes in bed level. Any change would be no greater than for the construction phase. If the cables are left in place at the end of the MHPGC Project lifespan, impacts will be the same as those described previously for the O&M phase [see **Paragraph 01.8.2.1 et seq.**].
- 1.8.4.31 On the basis of the above, the impact of removing MHPGC Project related infrastructure will be **low**. This is because whilst morphological change could theoretically occur to the seabed and beach in the immediate vicinity of the infrastructure being removed, any change would be temporary and highly localised. Away from these areas, any impact would be negligible. This holds true both for the designated vegetated sea cliffs within the Durham Coast SAC and Durham Coast SSSI (which are located within the MHPGC Project PEIR Red Line Boundary at the landfall), as well as other coastal

features (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed) in nearby areas including the Durham Coast SPA, located 2km to the north of the landfall.

Significance of effect

1.8.4.32 The receptors under consideration in this assessment are:

- Designated morphological features within the Durham Coast SAC (notably vegetated sea cliffs);
- Designated morphological features within the Durham Coast SSSI (notably vegetated sea cliffs);
- Morphological characteristics of the Durham Coast SPA (notably rocky shores, bedrock reefs, and cobble beaches, interspersed with small sandy bays);
- Morphological characteristics of non-designated coastline (notably cliffs, inter-tidal and nearshore sub-tidal areas of seabed).

1.8.4.33 For all of the above receptors, the sensitivity is no greater than **high** and the magnitude of all identified impacts is assessed as **low**. Therefore, the impact to these receptors during the construction phase, is considered to be no greater than **minor adverse**, which is not significant in EIA terms. On the basis of **Table 1.11**, the combination of high sensitivity and low magnitude can result in either minor or moderate impacts. A professional judgement of minor has been made here because any changes would be highly localised and temporary.

Secondary mitigation and residual effect

1.8.4.34 The significance of effect is **minor adverse** and therefore not significant in EIA terms, therefore no secondary mitigation is required.

1.9 Whole project assessment and Cumulative Effects Assessment methodology

1.9.1 Methodology

- 1.9.1.1 The Morven Programme comprises four distinct projects: Morven North, Morven South, MHPGC Project, and Morven Branxton Area Grid Connection Project (MBAGC Project).
- 1.9.1.2 The following assessment scenarios have been considered to identify the Likely Significant Effects (LSE) of MHPGC Project in combination with other projects on the same receptor, as follows (and summarised in **Table 1.19**):
- Whole project assessment: to identify the potential impacts associated with MHPGC Project together with Morven North and Morven South in turn, (Scenario 1: Morven North and Scenario 2: Morven South), each of which would comprise a “Whole Project”;
 - Morven Programme assessment: to identify potential impacts associated with all four components of the Morven Programme (Morven North, Morven South, MHPGC Project, and MBAGC Project) together with other relevant projects, plans and activities (Scenario 3);
 - CEA: to identify the potential impacts associated with MHPGC Project together with relevant projects, plans and activities, including other components of the Morven Programme, using a tiered approach (Scenario 4).
- 1.9.1.3 The whole project assessment and CEA have been undertaken in accordance with the methodology described in **Volume 1, Chapter 4: Approach to Environmental Impact Assessment, of the PEIR**.

Table 1.19: Scenarios to be considered in the MHPGC Project whole project assessment and Cumulative Effects Assessment for Physical Processes

Whole project assessment		Morven Programme assessment (Offshore Ornithology and Shipping and Navigation chapters only)	CEA
Scenario 1	Scenario 2	Scenario 3	Scenario 4
MHPGC Project and Morven North	MHPGC Project and Morven South	MHPGC Project, Morven North, Morven South and MBAGC Project	MHPGC Project, Tier 1 (including Morven North and Morven South), Tier 2 and Tier 3 (including MBAGC Project) projects and plans screened in

- 1.9.1.4 For the purposes of this Physical Processes chapter, Scenarios 1, 2, and 4 have been taken forward for assessment; Scenario 3 has not been included as it is not applicable to this chapter. As discussed in **Volume 1, Chapter 4: Approach to Environmental Impact Assessment, of the PEIR**, the Morven Programme assessment (Scenario 3) is only required for specific chapters to provide further context to, and to support, the conclusions of the CEA scenario (Scenario 4), in agreement with the relevant stakeholders for these topics. As Scenario 3 does not form the basis of the CEA conclusions, it is considered a supplementary assessment to the CEA scenario (Scenario 4) for these specific topics. The approach to the CEA presented in this Physical Processes chapter complies with the requirements under the EIA Regulations to assess the LSE on the environment arising from a project cumulatively with other relevant plans, projects and activities, and no supplementary assessment of the Morven Programme (Scenario 3) is required or has been requested by relevant stakeholders with regard to Physical Processes.
- 1.9.1.5 The projects and plans selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise (see **Volume 1, Annex 4.3: Cumulative Screening and Location Plan, of the PEIR**). Each project or plan 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.

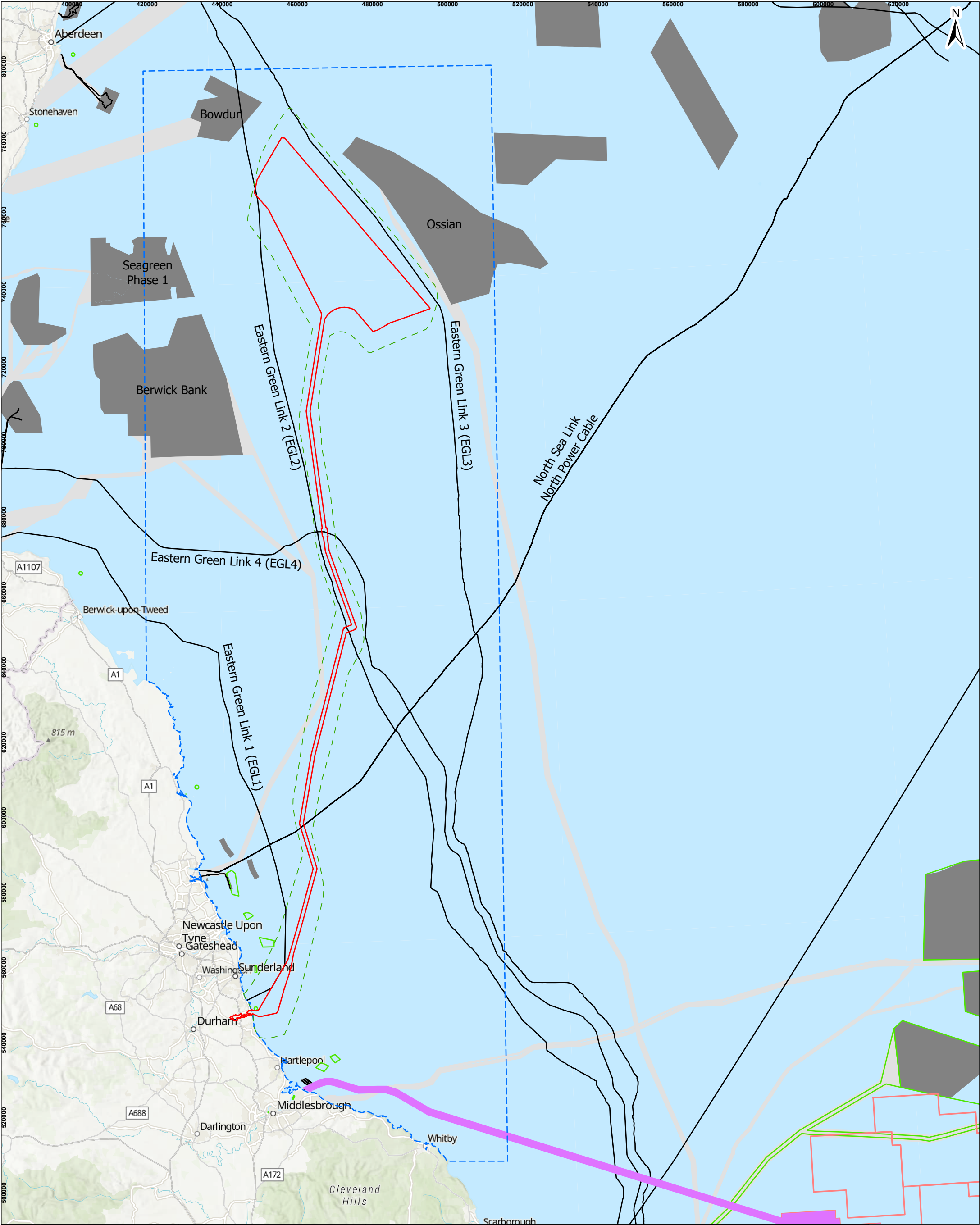
- 1.9.1.6 In undertaking the CEA for MHPGC Project, it should be noted that other projects and plans under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to a cumulative impact alongside MHPGC Project. Therefore, a tiered approach has been adopted, whereby all third-party projects and plans considered have been allocated into 'tiers' reflecting their current stage within the planning and development process. This provides a framework for placing relative weight upon the potential for each project/plan included in the CEA to ultimately be realised, based upon the project/plan's current stage of maturity and certainty in the project/plan's parameters. The tiered approach utilised within the MHPGC Project CEA employs the following tiers:
- Tier 1 assessment – Existing developments either built (operational) or under construction¹; approved developments awaiting implementation; and permitted/submitted application(s), but not yet determined, plus Morven North and Morven South;
 - Tier 2 assessment – All plans/projects assessed under Tier 1, plus plans/projects where a scoping report has been submitted and is in the public domain;
 - Tier 3 assessment – All plans/projects assessed under Tier 1 and 2, plus MBAGC Project, and plans/projects that are reasonably foreseeable (e.g. projects identified in development plans, projects in other plans and programmes, offshore renewable energy projects that have a Crown Estate Scotland Lease Option Agreement).
- 1.9.1.7 The specific projects and plans screened into the CEA for Physical Processes are outlined in **Table 1.20** and shown in **Figure 1-4**.
- 1.9.1.8 The potential impacts that have been considered in the CEA [listed in **Table 1.21**] represent a subset of those assessed for MHPGC Project alone. While all impacts scoped into the project-level assessment were considered for inclusion in the CEA, a number were screened out at the CEA stage on the basis that they are localised, temporary, and/or event-based in nature, or have been assessed as negligible or low magnitude. These impacts are not considered capable of interacting cumulatively with similar changes arising from other plans or projects in a manner that could give rise to a cumulative impact and have therefore been scoped out of the whole project and cumulative assessment. These impacts include:
- Changes to SSCs and associated deposition during O&M and decommissioning;
 - Changes to sediment transport pathways due to the presence of infrastructure during construction and decommissioning;
 - Impacts to seabed morphology during construction and decommissioning;
 - Impacts to coastal morphology during construction, O&M and decommissioning.
- 1.9.1.9 Similarly, some of the potential impacts considered within the MHPGC Project alone assessment are specific to a particular phase of development (e.g. construction, O&M or decommissioning). Where cumulative effects with other plans or projects only have potential to occur where there is spatial or temporal overlap with MHPGC Project during certain phases of development, impacts associated with a certain phase may be omitted from further consideration where no plans or projects have been identified that have the potential for cumulative effects during this period.

¹ Note that existing developments are included in Tier 1 CEA long list but are generally screened out of the CEA assessments, aside from the following exceptions:

1) Existing developments that were not present at the time of baseline characterisation, where a potential cumulative impact-receptor pathway has been identified.

2) Existing developments are screened into tier 1 assessments for specific topics where there is a large conceptual, temporal and spatial overlap between project impacts. In these instances, the potential for ongoing effects through cumulative impact-receptor pathways throughout project lifetime, across the development phases, means that they are considered within quantitative assessment for these topic CEAs (e.g., offshore ornithology assessments consider the cumulative effects of operational offshore wind farms).

-
- 1.9.1.10 In order to determine the potential for cumulative changes to SSC, bed levels and sediment type, other projects and activities located within a spring tidal excursion ellipse buffer of the MHPGC Project PEIR Red Line Boundary were scoped into the assessment (**Figure 1-4**). This includes projects that may themselves generate elevated SSC through sediment-disturbing activities.
- 1.9.1.11 In order to determine potential cumulative changes to sediment transport and seabed morphology other nearby projects with the potential to cause meaningful blockage of these parameters were scoped into the assessment. Expert judgement was used to determine the list of other projects to scope in and was based on the existing evidence base of blockage effects from other planned and operational wind farms, as well as other analogous projects.



 	Drawing Number: MHPGC-ABP-PP-0017
Project Name: MORVEN HAWTHORN PIT GRID CONNECTION PROJECT	Data Sources: © Natural England copyright. Contains Ordnance Survey data. © Crown copyright and database right 2024 © NatureScot 2024. OGL v3
Drawing Title: FIGURE 1.4: OTHER PROJECTS AND PLANS CONSIDERED WITHIN THE CEA FOR PHYSICAL PROCESSES	Geodetic Information: World Topographic Map: Esri, HERE, Garmin, FAO, NOAA, USGS World Hillshade: Esri, Intermap, NASA, NGA, USGS World Topographic Map Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community World Hillshade: Esri, USGS

LEGEND

Study Area

Carbon Capture Storage Site Agreements

Carbon Storage Licenses

Aggregate Areas (The Crown Estate)

Aggregate Site Agreements (EMODnet)

Power Subsea Cables

Open Disposal Sites

Offshore Wind Farms

OffShore Wind Farms Cable Corridors

Zone of Influence/ Spring Excursion Buffer

MHPGC Project PEIR Red Line Boundary

Figure 1-4: Other projects and plans considered within the Cumulative Effects Assessment for Physical Processes

Table 1.20: List of other projects and plans considered within the Cumulative Effects Assessment for Physical Processes

Project/plan	Status	Distance from MHPGC Project PEIR RLB (km)	Description of project/plan	Estimated dates of construction (If applicable)	Estimated dates of operation (If applicable)	Overlap with MHPGC Project
Tier 1						
Offshore wind projects and associated cables						
Morven North	Application submitted/awaiting decision	0km	Proposed for up to 96 turbines.	2033 to 2042	2038 to 2073-2077	Yes. Overlap of construction phase or operational phase with the construction or operational phases of MHPGC Project.
Morven South	Application submitted, awaiting decision	0km	Proposed for up to 95 turbines.	2033 to 2042	2038 to 2073-2077	Yes. Overlap of construction phase or operational phase with the construction or operational phases of MHPGC Project.
Cambois Connection (Berwick Bank Wind Farm Export Cable to Northumberland)	Consented	<0.5km	Export cable from Berwick Bank array to make landfall along Northumberland coast	2028 to 2031	2032 onwards	Yes. Overlap of operational phase with the construction or operational phases of MHPGC Project.
Other cables and pipelines						

Project/plan	Status	Distance from MHPGC Project PEIR RLB (km)	Description of project/plan	Estimated dates of construction (If applicable)	Estimated dates of operation (If applicable)	Overlap with MHPGC Project
North Sea Link Cable	Fully commissioned	0km	Cable connecting Blyth in Northumberland, UK, to Kvilldal in Norway	Operational	Operational	Yes. Overlap of operational phase with the construction or operational phases of MHPGC Project.
Eastern Green Link Cable 1 (EGL1)	Under construction	0.5km	Cable connecting to Torness in East Lothian and Hawthorn Pit in County Durham	2025 to 2029	2030 onwards	Yes. Overlap of operational phase with the construction or operational phases of MHPGC Project.
Eastern Green Link Cable 2 (EGL2)	Under construction	0km	Cable connecting Peterhead in Aberdeenshire and Drax in North Yorkshire	2024 to 2028	2029 onwards	Yes. Overlap of operational phase with the construction or operational phases of MHPGC Project.
Other projects						

Project/plan	Status	Distance from MHPGC Project PEIR RLB (km)	Description of project/plan	Estimated dates of construction (If applicable)	Estimated dates of operation (If applicable)	Overlap with MHPGC Project
Souter Point Outer Dredge Disposal Site (TY081)	Open	5km	Maintenance dredge disposal site	Operational	Operational	Yes. Overlap of operational phase with the construction or operational phases of MHPGC Project.
Noses Point Disposal Site (TY130)	Open	<0.5km	Maintenance dredge disposal site	Operational	Operational	Yes. Overlap of operational phase with the construction or operational phases of MHPGC Project.
Tier 2						
Other cables and pipelines						
Eastern Green Link Cable 3 (EGL3)	Scoping report submitted	2km	Cable between Aberdeenshire and Lincolnshire	2029 to 2032	2033 onwards	Yes. Overlap of operational phase with the construction or operational phases of MHPGC Project.

Project/plan	Status	Distance from MHPGC Project PEIR RLB (km)	Description of project/plan	Estimated dates of construction (If applicable)	Estimated dates of operation (If applicable)	Overlap with MHPGC Project
Eastern Green Link Cable 4 (EGL4)	Scoping report submitted	0km	Cable between Fife and Norfolk	2028 to 2032	2033 onwards	Yes. Overlap of operational phase with the construction or operational phases of MHPGC Project.
Eastern Green Link Cable 5 (EGL5)	Pre-application	3km	Cable between Peterhead and Lincolnshire	Unknown	Unknown	Yes. Construction, O&M and decommissioning phases may overlap with MHPGC Project construction, O&M and decommissioning phases.
Tier 3						
Offshore wind projects and associated cables						
MBAGC Project	Pre-application	0km	Potential transmission for Morven North or Morven South	Unknown	Unknown	Yes. Construction, O&M and decommissioning phases may overlap with MHPGC Project construction, O&M and decommissioning phases.

Project/plan	Status	Distance from MHPGC Project PEIR RLB (km)	Description of project/plan	Estimated dates of construction (If applicable)	Estimated dates of operation (If applicable)	Overlap with MHPGC Project
Ossian Offshore Wind Farm Export Cable	Scoping report submitted	4.5km	Export cable from Ossian array to make landfall along Lincolnshire coast	2031 to 2034	Unknown	Yes. Overlap of construction phase or operational phase with the construction or operational phases of MHPGC Project.

1.9.2 Maximum Design Scenario – Whole project assessment and Cumulative Effects Assessment

- 1.9.2.1 The MDSs identified in **Table 1.21** have been selected as those having the potential to result in the greatest potential effect on an identified receptor or receptor group in relation to the whole project assessment and CEA. The MDSs have been based on the MHPGC Project alone assessment MDS (**Table 1.14**), as well as publicly available information on other third-party projects and plans that have been screened into the CEA (Table 1.20). Where applicable, the Morven North and Morven South alone assessment MDSs have also informed the MDS outlined in **Table 1.21**.

Table 1.21: Maximum Design Scenario considered for the assessment of potential whole project and cumulative effects on Physical Processes

Potential Effect	Phase ²³			Maximum Design Scenario	Justification
	C	O	D		
Changes to SSCs and associated deposition	✓	x	x	Scenario 1 MDS as described for MHPGC Project [see Table 1.14], assessed cumulatively with Morven North. Scenario 2 MDS as described for MHPGC Project [see Table 1.14], assessed cumulatively with Morven South. Scenario 4 MDS as described for MHPGC Project [Table 1.14], assessed cumulatively with Tier 1 (including Morven North and Morven South), Tier 2 and Tier 3 (including MBAGC Project) projects and plans. Tier 1 • Morven North (construction phase); • Morven South (construction phase); • Cambois Connection (O&M phase); • North Sea link interconnector cable (O&M phase); • EGL1 interconnector cable (O&M phase); • EGL2 interconnector cable (O&M phase); • Souter Point Outer Dredge Disposal Site (TY081); • Noses Point Disposal Site (TY130). Tier 2 • EGL3 interconnector cables (O&M phase); • EGL4 interconnector cables (O&M phase); • EGL5 interconnector cables (construction phase). Tier 3	Scenario 1 The construction period of Morven North may overlap with the MHPGC Project construction period. Consequently, sediment-disturbing activities such as drilling foundations, MFE sandwave clearance, and dredging could occur simultaneously. Scenario 2 The construction period of Morven South may overlap with the MHPGC Project construction period. Consequently, sediment-disturbing activities such as drilling foundations, MFE sandwave clearance, and dredging could occur simultaneously. Scenario 4 The construction periods of Morven North, Morven South, Ossian Offshore Wind Farm export cable, EGL5 interconnector cable and the MBAGC Project may overlap with the MHPGC Project construction period. Consequently, sediment-

² C= Construction, O= Operations and maintenance, D= Decommissioning phases³ “✓” is used to denote the phase the potential impact can occur, “X” outlines there is no impact within this project phase

Potential Effect	Phase ²³			Maximum Design Scenario	Justification
	C	O	D		
				- MBAGC Project (construction phase); - Ossian Offshore Wind Farm export cable (construction phase).	disturbing activities such as drilling foundations, MFE sandwave clearance, and dredging could occur simultaneously. The operational periods of North Sea link interconnector cable, EGL1, EGL2, EGL3 and EGL4 interconnector cables, Cambois Connection, Souter Point Outer Dredge Disposal Site and Noses Point Dredge Disposal Site may overlap with the MHPGC Project construction period. Consequently, sediment-disturbing activities such as repairs and reburial for operational cables may overlap with construction activities such as MFE sandwave clearance, and dredging associated with the MHPGC Project.
Changes to sediment transport pathways due to the presence of infrastructure (including secondary scour assessment)	x	✓	x	Scenario 1 MDS as described for MHPGC Project [see Table 1.14], assessed cumulatively with Morven North. Scenario 2 MDS as described for MHPGC Project [see Table 1.14], assessed cumulatively with Morven South. Scenario 4 MDS as described for MHPGC Project [Table 1.14], assessed cumulatively with Tier 1 (including Morven North and Morven South), Tier 2 and Tier 3 (including MBAGC Project) projects and plans. Tier 1 - Morven North (O&M phase); - Morven South (O&M phase); - Cambois Connection (O&M phase);	Scenario 1 The operational period of Morven North overlaps with the MHPGC Project O&M period. Consequently, the presence of Wind Turbine and OSP foundations for Morven North and cable protection for the MHPGC Project could cause cumulative changes to sediment transport. Scenario 2 The operational period of Morven South overlaps with the MHPGC Project O&M period.

Potential Effect	Phase ²³			Maximum Design Scenario	Justification
	C	O	D		
				- North Sea link interconnector cable (O&M phase); - EGL1 interconnector cable (O&M phase); - EGL2 interconnector cable (O&M phase). Tier 2 - EGL3 interconnector cables (O&M phase); - EGL4 interconnector cables (O&M phase); - EGL5 interconnector cables (O&M phase). Tier 3 - MBAGC Project (O&M phase); - Ossian Offshore Wind Farm export cable (O&M phase).	Consequently, the presence of Wind Turbine and OSP foundations for Morven South and cable protection for the MHPGC Project could cause cumulative changes to sediment transport. Scenario 4 The operational periods of Morven North, Morven South, Ossian Offshore Wind Farm export cable, North Sea link interconnector cable, EGL1, EGL2, EGL3, EGL4 and EGL5 interconnector cables, Cambois Connection and the MBAGC Project overlap with the MHPGC Project O&M period. Consequently, the presence of Wind Turbine and OSP foundations for OWF projects and cable protection for cable projects could cause cumulative changes to sediment transport.
Impacts to seabed morphology	×	✓	×	Scenario 1 MDS as described for MHPGC Project [see Table 1.14], assessed cumulatively with Morven North. Scenario 2 MDS as described for MHPGC Project [see Table 1.14], assessed cumulatively with Morven South. Scenario 4 MDS as described for MHPGC Project [Table 1.14], assessed cumulatively with Tier 1 (including Morven North and Morven South), Tier 2 and Tier 3 (including MBAGC Project) projects and plans. Tier 1 Morven North (O&M phase);	Scenario 1 The operational period of Morven North overlaps with the MHPGC Project O&M period. Consequently, the presence of Wind Turbine and OSP foundations for Morven North and cable protection for the MHPGC project could cause cumulative blockage of waves, tides and changes to sediment transport. These changes could, in turn, impact seabed morphology in the designated

Potential Effect	Phase ²³			Maximum Design Scenario	Justification
	C	O	D		
				• Morven South (O&M phase); • Cambois Connection (O&M phase); • North Sea link interconnector cable (O&M phase); • EGL1 interconnector cable (O&M phase); • EGL2 interconnector cable (O&M phase). Tier 2 • EGL3 interconnector cables (O&M phase); • EGL4 interconnector cables (O&M phase); • EGL5 interconnector cables (O&M phase). Tier 3 • MBAGC Project (O&M phase); • Ossian Offshore Wind Farm export cable (O&M phase).	sites within the Physical Processes Study Area. Scenario 2 The operational period of Morven South overlaps with the MHPGC Project O&M period. Consequently, the presence of Wind Turbine and OSP foundations for Morven South and cable protection for the MHPGC project could cause cumulative blockage of waves, tides and changes to sediment transport. These changes could, in turn, impact seabed morphology in the designated sites within the Physical Processes Study Area. Scenario 4 The operational periods of Morven North, Morven South, Ossian Offshore Wind Farm export cable, North Sea link interconnector cable, EGL1, EGL2, EGL3, EGL4 and EGL5 interconnector cables, Cambois Connection and the MBAGC Project overlap with the MHPGC Project O&M period. Consequently, the presence of Wind Turbine and OSP foundations for OWF projects and cable protection for cable projects could cause cumulative blockage of waves, tides and changes to sediment transport.

Potential Effect	Phase ²³			Maximum Design Scenario	Justification
	C	O	D		
					These changes could, in turn, impact seabed morphology in the designated sites within the Physical Processes Study Area.

1.10 Whole project assessment and Cumulative Effects Assessment

1.10.1 Overview

- 1.10.1.1 A description of the significance of whole project and cumulative effects upon Physical Processes receptors arising from each identified impact is given below. The whole project assessment and CEA for MHPGC Project is presented in **Table 1.22** to **Table 1.27**.
- 1.10.1.2 As stated in **Section 1.5.1** onwards, for the most part Physical Processes (such as sediment transport) are not themselves receptors but are instead pathways. In this section the assessment of cumulative change to marine Physical Processes pathways is presented first, followed by an assessment of the significance of cumulative effects to marine processes receptors.

1.10.2 Pathway: changes to SSCs and associated deposition

- 1.10.2.1 There is potential for cumulative increases in SSC and associated deposition as a result of activities associated with MHPGC Project and other projects that are under construction, in operation or with planned decommissioning.
- 1.10.2.2 The summary of the whole project assessment for cumulative increases in SSC and associated deposition is presented in **Table 1.22** and the summary of the CEA is presented in **Table 1.23**.
- 1.10.2.3 To assess the potential for cumulative changes to SSC, seabed levels, and sediment type, other projects and activities located within a spring tidal excursion ellipse buffer of the MHPGC Project PEIR Red Line Boundary were scoped into the assessment. This included projects that may themselves generate elevated SSC through sediment-disturbing activities.
- 1.10.2.4 Sediment-disturbing activities associated with these projects include drilling of wind turbine and offshore substation platform foundations, MFE sandwave clearance, jetting, trenching and dredging during construction, and cable reburial and repair during operation. There is also potential for cumulative interaction with dredge disposal activities at the Souter Point Outer Dredge Disposal Site (TY081) and Noses Point Disposal Site (TY130).
- 1.10.2.5 For Tier 1 projects, the construction periods of the Morven North Wind Farm, Morven South Wind Farm and Cambois Connection may overlap with the construction period of the MHPGC Project. In addition, the operational phases of the North Sea Link interconnector cable and the EGL1 and EGL2 projects may also coincide with the MHPGC Project construction activities. As a result, sediment-disturbing activities (associated with remedial works and cable reburial activities) could occur concurrently.
- 1.10.2.6 For Tier 2 projects, the construction period of the EGL5 interconnector cable and operational phase of the EGL3 and EGL4 interconnector cable projects may overlap with the MHPGC Project construction activities.
- 1.10.2.7 For Tier 3 projects, the construction periods of the MBAGC Project and Ossian Offshore Wind Farm export cable may overlap with the MHPGC Project construction activities.

Table 1.22: MHPGC Project whole project assessment for changes to SSCs and associated deposition

	Whole project assessment	
	Scenario 1: MHPGC Project and Morven North	Scenario 2: MHPGC Project and Morven South
Construction phase		
Assessment of change	The whole project assessment for Scenario 1 considers the MHPGC Project together with Morven North whilst the whole project assessment for Scenario 2 considers the MHPGC Project together with Morven South. Potential changes to SSC and associated deposition are considered to be pathways of effect, rather than an impact on receptors, and as such, it is not appropriate to carry out an assessment of significance of effect. Instead, the potential for associated impacts to marine biodiversity is assessed in other chapters. The construction period of Morven North and/or Morven South may overlap with the construction period of the MHPGC Project. Morven North and Morven South overlaps with parts of the spring tidal excursion buffer of the MHPGC Project. Consequently, sediment-disturbing activities such as drilling wind turbine/OSP foundations, MFE sandwave clearance, and dredging could occur simultaneously within a spring tidal excursion distance of each other. This overlap may potentially result in cumulative changes in SSC and bed level if sediment disturbing activities are taking place both within Morven North and Morven South and the part of the MHPGC Project PEIR Red Line Boundary that overlaps with these areas. The modelled scenarios for the MHPGC Project, showing releases within the MHPGC Project PEIR Red Line Boundary that overlap with Morven North or Morven South [see Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR] show the limited spatial footprint and transient nature of the plumes created from disturbance activities in these locations. This therefore suggests any cumulative changes will be small and temporary, if indeed they occur at all.	

Table 1.23: MHPGC Project CEA for changes to SSCs and associated deposition

	Cumulative Effects Assessment
	Scenario 4: MHPGC Project, Tier 1 (including Morven North and Morven South), Tier 2, and Tier 3 (including MBAGC Project) Projects
Construction phase	
Assessment of change	The CEA for Scenario 4 considers MHPGC Project together with Morven North, Morven South and Tier 1, Tier 2 and Tier 3 projects and plans screened in. The construction period of the Morven North, Morven South and Cambois Connection (Tier 1) EGL5 interconnector cable (Tier 2) and MBAGC and Ossian Offshore Wind Farm export cable (Tier 3) projects may overlap with the construction period of the MHPGC Project. The operational periods of the interconnector cable projects North Sea link cable (Tier 1), EGL1 (Tier 1), EGL2 (Tier 1), EGL3 (Tier 2), EGL4 (Tier 2) may overlap with the construction period of the MHPGC Project. Consequently, sediment-disturbing activities such as MFE sandwave clearance, dredging and reburial works (for operational cables) may overlap with construction activities such as MFE sandwave clearance, and dredging associated with the MHPGC Project. However, the modelled scenarios also shows the limited spatial footprint and transient nature of the plumes created from disturbance activities associated with the MHPGC Project [see Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR]. This therefore suggests any cumulative changes are unlikely and will be small and of short duration if they do occur. It is also noted that cable installation vessels typically request a vessel safety zone when installing or handling cables, it is reasonable to assume that this zone could be around 500m. As set out in Volume 2, Annex 1.2: Model Design, Validation and Results, of the PEIR, at a distance of greater than 500m from the source of pre-lay trenching bed disturbance, any increases in SSC are expected to be modest (tens to low hundreds of mg/l) and fine sediment is unlikely to deposit in measurable thickness. In addition to direct communications between the vessels, this process will likely be managed via vessel management plans and official bulletins, such as Notice to Mariners. Accordingly, whilst plume interaction may still theoretically occur, the potential for much higher concentration and/or more persistent plumes than that previously described for the MHPGC Project alone is small. Cumulative increases in bed level could also theoretically occur, although the potential for this to occur is expected to be very low, given the expected separation distance of the vessels and the fact that seabed sediments are regularly reworked and transported by tidal currents in the Physical Processes Study Area.

1.10.3 Pathway: changes to sediment transport pathways due to the presence of infrastructure (including secondary scour assessment)

- 1.10.3.1 There is potential for cumulative changes to sediment transport pathways as a result of activities associated with MHPGC Project and other projects that are under construction, in operation or with planned decommissioning.
- 1.10.3.2 The summary of the whole project assessment for cumulative changes to sediment transport pathways is presented in **Table 1.24** and the summary of the CEA is presented in **Table 1.25**.
- 1.10.3.3 To determine potential cumulative changes to sediment transport pathways, other nearby projects with the potential to cause meaningful blockage of the waves, tides and sediment transport regime were scoped into the assessment. Expert judgement has been used to determine the list of other projects to scope in and was based on the existing evidence base of blockage effects from other planned and operational wind farms.
- 1.10.3.4 For Tier 1 projects, the construction periods of the Morven North, Morven South and Cambois Connection projects may overlap with the construction period of the MHPGC Project. In addition, the operational phases of the North Sea Link interconnector cable and the EGL1 and EGL2 projects may also coincide with the MHPGC Project construction activities. During the O&M phase the presence of wind turbine foundations, OSP foundations and cable protection associated with these developments could potentially interact with cable protection infrastructure from the MHPGC Project, resulting in cumulative blockage of waves, tides and sediment transport.
- 1.10.3.5 For Tier 2 projects, infrastructure associated with the Ossian Offshore Wind Farm export cable and planned interconnector routes (EGL3, EGL4, and EGL5) may similarly interact with cable protection infrastructure from the MHPGC Project. For Tier 3 projects, infrastructure associated with the MBAGC Project may interact with cable protection infrastructure from the MHPGC Project.

Table 1.24: MHPGC Project whole project assessment for changes to sediment transport pathways due to the presence of infrastructure

	Whole project assessment	
	Scenario 1: MHPGC Project and Morven North	Scenario 2: MHPGC Project and Morven South
O&M phase		
Assessment of change	For both Scottish and English waters, any blockage to waves, tides and sediment transport pathways arising from cable protection measures associated with the MHPGC Project will be extremely small and highly localised to the infrastructure, as discussed in Paragraph 1.8.3.1. Therefore, any cumulative impacts of changes to sediment transport pathways between the MHPGC Project and Morven North and/or Morven South are predicted to be immeasurable if they do occur. If cables associated with the MHPGC Project are buried, there is no potential for cable related scour to occur. If and where the cables becomes exposed due to natural seabed erosion, then a small, localised, area of additional scour may occur, as a result of currents interacting with the exposed part of the cable. The exact dimensions of the scour will depend on the height of the offshore export cables relative to the seabed but will be in proportion to the relatively small diameter of the cable (up to a few hundred mm diameter), namely that scour could be up to a few tens of centimetres deep and up to a few metres from the cable protection). Where used, cable protection is designed to prevent sediment scour. Where protection is applied, no scour will be caused by the protected cable itself. However, where surficial sediment is present, a small amount of localised secondary scour may form at the edges of the protection, the depth and extent of which will be less than for primary scour described alone. As such, for both Scottish and English waters, the effect of scour and/or secondary scour associated with the MHPGC Project infrastructure will be extremely small and highly localised. Therefore, any cumulative changes on changes to sediment transport pathways between the MHPGC Project and Morven North and Morven South are predicted to be immeasurable.	

Table 1.25: MHPGC Project CEA for changes to sediment transport pathways due to the presence of infrastructure

	Cumulative Effects Assessment
	Scenario 4: MHPGC Project, Tier 1 (including Morven North and Morven South), Tier 2, and Tier 3 (including MBAGC Project) Projects
O&M phase	
Assessment of change	The CEA for Scenario 4 considers MHPGC Project together with Morven North and Morven South and Tier 1, Tier 2 and Tier 3, including MBAGC, projects and plans screened in. For both Scottish and English waters, any blockage to waves, tides and sediment transport pathways arising from cable protection measures associated with the MHPGC Project will be extremely small and highly localised to the infrastructure, as discussed in Paragraph 1.8.3.1. Therefore, any cumulative changes to sediment transport pathways between the MHPGC Project and any Tier 1 (Morven North and Morven South, Cambois Connection, North Sea Link, EGL1 and EGL2), Tier 2 (EGL3, EGL4 and EGL5) and Tier 3 (MBAGC and Ossian Offshore Wind Farm export cable) projects in these areas will be extremely limited. If cables associated with the MHPGC Project are buried, there is no potential for cable related scour to occur. If and where the cables become exposed due to natural seabed erosion, then a small, localised, area of scour may occur. The exact dimensions of the scour will be in proportion to the relatively small diameter of the cable (up to a few hundred mm diameter), namely that scour could be up to a few tens of centimetres deep and up to a few metres from the cable protection. Where used, cable protection is designed to prevent sediment scour. Where protection is applied, no scour will be caused by the protected cable itself. However, where surficial sediment is present, a small amount of localised secondary scour may form at the edges of the protection, the depth and extent of which will be less than for primary scour described alone. As such, for both Scottish and English waters, the effect of scour and/or secondary scour associated with the MHPGC Project infrastructure will be extremely small and highly localised. No measurable cumulative change to the net rate or direction of sediment transport will occur.

1.10.4 Receptor: impacts to seabed morphology

- 1.10.4.1 There is potential for cumulative impacts to seabed morphology as a result of activities associated with MHPGC Project and other projects that are under construction, in operation or with planned decommissioning.
- 1.10.4.2 The summary of the whole project assessment for cumulative impacts to seabed morphology is presented in **Table 1.26** and the summary of the CEA is presented in **Table 1.27**.
- 1.10.4.3 To determine potential cumulative changes to seabed morphology, other nearby projects with the potential to cause meaningful blockage of the waves, tides and sediment transport regime were scoped into the assessment. Expert judgement was used to determine the list of other projects to scope in and was based on the existing evidence base of blockage effects from other planned and operational wind farms and interconnector cables.
- 1.10.4.4 For Tier 1 projects, there are several operational and planned offshore wind farms (Morven North and Morven South), export cables (Cambois Connection) as well as several operational and planned interconnector routes (North Sea Link, EGL1 and EGL2) within/close to the Physical Processes Study Area. During the O&M phase the presence of wind turbine foundations, OSP foundations and cable protection associated with these developments could potentially interact with cable protection infrastructure from the MHPGC Project, resulting in cumulative blockage of waves, tides and sediment transport. These changes could, in turn, impact seabed morphology within designated sites located in the Physical Processes Study Area.
- 1.10.4.5 For Tier 2 projects, infrastructure associated with the planned Ossian Offshore Wind Farm export cable and interconnector routes (EGL3, EGL4, and EGL5) may similarly interact with cable protection infrastructure from the MHPGC Project. For Tier 3 projects, infrastructure associated with the MBAGC Project may interact with cable protection infrastructure from the MHPGC Project.

Table 1.26: MHPGC Project whole project assessment for impacts to seabed morphology

	Whole project assessment	
	Scenario 1: MHPGC Project and Morven North	Scenario 2: MHPGC Project and Morven South
Operations and maintenance phase		
Magnitude of impact	The whole project assessment for Scenario 1 considers MHPGC Project together with Morven North whilst the whole project assessment for Scenario 2 considers the MHPGC Project together with Morven South. Scottish waters Any blockage to waves, tides and sediment transport pathways arising from cable protection measures associated with the MHPGC Project will be extremely small and highly localised to the infrastructure, as discussed in Paragraph 1.8.3.1. These changes will not extend to areas of designated seabed. Accordingly, there is no potential for cumulative change in combination with Morven North or Morven South in these areas. Overall, the cumulative impact to seabed morphology within the Firth of Forth Banks Complex MPA in Scottish waters arising from the presence of cable protection measures and/or Wind Turbine/OSP foundations would be immeasurably small. The impact is predicted to be of local spatial extent, short term duration, intermittent and medium reversibility. It is predicted that the impact will affect the receptor directly. The magnitude is therefore, considered to be negligible. English waters The region of potential cumulative impact on seabed morphology between the MHPGC Project and Morven North and/or Morven South does not extent into English waters.	
Sensitivity of receptor	Scottish waters The MHPGC Project PEIR Red Line Boundary does not directly intersect the Firth of Forth Banks Complex MPA, but it does pass very close to its boundary (within <100 m). This designated site is of high value/importance, with offshore sands and gravels (which are a PMF and support highly diverse biological communities) widespread. A number of the protected features are relict (subglacial tunnel valleys and moraines) with no ability to recover from impact. Therefore, it is considered that the receptor sensitivity is considered to be very high. English waters The region of potential cumulative impact on seabed morphology between the MHPGC Project and Morven North and Morven South does not extent into English waters, therefore no receptors in English waters have been identified for this assessment.	
Significance of effect	For Scottish and English waters, the sensitivity of the receptor is considered to be very high and the magnitude of the whole project impact is deemed to be negligible. The whole project effect of impact to seabed morphology will, therefore, be of minor adverse significance, which is not significant in EIA terms.	

	Whole project assessment	
	Scenario 1: MHPGC Project and Morven North	Scenario 2: MHPGC Project and Morven South
Further mitigation and residual significance	Because the significance of effect is minor adverse and therefore not significant in EIA terms, no secondary mitigation is required.	

Table 1.27: MHPGC Project CEA for impacts to seabed morphology

	Cumulative Effects Assessment
	Scenario 4: MHPGC Project, Tier 1 (including Morven North and Morven South), Tier 2, and Tier 3 (including MBAGC Project) Projects
Operations and maintenance phase	
Magnitude of impact	The CEA for Scenario 4 considers MHPGC Project together with Morven North, Morven South and Tier 1, Tier 2 and Tier 3, including MBAGC, projects and plans screened in. Tier 1 For both English and Scottish waters, any blockage to waves, tides and sediment transport pathways arising from cable protection measures associated with the MHPGC Project will be extremely small and highly localised to the infrastructure, as discussed in Paragraph 1.8.3.1. These changes will not extend to areas of designated seabed and will therefore not affect seabed morphology or sediment characteristics within these designated sites. Accordingly, there is no potential for cumulative change in combination with any Tier 1 projects (i.e. Morven North and Morven South, Cambois Connection, North Sea Link, EGL1 and EGL2). For both Scottish and English waters, the magnitude is therefore, considered to be negligible. Tier 2 The Tier 2 projects (i.e. EGL3, EGL4 and EGL5) are not considered to raise the category of magnitude of impact beyond what is assessed for Tier 1, summarised as negligible. Tier 3 The Tier 3 project (i.e. MBAGC and Ossian Offshore Wind Farm export cable) is not considered to raise the category of magnitude of impact beyond what is assessed for Tier 2 summarised as negligible.
Sensitivity of receptor	Scottish waters The only identified receptor within the ZOI in Scottish Waters is the seabed morphology and sediment characteristics of the Firth of Forth Banks Complex MPA (Figure 1-1). The MHPGC Project PEIR Red Line Boundary does not directly intersect the Firth of Forth Banks Complex MPA, but it does pass very close to its boundary (within <100 m). This site contains designated moraines, shelf banks and mounds, and subtidal sands and gravels that are of high value/importance. The designated moraines, shelf banks and mounds are relict (with no ability to recover from impact). Therefore, the receptor sensitivity is considered to be very high. English waters

	Cumulative Effects Assessment
	The only identified receptor within the ZOI in English Waters is the seabed morphology and sediment characteristics of the Farnes East MCZ although it should be noted that the MHPGC Project PEIR Red Line Boundary does not directly pass through this MCZ. The North East of Farnes Deep MCZ and HPMA is located very close (<2km) the ZOI so the seabed morphology and sediment characteristics of this designated site is also included here as a receptor (Figure 1-1). Both designated sites contain protected sedimentary features (notably subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments). These are considered to be of high value/importance. Their ability to recover from impact is both spatial and temporarily variable although in most instances are likely to have at least some ability to recover from impact. Overall, the receptor sensitivity is considered to be high to very high.
Significance of effect	The receptors under consideration in this assessment are seabed morphology and sediment characteristics within the following designated areas of seabed: Firth of Forth Banks Complex MPA (notably Moraines shelf Banks & mounds and offshore subtidal sands and gravels); Farnes East MCZ (notably moderate energy circalittoral rock, subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments) and North East of Farnes Deep MCZ and HPMA (notably moderate energy circalittoral rock, subtidal coarse sediment, subtidal sand, subtidal mud and subtidal mixed sediments). For all of the above receptors, the sensitivity is high to very high and the magnitude of identified impacts is assessed as negligible. Therefore, the impact to seabed morphology and sediment characteristics within these designated seabed areas is considered to be minor adverse, which is not significant in EIA terms.
Further mitigation and residual significance	Because the significance of effect is minor adverse and therefore not significant in EIA terms, no secondary mitigation is required.

1.11 Transboundary effects

- 1.11.1.1 A screening of transboundary impacts has been carried out and any potential for significant transboundary effects with regard to Physical Processes from the construction, O&M and decommissioning phases of the MHPGC Project upon interests of other states has been assessed as part of the PEIR. The potential transboundary impacts are screened within **Volume 1, Annex 4.3: Transboundary Screening, of the PEIR**.
- 1.11.1.2 As agreed during the Scoping phase, no transboundary effects with regards to Physical Processes are expected to occur. Transboundary effects have therefore been scoped out of further assessment [see **Section 1.3** and **Table 1.5**.]

1.12 Inter-related effects

- 1.12.1.1 Inter-related effects are the combined impact of multiple aspects of the MHPGC Project on a single receptor. These are as follows:
- **Project lifetime effects:** Assessment of the scope for effects that occur throughout more than one phase of the MHPGC Project (construction, O&M and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three phases.
 - **Receptor led effects:** Assessment of the scope for all effects (including inter-relationships between environmental topics) to interact, spatially and temporally, to create inter-related effects on a receptor.
- 1.12.1.2 For Physical Processes, the following potential impacts have been considered within the inter-related assessment:
- Increased SSCs and associated deposition;
 - Impacts to sediment transport pathways due to the presence of infrastructure;
 - Impacts to seabed morphology;
 - Impacts to coastal morphology.
- 1.12.1.3 **Table 1.29** lists the inter-related effects (project lifetime effects) that are predicted to arise during the construction, O&M phase, and decommissioning of the MHPGC Project and also the inter-related effects (receptor led effects) that are predicted to arise for Physical Processes receptors.
- 1.12.1.4 Inter-related effects are assessed within **Volume 4, Chapter 5: Inter-related Effects, of the PEIR** with no likely significant inter-related effects anticipated.

Table 1.28: Summary of likely significant inter-related effects on the environment from individual effects occurring across the construction, O&M and decommissioning phases of the MHPGC Project (project lifetime effects) and from multiple effects interacting across all phases (receptor led effects)

Description of impact	Phase			Likely significant inter-related effect	Significance
	C	O&M	D		
MHPGC Project lifetime effects					
Changes to SSCs and associated deposition	✓	✓	✓	Increased SSC caused by seabed disturbance will primarily occur during the construction and decommissioning phases of the MHPGC Project. The spatial extent of meaningful seabed disturbance and associated increases in SSC and deposition is expected to be localised, mainly within the near-field and intermediate impact zones of the activity (up to 500m). Combined changes over the lifetime of the MHPGC Project are therefore not	This change relates to a pathway, rather than an impact on a receptor. Accordingly, no statement is made with regards to the likelihood of

Description of impact	Phase			Likely significant inter-related effect	Significance
	C	O&M	D		
				expected to result in measurably greater change than for those assessed individually.	significant inter-related effects.
Changes to sediment transport pathways	✓	✓	✓	Changes to the sediment regime will be greatest when all MHPGC Project infrastructure is in place. Although some change may occur during the construction and decommissioning phase (when the MHPGC Project is partially built/decommissioned), the combined changes over the MHPGC Project lifetime are not expected to be measurably greater than those assessed separately.	This change relates to a pathway, rather than an impact on a receptor. Accordingly, no statement is made with regards to the likelihood of significant inter-related effects
Impacts to seabed morphology	✓	✓	✓	No likely significant inter-related effects are expected. In theory, the seabed morphology within designated sites could be subject to project-lifetime inter-related effects, with direct seabed disturbance occurring in the construction and decommissioning phase and indirect disturbance occurring during the O&M phase due to HD, wave and sediment transport blockage related effects. However, in all cases the extent of change is expected to be negligible and even if combined over the MHPGC Project lifetime, the magnitude of change (and therefore overall significance of effect) would be no greater than if assessed in isolation.	The effects on Physical Processes across the MHPGC Project phases are not anticipated to interact in such a way as to result in inter-related effects of greater significance than the assessments presented for each individual phase and are therefore of minor adverse significance, which is not significant in EIA terms.
Impacts to coastal morphology	✓	✓	✓	No likely significant inter-related effects are expected. In theory, the morphology of designated areas of the coast could be subject to project-lifetime inter-related effects, with direct seabed disturbance occurring in the construction and decommissioning phase and indirect disturbance occurring during the O&M phase due to HD, wave and sediment transport blockage related effects. However, in all cases the extent of change is expected to be negligible and even if combined over the MHPGC Project lifetime, the magnitude of change (and therefore overall significance of effect) would be no greater than if assessed in isolation.	
Receptor led effects					
No receptor-led impacts have been identified. This is because the different Physical Processes studied are already inter-related; for instance, morphological change is closely linked to change in sediment transport and therefore these linked processes have already been considered within the assessment. In turn, this information on changes to Physical Processes has been used to inform other EIA Report topics. Assessments have therefore been undertaken separately within these individual topic chapters and are not reported here as additional inter-relationships.					

C= Construction, O&M= Operations and maintenance, D= Decommissioning phases

"✓" is used to denote the phase the potential impact can occur, "X" outlines there is no impact

1.13 Summary

1.13.1 Summary of effects

- 1.13.1.1 This chapter has assessed the potential impacts on Physical Processes from the construction, O&M and decommissioning phases of the MHPGC Project. **Table 1.29** presents a summary of impacts and confirms the residual effects.

1.13.2 Summary of secondary mitigation and monitoring

- 1.13.2.1 **Table 1.29** presents a summary of the secondary mitigation and monitoring proposed. At this stage, no additional mitigation is proposed for impacts to Physical Processes as no significant residual effects have been identified.
- 1.13.2.2 Site specific monitoring is also not proposed because the assessment concluded that MHPGC Project would not give rise to significant effects for Physical Processes, either alone or when considered cumulatively with other plans, projects or activities. The Applicant will, however, continue to liaise with MD-LOT, NatureScot, MMO, Natural England, JNCC and other key stakeholders to help identify opportunities for proportionate, evidence led regional or strategic monitoring that can improve understanding of the environmental implications of transmission asset, particularly where recognised evidence gaps exist.

Table 1.29: Summary of potential impacts and residual effects

Impact	Jurisdictional relevance	Sensitivity of receptor	Magnitude of impact	Significance of impact	Secondary mitigation and monitoring	Residual effect
Construction phase						
Changes to SSCs and associated deposition	Scotland	N/A	N/A	N/A	N/A	N/A
	England	Potential pathway of effect for other topics	Potential pathway of effect for other topics	Potential pathway of effect for other topics	N/A	Potential pathway of effect for other topics
Changes to sediment transport pathways due to the presence of infrastructure (including secondary scour assessment)	Scotland	N/A	N/A	N/A	N/A	N/A
	England	Potential pathway of effect for other topics	Potential pathway of effect for other topics	Potential pathway of effect for other topics	N/A	Potential pathway of effect for other topics
Impact to seabed morphology	Scotland	Very high	Negligible	Minor adverse	N/A	Minor adverse
	England	High to very high	Negligible	Minor adverse	N/A	Minor adverse
Impact to coastal morphology	England	High	Negligible/low	Minor adverse	N/A	Minor adverse
O&M phase						
Changes to SSCs and associated deposition	Scotland	N/A	N/A	N/A	N/A	N/A
	England	Potential pathway of effect for other topics	Potential pathway of effect for other topics	Potential pathway of effect for other topics	N/A	Potential pathway of effect for other topics
Changes to sediment transport pathways due to the presence of infrastructure (including	Scotland	N/A	N/A	N/A	N/A	N/A
	England	Potential pathway of effect for other topics	Potential pathway of effect for other topics	Potential pathway of effect for other topics	N/A	Potential pathway of effect for other topics

Impact	Jurisdictional relevance	Sensitivity of receptor	Magnitude of impact	Significance of impact	Secondary mitigation and monitoring	Residual effect
secondary scour assessment)						
Impact to seabed morphology	Scotland	Very high	Negligible	Minor adverse	N/A	Minor adverse
	England	High to very high	Negligible	Minor adverse	N/A	Minor adverse
Impact to coastal morphology	England	High	Low	Minor adverse	N/A	Minor adverse
Decommissioning phase						
Changes to SSCs and associated deposition	Scotland	N/A	N/A	N/A	N/A	N/A
	England	Potential pathway of effect for other topics	Potential pathway of effect for other topics	Potential pathway of effect for other topics	N/A	Potential pathway of effect for other topics
Changes to sediment transport pathways due to the presence of infrastructure (including secondary scour assessment)	Scotland	N/A	N/A	N/A	N/A	N/A
	England	Potential pathway of effect for other topics	Potential pathway of effect for other topics	Potential pathway of effect for other topics	N/A	Potential pathway of effect for other topics
Impact to seabed morphology	Scotland	Very high	Negligible	Minor adverse	N/A	Minor adverse
	England	High to very high	Negligible	Minor adverse	N/A	Minor adverse
Impact to coastal morphology	England	High	Low	Minor adverse	N/A	Minor adverse

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