MORGAN OFFSHORE WIND PROJECT GENERATION ASSETS

Preliminary Environmental Information Report

Volume 2, chapter 6: Physical processes

Image of an offshore wind farm

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Prepared by:	Prepared for:
RPS	**Morgan Offshore Wind Ltd.**

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Glossary

Term	Meaning
Bathymetry	The measurement of depth of water in oceans, seas, or lakes.
Ebb tide	The tidal phase during which the water level is falling.
Erosion	Depletion of sediment in the intertidal region.
Fetch	Length in the wind direction of the marine area where water waves are generated by wind.
Flood tide	The tidal phase during which the water level is rising.
High Water Mark	The level reached by the sea at high tide.
Highest Astronomical Tide	The highest tidal height predicted to occur under average meteorological conditions and any combination of astronomical conditions.
Hydrodynamic boundary conditions	The conditions used in a model boundary which can included surface elevation and velocity which will affect the rest of the model domain. The boundary condition can vary with time and along the boundary.
Intertidal region	An area of a shoreline that is covered at high tide and uncovered at low tide.
Lee	Shelter from wind or weather given by an object.
Littoral currents	Flow derived from tide and wave climate.
Low Water Mark	The level reached by the sea at low tide.
Lowest Astronomical Tide	The lowest tidal height predicted to occur under average meteorological conditions and any combination of astronomical conditions.
Mean High Water	The highest water level reached during and average tide.
Mean High Water Spring	The most inshore level location reached by the sea at high tide during mean high water spring tide. This is defined as the average 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 Spring	The most offshore location reached by the sea at low tide during low water spring tide. This is defined as the average throughout the year, of two successive low waters, during a 24-hour period in each month when the range of the tide is at its greatest.
Mean Sea Level	The average tidal height over a long period of time.
Metocean	Refers to the syllabic abbreviation of meteorology and (physical) oceanography.
Neap tide	Tide that occurs when the sun and moon are at right angles to each other and the gravitational pull of the sun partially cancels out the pull of the moon on the ocean.
Refraction	The change in direction of a wave passing from one medium to another caused by its change in speed.
Residual current	The net flow over the course of the tidal cycle. This is effectively the driving force of the sediment transport.
Sandwave	A lower regime sedimentary structure that forms across from tidal currents.
Scour protection	Measures to prevent loss of seabed sediment around any structure placed in or on the seabed (e.g. by use of protective aprons, mattresses, rock and gravel placement)
Sedimentation	The process of settling or being deposited as a sediment.
Significant wave height	Mean wave height (trough to crest) of the highest third of the waves.
Slack tide	Tidal phase at which the current turns from flood to ebb (high-water slack tide) or from ebb to flood (low-water slack tide).
Spectral waves	Describes the distribution of wave energy with frequency (1/period) and direction.
Spring tide	Tide that occurs when the sun and moon are directly in line with the Earth and their gravitational pulls on the ocean reinforce each other.
Suspended Particulate Matter	Particles that are suspended in the water column.
Turbidity	The quality of being cloudy, opaque, or thick with suspended matter.
Wave height	The distance from trough to crest of a wave.
Wave period	The time it takes for two successive crests (one wavelength) to pass a specified point.

Acronyms

Acronym	Description
2D UHRS	2D Ultra High Resolution Seismic
BODC	British Oceanographic Data Centre
CEA	Cumulative Effect Assessment
Cefas	Centre for Environment Fisheries and Aquaculture Science
CIRIA	Construction Industry Research and Information Association
COWRIE	Collaborative Offshore Wind Energy Research into the Environment
CPT	Cone Penetration Test
DSV	Digital Sound Velocity
ECMWF	European Centre for Medium-range Weather Forecast
EIA	Environmental Impact Assessment
EMODnet	European Marine Observation and Data Network
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
MBES	Multi-Beam Echo Sounder
MCZ	Marine Conservation Zone
MEDIN	Marine Environmental Data Information Network
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MPA	Marine Protected Area
NIS	Natura Impact Statement

Acronym	Description
NRW	Natural Resources Wales
OSP	Offshore Substation Platforms
SBP	Sub-Bottom Profiler
SPM	Suspended Particulate Matter
SSC	Suspended sediment concentrations
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
TWT	The Wildlife Trusts
UK	United Kingdom
UKHO	United Kingdom Hydrographic Office
ZOI	Zone of Influence

Units

Unit	Description
º	Degrees (angle from true north)
%	Percentage
cm/s	Centimetres per second (speed)
km	Kilometres (distance)
km2	Square kilometres (distance)
m	Metres (distance)
m2	Square metres (area)
m3/h	Cubic metres per hour (discharge rate)
mg/l	Milligrams per litre (concentration)
mm	Millimetres (distance)
m/hour	Metres per hour (rate)
m/s	Metres per second (speed)
m3/s/m	Cubic metres per second per metre (total load)

6 Physical processes

6.1 Introduction

6.1.1 Overview

6.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the assessment of the potential impact of the Morgan Offshore Wind Project Generation Assets (hereafter referred to as the Morgan Generation Assets) on physical processes. Specifically, this chapter considers the potential impact of the Morgan Generation Assets seaward of Mean High Water Springs (MHWS) during the construction, operations and maintenance, and decommissioning phases.

6.1.1.2 The assessment presented also informs and is informed by the following technical chapters:

- Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR
- Volume 2, chapter 8: Fish and shellfish ecology of the PEIR
- Volume 2, chapter 9: Marine mammals of the PEIR
- Volume 2, chapter 13: Marine archaeology of the PEIR
- Volume 2, chapter 14: Other sea users of the PEIR.

6.1.1.3 This chapter also draws upon information contained within volume 4, annex 6.1: Physical processes technical report of the PEIR. Previous experience in offshore wind developments has indicated that changes in physical processes are generally limited in magnitude and scale. An exhaustive detailed study was not undertaken from the outset rather reference made to published characteristics and noted sensitivities. For the purposes of identifying significant impacts a comparative study was undertaken - assessing potential changes in physical process drivers (i.e. tidal currents and waves using numerical modelling techniques). These changes were not found to be significant therefore further detailed studies were not required.

6.1.2 Purpose of chapter

6.1.2.1 The primary purpose of the PEIR is outlined in volume 1, chapter 1: Introduction of the PEIR. In summary, the primary purpose of an Environmental Statement is to support the Development Consent Order (DCO) application for Morgan Generation Assets under the Planning Act 2008 (the 2008 Act). The PEIR constitutes the Preliminary Environmental Information for Morgan Generation Assets and sets out the findings of the EIA to date to support the pre-application consultation activities required under the 2008 Act. The EIA will be finalised following completion of pre-application consultation and the Environmental Statement will accompany the application to the Secretary of State for Development Consent.

6.1.2.2 The PEIR forms the basis for statutory consultation which will last for 47 days and conclude on 4 June 2023 as outlined in volume 1, chapter 2: Policy and legislation of the PEIR. At this point, comments received on the PEIR will be reviewed and incorporated (where appropriate) into the Environmental Statement, which will be submitted in support of the application for Development Consent scheduled for quarter one of 2024.

6.1.2.3 In particular, this PEIR chapter:

- Presents the existing environmental baseline established from desk studies and site-specific surveys
- Identifies any assumptions and limitations encountered in compiling the environmental information
- Presents the potential environmental effects on physical processes arising from the Morgan Generation Assets, based on the information gathered and the analysis and assessments undertaken
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental effects of the Morgan Generation Assets on physical processes.

6.1.3 Study area

6.1.3.1 The Morgan physical processes study area is illustrated in Figure 6.1 and encompasses the:

- Morgan Array Area (i.e. the area within which the wind turbines, foundations, inter-array cables, interconnector cables and Offshore Substation Platforms (OSPs) forming part of the Morgan Generation Assets will be located)
- Seabed that may be influenced by changes to physical processes due to the Morgan Generation Assets defined as one spring tidal excursion which is the distance suspended sediment is transported prior to being carried back on the returning tide.

6.1.3.2 It is however noted that the Morgan physical processes study area forms the focus for the assessment and that the numerical modelling study undertaken to support the assessment is not limited to this region, as detailed in volume 4, annex 6.1: Physical processes technical report of the PEIR. The physical processes modelling study therefore also identifies any potential impacts beyond the Morgan physical processes study area. The Morgan physical processes study area for the Cumulative Effects Assessment (CEA) presented in section 6.9 is defined as two spring tidal excursions which represents where study areas for adjacent projects and developments, defined in a similar way, may intersect.

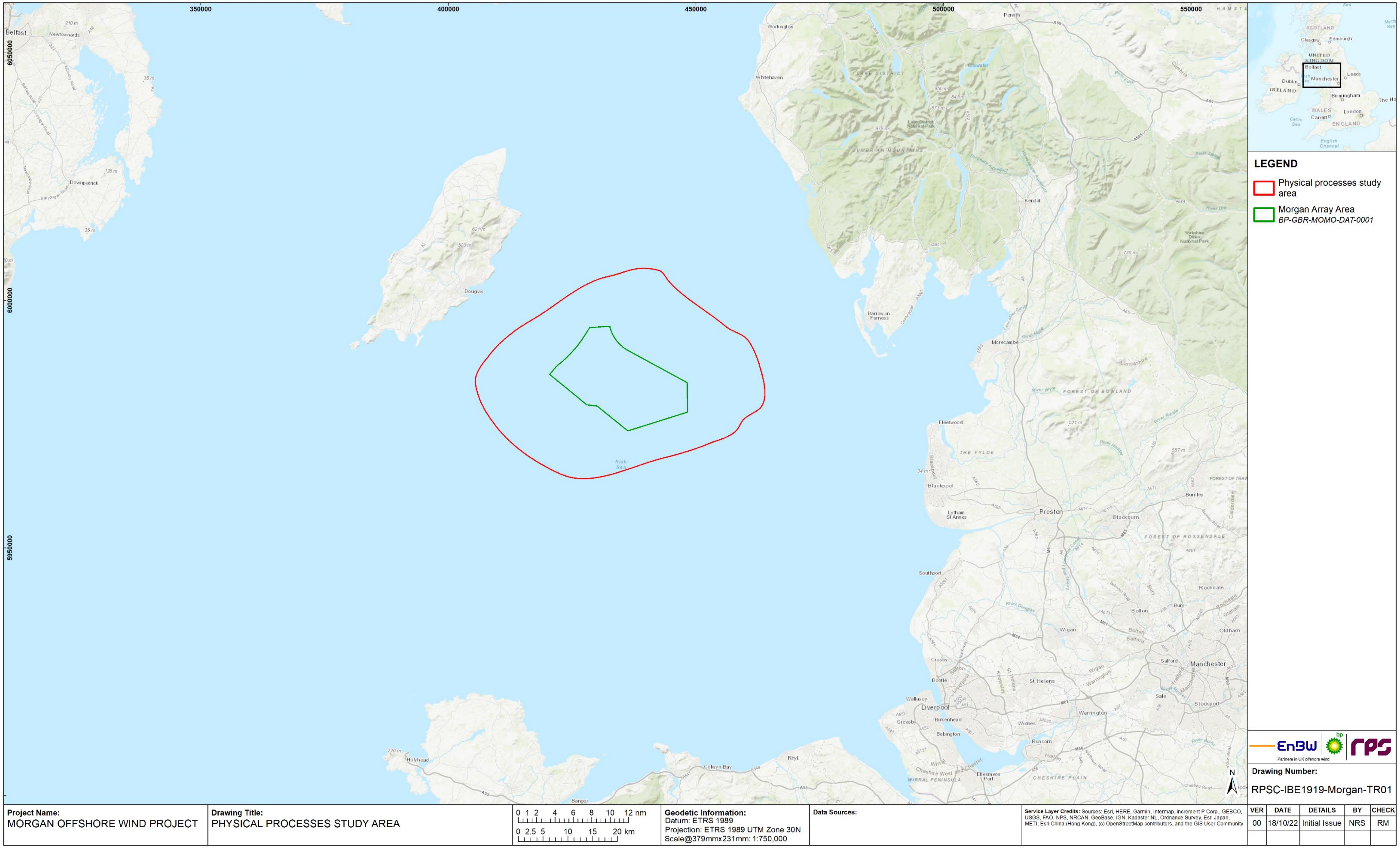


Figure 6.1: Morgan Generation Assets physical processes study area.

6.2 Policy context

6.2.1.0 The policy context for the Morgan Generation Assets is set out in volume 1, chapter 2: Policy and legislation of the PEIR. A summary of the policy provisions relevant to physical processes are provided in Table 6.1, with other relevant policy on decision making is set out in Table 6.2.

6.2.1 National Policy Statements

6.2.1.1 Planning policy on renewable energy infrastructure is presented in volume 1, chapter 2: Policy and legislation of the PEIR. Planning policy on offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to physical processes, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; DECC, 2011a) and the NPS for Renewable Energy Infrastructure (EN-3, DECC, 2011b).

6.2.1.2 NPS EN-1 and NPS EN-3 include guidance on what matters are to be considered in the assessment. These are summarised in Table 6.1 below. NPS EN-1 and NPS EN-3 also highlight a number of factors relating to the determination of an application and in relation to mitigation. These are summarised in Table 6.2 below.

6.2.1.3 Table 6.1 refers to the current NPSs, specifically NPS EN-1 (DECC, 2011a) and NPS EN-3 (DECC, 2011b). If the NPSs are updated prior to the application for Development Consent, the revised NPSs will be fully considered in relation to physical processes within the Environmental Statement.

Table 6.1: Summary of the NPS EN-1 and EN-3 provisions relevant to physical processes.

NPS EN-1 and EN-3 provisions	How and where considered in the PEIR
NPS EN-1	
Applicants should undertake coastal geomorphological and sediment transfer modelling to predict and understand impacts and help identify relevant mitigating or compensatory measures. (EN-1, paragraph 5.5.6).	Assessment of sediment dynamics undertaken using the hydrodynamic and spectral wave modelling, together with an understanding of the sediment regime. Refer to volume 4, annex 6.1: Physical processes technical report of the PEIR.
The ES should include an assessment of the effects on the coast. 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 effects of the proposed project on maintaining coastal recreation sites and features; and • The effects of the proposed project on marine ecology, biodiversity and protected sites. (EN-1, paragraph 5.5.7)	Baseline and post-construction physical processes were compared alongside extreme storm conditions to consider the wave climate detailed in volume 4, annex 6.1: Physical processes technical report of the PEIR, whilst climate change is discussed in section 6.4.15. A CEA has been undertaken and is outlined in section 6.10.
For any projects involving dredging or disposal into the sea, the applicant should consult the Marine Management Organisation (MMO) at an early stage. Where the project has the potential to have a major impact in this respect, this is covered in the technology-specific NPSs. (EN-1, paragraph 5.5.8)	The procedures are considered within volume 1, chapter 3: Project description of the PEIR. Best practice techniques will be employed to ensure sediment mobilisation is minimised. Assessment of sediment dynamics undertaken using the hydrodynamic and spectral wave modelling, together with an understanding of the sediment regime. Refer to volume 4, annex 6.1: Physical processes technical report of the PEIR. Predicted changes to the tidal current, wave climate, littoral currents and sediment transport are quantified in volume 4, annex 6.1: Physical processes technical report of the PEIR.
The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of Marine Conservation Zones, candidate marine Special Areas of Conservation (SACs), coastal SACs and candidate coastal SACs, coastal Special Protection Areas (SPAs) and potential coastal SPAs, Ramsar sites, Sites of Community Importance (SCIs) and potential SCIs and Sites of Special Scientific Interest. (EN-1, paragraph 5.5.9)	Designated sites and features of importance within and surrounding the physical processes study area have been identified in section 6.4.14. Further information is also provided in the Information to support the appropriate assessment. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
NPS EN-3	
Where necessary, 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; • environmental appraisal of inter-array and cable routes and installation methods; • habitat disturbance from construction vessels' extendible legs and anchors; • increased suspended sediment loads during construction; and • predicted rates at which the subtidal zone might recover from temporary effects. (EN-3, paragraph 2.6.113)	Assessment of the significance of effects during installation of foundations and site preparation (construction phase) on physical processes receptors is detailed in section 6.8. The procedures are considered within volume 1, chapter 3: Project description of the PEIR. Best practice techniques will be employed to ensure sediment mobilisation is minimised. Assessment of sediment dynamics undertaken using the hydrodynamic and spectral wave modelling, together with an understanding of the sediment regime. Refer to volume 4, annex 6.1: Physical processes technical report of the PEIR.
If it is proposed to install offshore cables to a depth of at least 1.5m below the seabed, the applicant should not have to assess the effect of the cables on subtidal habitat during the operations phase of the offshore wind farm. (EN-3, paragraph 2.6.114)	The installation of cable is considered within volume 1, chapter 3: Project description of the PEIR.
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 effect 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	Baseline and post-construction physical processes were compared under the maximum design scenario (MDS) as described in Table 6.11 and a CEA has been undertaken and is outlined in section 6.10 which includes operational offshore wind farm within the physical processes CEA study area with ongoing impacts such as those related to maintenance activities. In accordance with The Planning Inspectorate (PINS) advice (PINS, 2019), where other projects are expected to be completed before construction

NPS EN-1 and EN-3 provisions	How and where considered in the PEIR
accordance with the appropriate policy for offshore wind farm EIAs. (EN-3, paragraph 2.6.179) Marine plans (paragraph 2.22.5 of this NPS and Section 4.4 of EN-1) will help applicants consider which activities may be most affected by their proposal and thus where to target their assessment. (EN-3, paragraph 2.34.4)	of the proposed NSIP and the effects of those projects are fully determined, effects arising from them should be considered as part of the baseline and may be considered as part of both the construction and operations assessment. Legislative requirements for offshore wind farms are considered within volume 1, chapter 2: Policy and legislation of the PEIR.
Applicants should engage with interested parties in the potentially affected offshore sectors early in the development phase of the proposed offshore wind farm, with an aim to resolve as many issues as possible prior to the submission of an application to the [Secretary of State]. (EN-3, paragraph 2.6.180). Such stakeholder engagement should continue throughout the life of the development including construction, operations, and decommissioning phases where necessary. As many of these offshore industries are regulated by Government, the relevant Secretary of State should also be a consultee where necessary. Such engagement should be taken to ensure that solutions are sought that allow offshore wind farms and other uses of the sea to successfully co-exist. (EN-3, paragraph 2.6.181)	Key issues have been raised and discussed during consultation activities and engagement specific to physical processes. A summary of the key issues and responses have been provided in Table 6.4 below. Supporting documentation in the form of a consultation report will include a response to each comment, included at application to accompany the ES (not included for PIER application).
Assessment should be undertaken for all stages of the lifespan of the proposed wind farm in accordance with the appropriate policy for offshore wind farm EIAs. (EN-3, paragraph 2.6.190) The Environment Agency (EA) regulates emissions to land, air and water out to 3nm. Where any element of the wind farm or any associated development included in the application to the [Secretary of State] is located within 3nm of the coast, the EA should be consulted at the pre-application stage on the assessment methodology for impacts on the physical environment. (EN-3, paragraph 2.6.191) Beyond 3nm, the MMO is the regulator. The applicant should consult the MMO and the Centre for Environment, Fisheries & Aquaculture Science (CEFAS) on the assessment methodology for impacts on the physical environment at the pre-application stage. (EN-3, paragraph 2.6.192) Geotechnical investigations should form part of the assessment as this will enable design of appropriate construction techniques to minimise any adverse effects. (EN-3, paragraph 2.6.193) The assessment should include predictions of the physical effect that will result from the construction and operations of the required infrastructure and include effects such as the scouring that may result from the proposed development. (EN-3, paragraph 2.6.194)	Hydrodynamic modelling undertaken for physical processes assessment (refer to volume 4, annex 6.1: Physical processes technical report of the PEIR.) Scour protection is included within the assessment as defined by the project description outlined in volume 1, chapter 3: Project description of the PEIR. Legislative requirements for offshore wind farms are considered within volume 1, chapter 2: Policy and legislation of the PEIR. Key issues have been raised and discussed during consultation activities and engagement specific to physical processes. A summary of the key issues and responses have been provided in Table 6.4 below. Supporting documentation in the form of a consultation report, included at application to accompany the ES (not included for PIER application). Geophysical surveys and other site specific surveying has been carried out to support modelling and assessment, as described in Table 6.6.

Table 6.2: Summary of NPS EN-1 and NPS EN-3 policy on decision making relevant to physical processes.

NPS EN-1 and EN-3 policy	How and where considered in the PEIR
NPS EN-1	
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. (EN-1, paragraph 5.5.10)	Details of the project design criteria are detailed in volume 1, chapter 3: Project description of the PEIR, whilst climate change is discussed in section 6.4.15.
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. (EN-1, paragraph 5.5.11)	Assessment of sediment dynamics undertaken using the hydrodynamic and spectral wave modelling, together with an understanding of the sediment regime. Refer to volume 4, annex 6.1: Physical processes technical report of the PEIR. Predicted changes to the tidal current, wave climate, littoral currents and sediment transport are assessed in volume 4, annex 6.1: Physical processes technical report of the PEIR. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
In addition to this NPS the [Secretary of State] must have regard to the appropriate marine policy documents, as provided for in the Marine and Coastal Access Act 2009. The [Secretary of State] may also have regard to any relevant SMPs. (EN-1, paragraph 5.5.15)	Legislative requirements for offshore wind farms are considered within volume 1, chapter 2: Policy and legislation of the PEIR.
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. (EN-1, paragraph 5.5.13)	The project design detailed in volume 1, chapter 3: Project description takes consideration of the impacts of physical processes on the infrastructure whilst this chapter considers the effect of the Morgan Generation Assets on physical processes.
NPS EN-3	
The conservation status of subtidal habitat is of relevance to the [Secretary of State]. (EN-3, paragraph 2.6.115)	Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8. Designated sites and features of importance within and surrounding the physical processes study area have been identified in section 6.4.14.

NPS EN-1 and EN-3 policy	How and where considered in the PEIR
The [Secretary of State] should be satisfied that activities have been designed taking into account sensitive subtidal environmental aspects. (EN-3, paragraph 2.6.116)	The procedures are considered within volume 1, chapter 3: Project description of the PEIR. Best practice techniques will be employed to ensure sediment mobilisation is minimised.
Where adverse effects are predicted, in coming to a judgement, the [Secretary of State] should consider the extent to which the effects are temporary or reversible. (EN-3, paragraph 2.6.117)	Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
As set out above, the direct effects on the physical environment can have indirect effects on a number of other receptors. Where indirect effects are predicted, the [Secretary of State] should refer to relevant sections of this NPS and EN-1. (EN-3, paragraph 2.6.195)	Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
The [Secretary of State] should be satisfied that the methods of construction, including use of materials, are such as to reasonably minimise the potential for impact on the physical environment. This could involve, for instance, the exclusion of certain foundations on the basis of their impacts or minimising quantities of rock that are used to protect cables whilst taking into account other relevant considerations such as safety. (EN-3, paragraph 2.6.196)	The procedures are considered within volume 1, chapter 3: Project description of the PEIR. Best practice techniques will be employed to ensure sediment mobilisation is minimised.

6.2.2 North West Inshore and North West Offshore Coast Marine Plans

6.2.2.1 The assessment of potential changes to physical processes has also been made with consideration to the specific policies set out in the North West Inshore and North West Offshore Coast Marine Plans (MMO, 2021). Key provisions are set out in Table 6.3 along with details as to how these have been addressed within the assessment.

Table 6.3: North West Inshore and North West Offshore Marine Plan policies of relevance to physical processes.

Policy	Key provisions	How and where considered in the PEIR
NW-CAB-1	Preference should be given to proposals for cable installation where the method of protection is burial. Where burial is not achievable, decisions should take account of protection measures for the cable that may be proposed by the applicant. Where burial or protection measures are not appropriate, proposals should state the case for proceeding without those measures.	Details of the project design criteria are detailed in volume 1 chapter 3: Project description of the PEIR.
NW-MPA-1	Proposals that may have adverse impacts on the objectives of marine protected areas must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts, with due regard given to statutory advice on an ecologically coherent network.	Designated sites and features of importance within the physical processes study area have been identified in section 6.4.14. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
NW-MPA-4	Proposals that may have significant adverse impacts on designated geodiversity must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts so they are no longer significant.	Designated sites and sites of interest due to geological importance within the physical processes study area have been identified in section 6.4.14. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
NW-BIO-1	Proposals that may have significant adverse impacts on the distribution of priority habitats and priority species must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse impacts so they are no longer significant d) compensate for significant adverse impacts that cannot be mitigated.	Sites identified as habitat directive Annex I habitats within the physical processes study area have been identified in section 6.4.14. Potential impacts have also been identified and the significance of the effects on physical processes receptors has been assessed in section 6.8.
NW-CE-1	Proposals which may have adverse cumulative effects with other existing, authorised, or reasonably foreseeable proposals must demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate - adverse cumulative and/or in-combination effects so they are no longer significant.	A CEA has been undertaken and is outlined in section 6.10. Potential impacts from the CEA have also been identified and the significance of the effects on physical processes receptors has been assessed in 6.10.

6.3 Consultation

6.3.1.0 A summary of the key issues raised during consultation activities undertaken to date specific to physical processes is presented in Table 6.4 below, together with how these issues have been considered in the production of this PEIR chapter.

6.3.1 Evidence plan

6.3.1.1 The purpose of the Evidence Plan process is to agree the information the Morgan Generation Assets needs to supply to the Secretary of State, as part of a DCO application for Morgan Generation Assets, with MMO, Natural England, Joint Nature Conservation Committee (JNCC), CEFAS, The Wildlife Trusts (TWT) and the Environment Agency. The Evidence Plan seeks to ensure compliance with the Habitat Regulations Assessment (HRA) and EIA.

6.3.1.2 In February 2022, the first Benthic Ecology, Fish and Shellfish and Physical Processes Expert Working Group (EWG) meeting was undertaken. In terms of physical processes an overview of the supporting study objectives, methodology and datasets was presented. Preliminary modelling results were presented in the second EWG meeting held in November 2022.

Table 6.4: Summary of key consultation issues raised during consultation activities undertaken for the Morgan Generation Assets relevant to physical processes.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
14/07/2022	Natural England: Scoping Opinion	It is vital that the marine and coastal physical processes within, and in the vicinity of, the proposed development are well understood in order to provide robust estimates of the temporal and spatial scale of changes to hydrodynamic and sediment transport regimes. This should describe both contemporary conditions as well as longer-term historical change.	Physical processes baseline conditions (without wind farm infrastructure) such as tidal regime, wave climate and sediment transport, and comparisons to post – construction are outlined in volume 4, annex 6.1: Physical processes technical report of the PEIR. Storm conditions have also been assessed for 1in1 and 1in20 year storm events.
14/07/2022	Natural England: Scoping Opinion	We advise that secondary scour protection impacts on seabed habitats are scoped in until further detailed methods and impacts can be assessed, and justification provided to scope out of the ES.	Seabed clearance/secondary scour is included within the assessment as defined by the project description outlined in volume 1, chapter 3: Project description of the PEIR.
14/07/2022	Natural England: Scoping Opinion	Little information is provided on seabed preparation activities (e.g. sandwave clearance, material disposal) and the impacts on sediment transport patterns and morphological change, due to the early stage of the project. Natural England reserve the right to make future detailed comments once further information is known, this could include scoping in of additional impacts.	Seabed preparation such as sandwave clearance involves movement of material along the pathway, no material will be disposed of beyond the Morgan Array Area. Volume 4, annex 6.1: Physical processes technical report of the PEIR includes the dredging and fate of material mobilised in sandwave clearance. Secondary impacts due to seabed preparation are not currently included in the modelling of post construction bathymetry for two reasons, firstly in areas of active sediment transport this is a temporary condition, and secondly the uncertainty on scale & location of preparation activities.
14/07/2022	Natural England: Scoping Opinion	It will be important for any assessment to consider the potential cumulative effects of this proposal, including all supporting infrastructure, with other similar proposals and a thorough assessment of the 'in combination' effects of the proposed development with any existing developments and current applications. A full consideration of the implications of the whole scheme should be included in the ES. All supporting infrastructure and activities should be included within the assessment. An impact assessment should identify, describe, and evaluate the effects that are likely to result from the project in combination with other projects and activities that are being, have been or will be carried out. The following types of projects should be included in such an assessment (subject to available information): existing completed projects; approved but uncompleted projects; ongoing activities; plans or projects for which an application has been made and which are under consideration by the consenting authorities; and plans and projects which are reasonably foreseeable (i.e. projects for which an application has not yet been submitted, but which are likely to progress before completion of the development and for which sufficient information is available to assess the likelihood of cumulative and in-combination effects).	A cumulative impact assessment is undertaken for physical processes with screening for all relevant projects in section 6.9. A tiered approach has been applied to capture different stages of development of other projects which may cause a cumulative impact.
14/07/2022	Natural England: Scoping Opinion	The ES should thoroughly assess the potential for the proposal to affect designated sites. Internationally designated sites (e.g. designated Special Areas of Conservation (SAC) and Special Protection Areas (SPA)) fall within the scope of the Conservation of Habitats and Species Regulations 2017 (as amended). Assessment should include a full assessment of the direct and indirect effects of the development on the features of special interest within these sites and should identify such mitigation measures as may be required in order to avoid, minimise or reduce any adverse significant effects.	Designated sites within the physical processes study area are identified as discussed in section 6.4.3. Designated sites with features of importance that can be considered a receptor of physical processes are then assessed in section 6.8, with reference to the construction, operations and maintenance and decommission activities of the Morgan Generation Assets.
14/07/2022	Natural England: Scoping Opinion	Increases in suspended sediment concentrations (SSC) during construction and operation (e.g. future dredging works) have the potential to smother sensitive habitats. The ES should include information on the sediment quality and potential for any effects on water quality through suspension of contaminated sediments. The EIA should also consider whether increased SSC are likely to impact upon the interest features and supporting habitats of the designated sites.	The fate of mobilised material has been described within volume 4, annex 6.1: Physical processes technical report of the PEIR. The impact of SSC and sedimentation on receptors such as features of interest is discussed within this chapter in section 6.8, whilst the impacts on the supporting habitats are assessed in volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or were considered in this chapter
14/07/2022	Natural England: Scoping Opinion	It would be beneficial to have mapped display of the deployed metocean buoys, including both site-specific deployment as well as historic data from Ormonde offshore wind farm and the proposed Round 3 Irish Sea Offshore Wind Farm Development Zone.	A figure has been provided in volume 4, annex 6.1: Physical processes technical report of the PEIR to display survey buoy locations and the location of data sources.
14/07/2022	Natural England: Scoping Opinion	The evidence presented set out variation in the tidal currents across the physical processes study area, further evidence on the tidal currents and current directions, for both flood and ebb currents would be beneficial. It would be beneficial to have a mapped display of this information. This would support a clear baseline of the hydrodynamics within the physical processes study area.	Further information has now been provided on tides, waves and sediment transport specific to the Morgan Generation Assets as part of the modelling both pre and post-construction in volume 4, annex 6.1: Physical processes technical report of the PEIR.
14/07/2022	Natural England: Scoping Opinion	We seek clarity on the presence of any sand wave features within the area. In understanding any potential impacts, it would be beneficial to have a clear understanding of sand wave height, wave lengths and migratory rates.	Geophysical surveys specific to the Morgan Generation Assets has been carried out with further information sourced from a number of resources as detailed in Table 6.5 and project specific datasets as detailed in Table 6.6 with seabed features illustrated in Figure 6.3. Further detail is provided in volume 4, annex 6.1: Physical processes technical report of the PEIR.
14/07/2022	Natural England: Scoping Opinion	While we do not anticipate significant impacts resulting from the scour protection measures (as these will be subject to engineering design to ensure suitable for this project), it is our view that it is too early to scope out secondary scour protection impacts on the seabed at this stage. We advise that this is scoped in until further detailed methods and impacts can be assessed, and justification provided to scope out of the ES.	Scour protection is provided within the project infrastructure. The project description, volume 1, chapter 3: Project description of the PEIR, details that the provision made is adequate/proportionate. The physical processes assessment includes provision of scour protection as an integral part of the design.
14/07/2022	Natural England: Scoping Opinion	If a modelling approach is to be adopted, early engagement with the SNCBs is recommended. We advise that the model is discussed and agreed through the Evidence Plan process via the EWG.	The modelling methodology, software and datasets were presented in the first EWG held in February 2022, whilst preliminary modelling outcomes were presented in the second EWG meeting, November 2022. The MIKE modelling software was utilised as described in volume 4, annex 6.1: Physical processes technical report of the PEIR.
14/07/2022	Natural England: Scoping Opinion	Consideration of the Mersey Tidal Power Project in the cumulative effects assessment is advised. Currently this project is only at early concept planning stage.	The Mersey Tidal Power Project is included within the CEA long list (see volume 3, annex 5.1: Cumulative effects screening matrix of the PEIR) and was subsequently screened out of the physical processes assessment as there is no physical effect pathway due to distance from the Morgan Generation Assets.
15/06/22	The Planning Inspectorate: Scoping Opinion	The ES should provide further detail on the proposed seabed preparation activities and identify the worse-case scenario assessed in relation to seabed disturbance. The need for dredging, quantities of material and likely disposal location should be identified, and likely significant effects assessed in the ES.	The fate of mobilised material has been described within volume 4, annex 6.1: Physical processes technical report of the PEIR. The impact of SSC and sedimentation on receptors such as features of interest is discussed within this chapter in section 6.8. The dredging quantities, types of sediment and disposal plumes are identified in the volume 4, annex 6.1: Physical processes technical report of the PEIR.
15/06/22	The Planning Inspectorate: Scoping Opinion	Drilling arisings disposal site. The ES should identify the likely site for disposal of drilling arisings and include an assessment of effects from these activities.	No material will be disposed of beyond the Morgan Generation Assets. Supporting studies, volume 4, annex 6.1: Physical processes technical report of the PEIR, include the fate of material mobilised from drilling activities.
15/06/22	The Planning Inspectorate: Scoping Opinion	No justification is provided to scope out impacts from jack- up vessel spud-cans and footprints on the sedimentary regime. There is also no evidence that additional scour from depressions would not give rise to significant effects. The Inspectorate therefore does not agree this matter can be scoped out.	The bathymetry and sediment transport parameters are intrinsically linked, and further information is provided to justify scoping out of effects of depression on sediment regime in Table 6.12.
15/06/22	The Planning Inspectorate: Scoping Opinion	Scoping Report paragraph 3.4.4.1 states that seabed levelling may be required but this is not mentioned in the physical processes chapter. The ES should assess any likely significant secondary effects that this may have on changes to the current/flow regime, wave regime and sediment transport regime and any morphological changes.	Supporting studies and assessment include the dredging and fate of material mobilised in sandwave clearance operations undertaken during the construction phase of the project. Secondary impacts due to seabed preparation are not included in the modelling (i.e. with post seabed preparation bathymetry prior to the installation of the infrastructure) for two reasons, principally because in areas of active sediment transport this is a temporary condition and secondly the precise location of preparation activities would be determined during detailed design stages and micro-siting.

6.4 Baseline environment

6.4.1 Methodology to inform baseline

6.4.1.1 The baseline environment was established by undertaking a desktop study utilising existing studies and datasets as described in the following section.

6.4.2 Desktop study

6.4.2.1 Information on physical processes within the physical processes study area was collected through a detailed desktop review of existing studies and datasets. These are summarised at Table 6.5 below. The baseline was characterised by a combination of literature review of the reports and numerical modelling using the datasets. Full details of the analysis undertaken to develop the physical processes baseline is provided in the volume 4, annex 6.1: Physical processes technical report of the PEIR.

Table 6.5: Summary of key desktop reports.

Title	Source	Year	Author
European Marine Observation and Data Network (EMODnet) – Seabed classification	https://www.emodnet-geology.eu/	2022	EMODnet
European Marine Observation and Data Network (EMODnet) – Bathymetry data	https://www.emodnet-bathymetry.eu/	2022	EMODnet
European Marine Observation and Data Network (EMODnet) – Metocean data	https://map.emodnet-physics.eu/	2022	EMODnet
Department for Environment Food and Rural Affairs – Bathymetry data	https://environment.data.gov.uk/DefraDataDownload	2022	DEFRA
The Environment Agency National LiDAR Programme	National LIDAR Programme - data.gov.uk	2022	Environment Agency
National Oceanic and Atmospheric Administration (NOAA) – Atmospheric data	DHI Metocean Data Portal	2022	NOAA
National Network of Regional Coastal Monitoring Programmes	https://coastalmonitoring.org/cco/	2022	Coastal Channel Observatory
Centre for Environment, Fisheries and Aquaculture Science (CEFAS) – wave data	https://wavenet.cefas.co.uk/map	2022	CEFAS
ABPmer Data explorer	https://www.seastates.net/explore-data/	2022	ABPmer
Hydrography of the Irish Sea, SEA6 Technical Report	UK Government	2005	Howarth M.J.
Atlas of UK Marine Renewable Energy Resources	https://www.renewables-atlas.info/	2022	ABPmer
Geology of the seabed and shallow subsurface: The Irish Sea.	British Geological Survey	2015	Mellett *et al.*
British Geological Survey – sediment sample data	https://mapapps2.bgs.ac.uk/geoindex_offshore	2022	BGS
Suspended Sediment Climatologies around the UK.	Department for Business, Energy & Industrial Strategy (BEIS)	2016	Cefas
Metocean Data collection for the Ormonde offshore wind project.	Marine Data Exchange	2011	Geotechnical Engineering and Marine Surveys (GEMS)
Irish Sea Zone Hydrodynamic measurement campaign	Marine Data Exchange	2010 to 2013	EMU Ltd (now Fugro Ltd)
Admiralty Tide Tables	United Kingdom Hydrographic Office (UKHO)	2022	UKHO
Marine Environmental Data Information Network (MEDIN) Seabed Mapping Programme	Admiralty Marine Data Portal	2022	MEDIN
Integrated Mapping for the Sustainable Developments of Ireland's Marine Resource (INFOMAR) Seabed Mapping Programme	Geological Survey Ireland (GSI) and Marine Institute	2022	INFOMAR
Long term wind and wave datasets	European Centre for Medium-range Weather Forecast (ECMWF)	2022	ECMWF
UK tide gauge network and database of current observation	British Oceanographic Data Centre (BODC)	2021	BODC
UK Climate Projections (UKCP)	Met Office	2018	Met Office
Review of aggregate dredging off the Welsh coast	HR Wallingford	2016	HR Wallingford
A user-friendly database of coastal flooding in the UK from 1915-2014	Scientific Data (journal)	2015	Haigh *et al.*
British Oceanographic Data Centre	National Oceanography Centre	various	National Oceanography Centre
Designated sites (SPAs and SACs)	JNCC mapping data (https://jncc.gov.uk/mpa-mapper/)	2022	JNCC
Designated sites (SSSIs)	Defra Spatial Data Download	2022	DEFRA
Designated Ramsar sites	Map (ramsar.org)	2022	Ramsar

6.4.3 Identification of designated sites

6.4.3.1 All designated sites within the physical processes study area and qualifying interest features that could be affected by the construction, operations and maintenance, and decommissioning phases of the Morgan Generation Assets were identified using the three-step process described below:

- Step 1: All designated sites of international, national and local importance within the physical processes study area were identified using a number of sources. Using the JNCC website (https://jncc.gov.uk/mpa-mapper/)
- Step 2: Information was compiled on the relevant geomorphological/coastal features for each of these sites
- Step 3: Using the above information and expert judgement, sites were included for further consideration if:
  - A designated site directly overlaps with the Morgan Array Area therefore has the potential to be directly affected by the Morgan Generation Assets; or
  - Sites and associated qualifying interests were located within the potential Zone Of Influence (ZOI) for impacts associated with the Morgan Generation Assets.

6.4.4 Site specific surveys

6.4.4.1 In order to inform the PEIR, site-specific surveys were undertaken, as agreed with the, JNCC and Natural England. A summary of the surveys undertaken to inform the physical processes impact assessment is outlined in Table 6.6 below.

Table 6.6: Summary of site-specific survey data.

Title	Extent of survey	Overview of survey	Survey contractor	Date	Reference to further information
Environmental Baseline Surveys and Habitat Assessments	Morgan Array Area	Geophysical, geotechnical and environmental survey to determine characteristics of seabed sediment, characterise benthic communities (infauna and epifauna) and identification of any environmentally significant habitats (e.g. potential Habitats Directive Annex I and priority marine features). The geophysical survey elements consisted of multi-beam echo sounder (MBES), digital sound velocity (DSV) sensor, side scan sonar system (SSS), Sub-Bottom Profiler (SBP) & 2D Ultra High Resolution Seismic (2D UHRS) sensor. The environmental survey elements included the collection of seabed imagery along with grab samples. The geotechnical survey elements included cone penetration testing (CPT) and boreholes.	Gardline Ltd	2021	Gardline (2022)
Geophysical survey	Morgan Array Area	Geophysical survey to establish bathymetry, seabed sediment and identify seabed features. Deployment included MBES with multibeam backscatter.	XOCEAN Ltd	2022	XOcean (2022)
Metocean survey	Morgan and Mona Array Area	Metocean and floating lidar deployments to ascertain wind, wave and tidal currents.	Fugro	2022	Fugro (2022)

6.4.5 Baseline environment

6.4.5.1 A summary of the physical processes baseline environment is provided in the following sections. Full details of the analysis undertaken to develop the physical processes baseline for the supporting modelling study is provided in volume 4, annex 6.1: Physical processes technical report of the PEIR, which includes information on model development, resolution, calibration, and the modelling techniques implemented to develop the baseline characteristics.

6.4.6 Bathymetry

6.4.6.1 Seabed levels across the Morgan Array Area range from depths of 32m to 54m Mean Sea Level (MSL) with a deeper corridor travelling across the Morgan Array Area from the southwest to the northeast, as illustrated in Figure 6.2. Shallower depths are observed in the north and the south of the Morgan Array Area.

6.4.7 Hydrography

6.4.7.1 The Morgan Array Area has an average tidal range of 3.65m as published by Admiralty (United Kingdom Hydrographic Office (UKHO)) at Holyhead and a mean tidal range of 4.55m at the standard port of Douglas. These ports are one of a number in the proximity of the physical processes study area and were used as a calibration point alongside several other reference points taken across the model domain, as detailed in volume 4, annex 6.1: Physical processes technical report of the PEIR.

6.4.7.2 Semi-diurnal tides are the dominant physical process in the Irish Sea coming from the Atlantic Ocean through both the North Channel and St Georges Channel. The tidal range in the Irish Sea is highly variable with a range greater than 10m on the largest spring tides, the second largest in Britain.

6.4.7.3 Across the Morgan Array Area, the tidal current floods to the eastnortheast and ebbs to the westsouthwest. A flood dominance is more evident and pronounced during spring tides (Fugro, 2022). The tidal flow is characterised by relatively strong flows during spring tides; with tidal current speeds typically between 0.8 and 0.9m/s during flood tide and slightly weaker ebb tide currents between 0.7 and 0.8m/s. Tidal flow fields for the east Irish Sea are presented in volume 4, annex 6.1: Physical processes technical report of the PEIR.

6.4.8 Wave climate

6.4.8.1 Characteristic of the east Irish Sea, waves are generated by either local winds or from remote winds (swell waves). At the centre of the Morgan Array Area, the largest proportion of waves approach from the westerly sectors, typically combined wind and swell for the Irish Sea. However, a wave field can also develop from the north of the Morgan Array Area as there is a sufficient fetch length.

6.4.8.2 The wave climate in the Morgan Array Area is described as having dominant short period, southwest direction waves. During the metocean buoy deployment the largest wave height recorded was 8.92m (Hmax) during Storm Franklin (Fugro, 2022).

6.4.8.3 The highest mean annual significant wave height of 1.39m was recorded between the Isle of Man and Anglesey with the significant wave height reducing closer to the coast with a low of 0.73m recorded to the west of the Dee Estuary (ABPmer, 2008).

6.4.8.4 Within the Morgan Generation Assets mean annual wave height ranges from 1.1m to 1.3m. Over 40% of waves arise from the southwest and all significant wave heights greater than 4m originate from the southwest or west (ABPmer, 2018).

6.4.8.5 Further detail on the wave climate analysis is provided in volume 4, annex 6.1: Physical processes technical report of the PEIR.

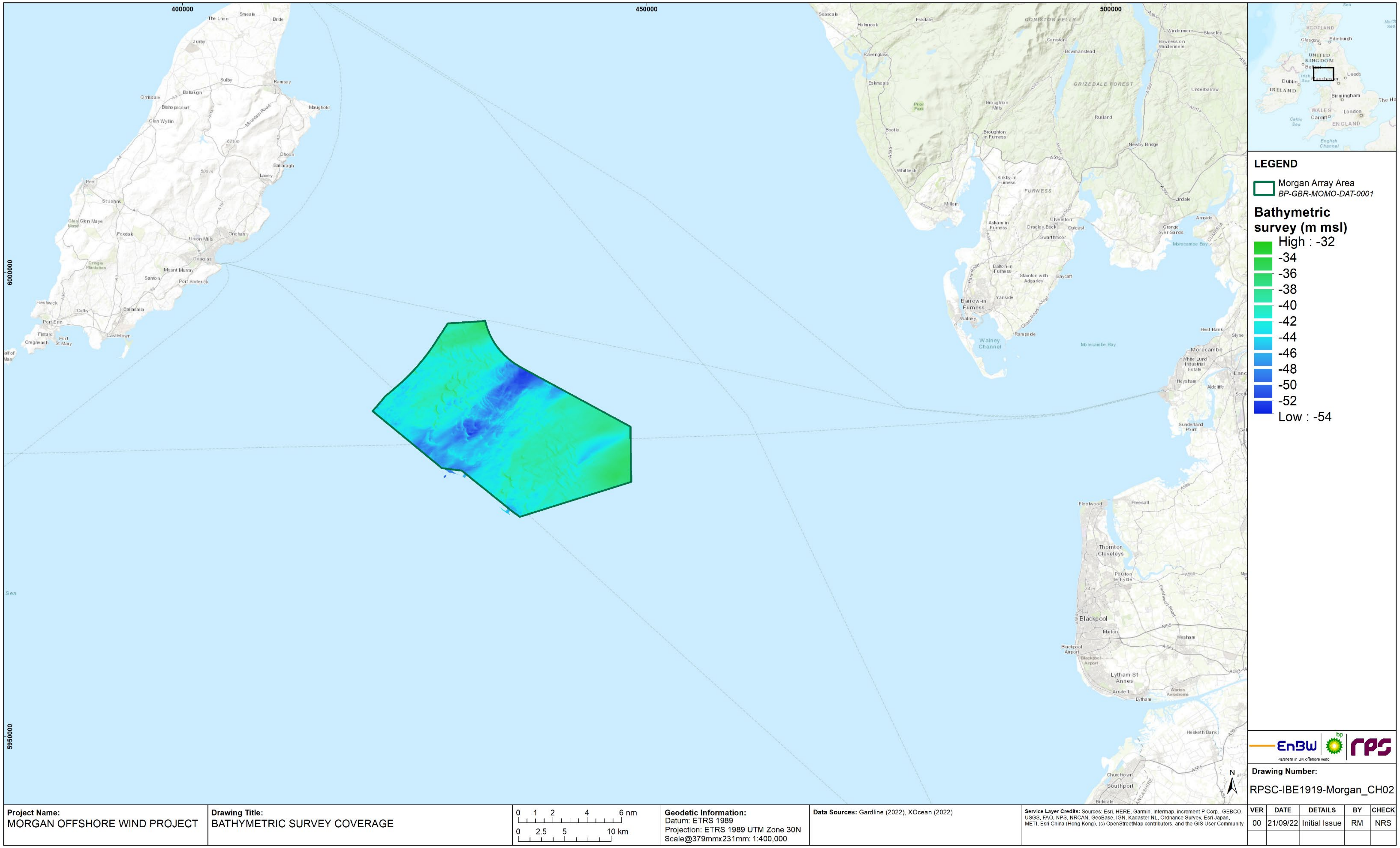


Figure 6.2: Bathymetric surveys of the Morgan Array Area undertaken by Gardline 2022 and XOCEAN 2022.

6.4.9 Littoral currents

6.4.9.1 Littoral currents are driven by tides, waves, and meteorological events. The littoral currents were modelled from the westerly sector (270°) during a 1in1 year storm event, resulting in the increase of currents on the peak flood tide to circa 0.8-0.9m/s and reducing to 0.7-0.8m/s during the peak ebb within the Morgan Array Area. With the largest and most prevalent waves approaching from the west, these waves cause an increase in currents during the flood tide and a decrease on the ebb tide.

6.4.10 Sedimentology

6.4.10.1 Across the Morgan Array Area, the underlying geology consists of Triassic and Carboniferous sandstone and mudstone bedrock lithologies (Mellett *et al*., 2015). The bedrock of sandstone and mudstone is covered by sediments from the Quaternary age with small areas exposed (Mellett *et al.,* 2015). Potential weathering during the last glacial period may have weakened the uppermost surface of underlying bedrock (Mellett *et al.,* 2015). Quaternary sediment thickness in the central Irish Sea is <20m although in short distances this can increase to >100m due to the presence of glacial valleys. However, in the east and west of the Irish Sea sediment thickness is circa 50m (Mellett *et al.,* 2015).

6.4.10.2 In the Irish Sea, there is a high variability in the bedforms ranging from very small ripples (5cm high) to very large sediment waves (>10m high). The seafloor morphology of the Morgan Array Area also includes several distinct features such as sandwaves, megaripples, sediment waveforms and outcrops (XOCEAN, 2022 and Gardline, 2022). Seabed substrate within the Morgan Array Area ranged from sand, sandy gravel, and gravelly sand, as illustrated in Figure 6.3.

6.4.10.3 In the east and west Irish Sea seabed sediments are subdivided into regions of soft mud (clay and silt) rich sediment. However, Morgan Array Area lies within the central gravel belt in the Irish Sea containing coarse sand and gravel (Mellett *et al.,* 2015). Small areas of bedrock outcrop at the seabed have been observed.

6.4.11 Stratification

6.4.11.1 The temperature distribution of the east Irish Sea is dominated by vertical exchanges and heat input at the sea surface leading to seasonal cycles. The water is coolest in February or March with temperature decreasing from the deeper channel towards the coasts (Howarth, 2005). The coolest water is towards the coast in the eastern Irish Sea – between the Solway Firth and Liverpool Bay where the temperature is below 5ºC (Howarth, 2005). The temperatures are highest in August with the warmest water close to the coasts, exceeding 16ºC in Liverpool Bay (Howarth, 2005).

6.4.11.2 The annual mean salinity decreases from south to north and from the centre of the channel to the edges. In the east Irish Sea there is often a marked change in salinity, running approximately north/south at the east Irish front at the west side of the Isle of Man (Foster *et al*, 1985). Seasonal variations are much less pronounced than for temperature, especially away from the coasts (Howarth, 2005).

6.4.11.3 Throughout most of the region tidal mixing is sufficiently intense to ensure that the water column remains well mixed throughout the year (Howarth, 2005). To the east of the Isle of Man conditions for this are only marginal so that stratification is only likely to develop during hot, calm conditions and can easily be mixed away by storms or spring tides (Howarth, 2005). Near to estuaries and especially in Liverpool Bay the water column can also stratify because fresh water is lighter than salty; conditions are most suitable at neap tides, when the weather is calm and when river discharges are large (Howarth, 2005).

6.4.12 Sediment Transport

6.4.12.1 There are strong circulatory currents in the east Irish Sea where tidal flows interact with headlands and embayments. The greatest sediment transport rates are evident in estuaries and at headlands where finer sand fractions are present and where tidal currents are strongest. The littoral currents and dominant flood tide subsequently increase sediment transport during storm conditions.

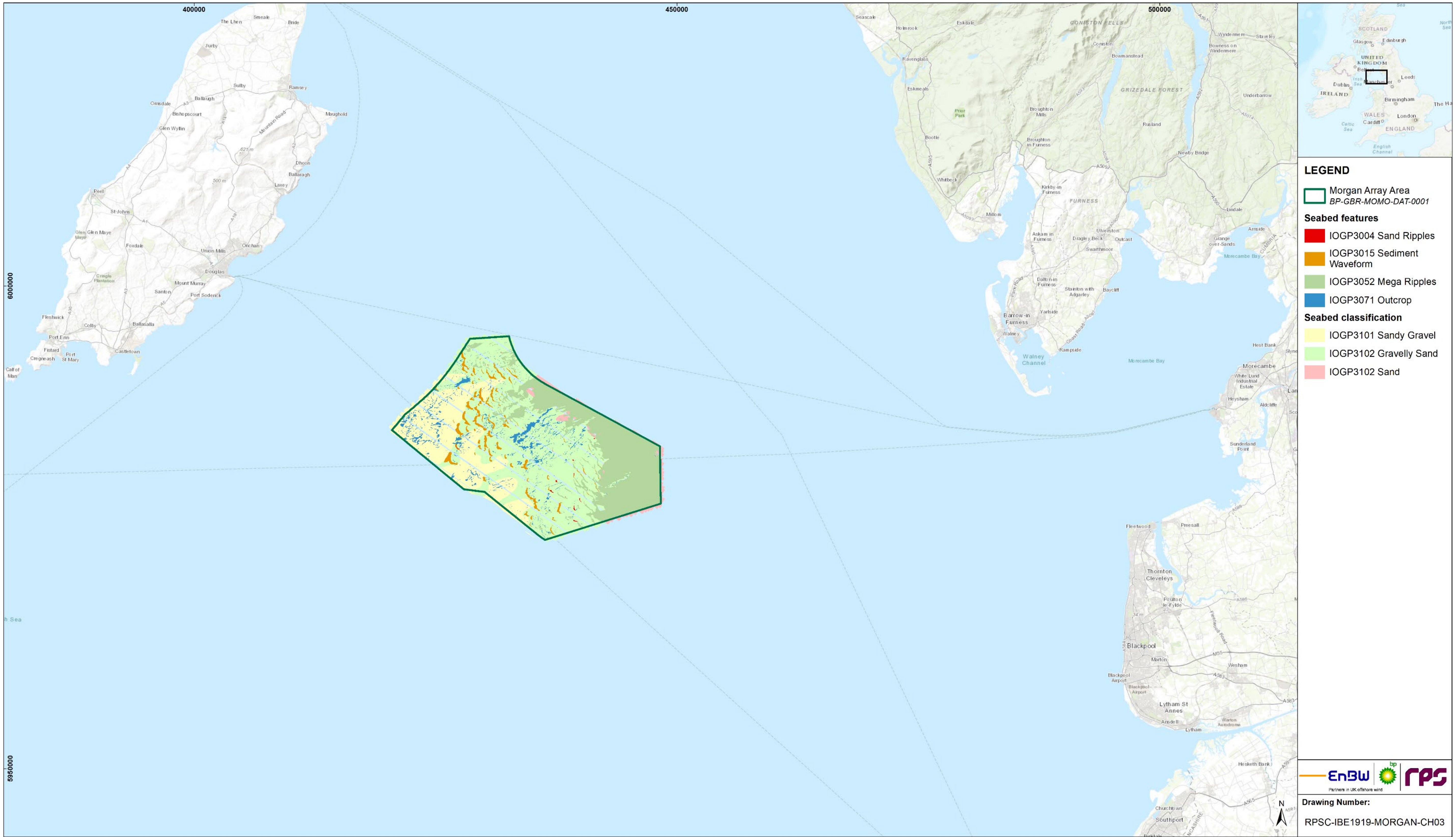
6.4.12.2 Within the Morgan Array Area, the residual current speeds are several orders of magnitude smaller than those along the coastline. Residual currents are the net flow over a full tidal cycle and drive the sediment transport. Residual currents flow into the east Irish Sea from the north of the Isle of Man and also west around Anglesey. This correlates with this region being a sediment sink. In the Morgan Array Area, sediment transport rates are highest during springs on the flood tide, with total sediment loads of up to 0.0001m^3/s/m and 0.00005m^3/s/m on the peak of the flood and ebb tides respectively. Net sediment transport rates are circa 0.4-1.5 m^3/d/m within the Morgan Array Area.

6.4.12.3 The physical processes study area largely coincides with the Solway Firth sediment cell and sub-cell 11a Great Orme's Head to Southport Pier. In the sub-cell 11a the general direction of sediment transport is west to east. This direction of travel supplies the southeast shoreline with sediment (Price *et al.,* 2010).

6.4.13 Suspended Sediments

6.4.13.1 Suspended sediment concentrations (SSC) are regulated by tidal currents and intensify during wind-driven storm events. SSC levels have a seasonal pattern due to the seasonality of storm events. Offshore monitoring within the proposed Morgan Generation Assets recorded typical SSC levels of 3mg/l, however as expected during a storm event this increased to circa 20mg/l corresponding with increased wave heights (Fugro (2022).

6.4.13.2 Cefas records SSC as non-algal suspended particulate matter (SPM). Within the Morgan Array Area, this was estimated to be on average 0.9mg/l to 3mg/l between 1998 and 2015 (Cefas, 2016). These values display a seasonal pattern with heightened levels during winter months and are regulated by tidal currents.



Project Name:	Drawing Title:	Scale	Geodetic Information:	Data Sources:	Service Layer Credits:
MORGAN OFFSHORE WIND PROJECT	SEABED CLASSIFICATION AND FEATURES	0 1 2 4 6 nm; 0 2.5 5 10 km	Datum: ETRS 1989 Projection: ETRS 1989 UTM Zone 30N Scale@379mmx231mm: 1:400,000	Garline (2022), XOcean (2022)	Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

VER	DATE	DETAILS	BY	CHECK
00	21/09/22	Intial issue	RM	NRS

Figure 6.3: Sediment classification and seabed features within the Morgan Array Area characterised by Gardline Ltd. (2022) and XOCEAN (2022)

6.4.14 Designated sites

6.4.14.1 Using the JNCC database (https://jncc.gov.uk/mpa-mapper/), designated sites identified for the physical processes chapter are described in Table 6.7 and illustrated in Figure 6.4.

Table 6.7: Designated sites and relevant qualifying interests for the physical processes chapter.

Designated site	Closest distance to the Morgan Array Area (km)	Relevant qualifying interest
West of Copeland MCZ	7.3	Protected feature: • Subtidal sand • Subtidal coarse sediment • Subtidal mixed sediments
West of Walney MCZ	7.5	Protected feature: • Subtidal sand • Subtidal mud • Sea-pen and burrowing megafauna communities

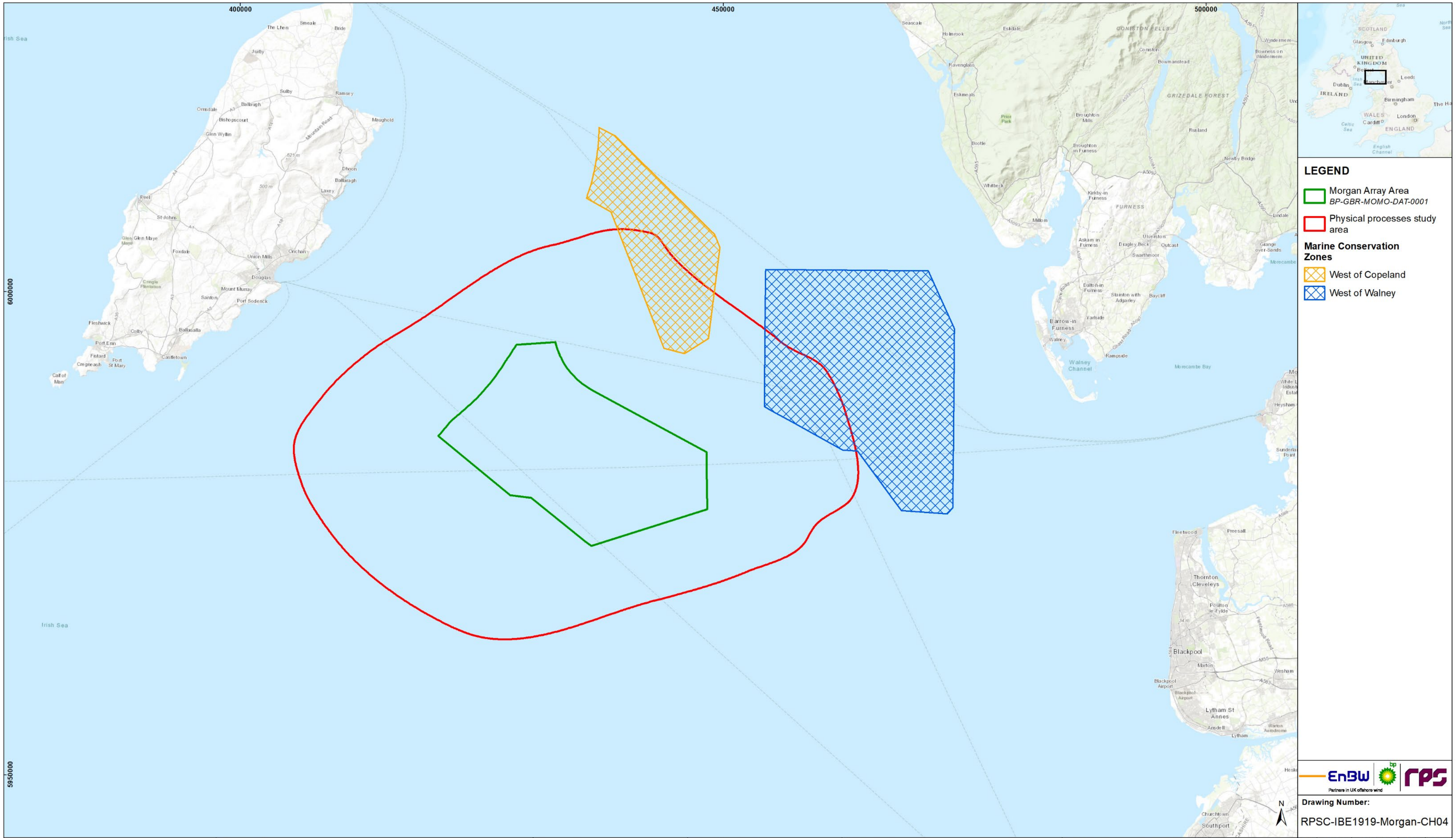
6.4.15 Future baseline scenario

6.4.15.1 Schedule 4 of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (EIA Regulations), require that a "a description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the project 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 within the Environmental Statement. In the event that the Morgan Generation Assets does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section.

6.4.15.2 The baseline environment for physical processes is not static and will exhibit a degree of natural change over time. Such changes will occur with or without the Morgan Generation Assets in place due to natural variability. Future baseline conditions would be altered by climate change resulting in sea level rise and increased storminess. This is unlikely to have the effect of significantly altering tidal patterns and sediment transport regimes offshore at the Morgan Array Area. The return period of the wave climates would be altered (e.g. what is currently defined as a 1in50 year event may become a 1in20 year event) as deeper water would allow larger waves to develop.

6.4.16 Data limitations

6.4.16.1 The physical processes study area has been the focus of study for both academic and government institutions. Additionally, significant data collection campaigns have been undertaken by the bp/EnBW and other offshore wind farm developers in the locality. Although some physical processes are complex and inter-related, there is a significant amount of data available. It is therefore considered that the data used in this assessment are robust and sufficient for the purposes of the impact assessment presented.



Project Name:	Drawing Title:	Geodetic Information:	Data Sources:	Service Layer Credits
MORGAN OFFSHORE WIND PROJECT	PHYSICAL PROCESSES DESIGNATED SITES	Datum: ETRS 1989 Projection: ETRS 1989 UTM Zone 30N Scale@379mmx231mm: 1:400,000		Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

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00	19/10/22	Initial Issue	NRS	RM
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Figure 6.4: Designated sites relevant to the Morgan Generation Assets physical processes chapter.

6.5 Impact assessment methodology

6.5.1 Overview

6.5.1.1 The physical processes impact assessment has followed the methodology set out in volume 1, chapter 5: EIA methodology of the PEIR. Specific to the physical processes impact assessment, the following guidance documents have also been considered.

- Collaborative Offshore Wind Energy Research into the Environment (COWRIE) - Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment (Lambkin *et al.*,2009)
- Guidelines in the use of metocean data through the lifecycle of a marine renewable's development (Cooper *et al.*, 2008)
- Marine Physical Processes Guidance to inform Environmental Impact Assessment (EIA) (Natural Resources Wales, 2020)
- Guidance on Marine Baseline Ecological Assessments and Monitoring Activities for Offshore Renewable Energy Projects Parts 1 and 2, Department of the Environment, Climate and Communications, (DECC, 2018)
- Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments. NRW Report No 208, 139pp, Natural Resources Wales. (Pye *et al.*, 2017)
- Guidance on Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to inform EIA of Major Development Projects, NRW Report No: 243, 119 pp, Natural Resources Wales, Cardiff. (Brooks *et al.*, 2018).)
- Guidance on EIS and NIS Preparation for Offshore Renewable Energy Projects, Department of Communications, Climate Action and Environment, (Barnes, 2017

6.5.1.2 In addition, the physical processes impact assessment has considered the legislative framework as defined by:

- Overarching NPS for Energy (EN-1; DECC, 2011a)
- NPS for Renewable Energy Infrastructure (EN-3, DECC, 2011b)
- North West Inshore and North West Offshore Coast Marine Plans (MMO, 2021)
- The Welsh National Marine Plan (Welsh Government, 2019).

6.5.2 Impact assessment criteria

6.5.2.1 Physical processes are not generally receptors in themselves; they may be a pathway by which coastal features may be impacted or a pathway for indirect impacts on other receptors. For example, increases in suspended sediments during the construction phase may lead to the deposit of these sediments and smothering of benthic habitats. For this impact, the magnitude of the potential changes has been assessed, with the sensitivity of the receptors to these changes and the significance of effects assessed within volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR.

6.5.2.2 A full impact assessment has however been provided within this chapter, section 6.8, for the hydrodynamic regime and the sediment transport regime, which have been identified as potentially sensitive physical processes receptors.

6.5.2.3 The criteria for determining the significance of effects is a two-stage process that involves defining the magnitude of the impacts and the sensitivity of the receptors. This section describes the criteria applied in this chapter to assign values to the magnitude of potential impacts and the sensitivity of the receptors. The terms used to define magnitude and sensitivity are based on those which are described in further detail in volume 1, chapter 5: EIA methodology of the PEIR.

6.5.2.4 The criteria for defining magnitude in this chapter are outlined in Table 6.8 below.

Table 6.8: Definition of terms relating to the magnitude of an impact.

Magnitude of impact	Definition
High	Change in physical processes which results in the loss of a coastal feature (e.g. blockage of sediment pathway resulting in loss of spit (Adverse)).
	Change in physical processes which results in the creation of a coastal feature (e.g. reduction in wave climate giving rise to dune formation (Beneficial)).
Medium	Alteration of physical processes which effects the rate at which a coastal feature is maintained (e.g. reduction in accretion rate (Adverse)).
	Alteration of physical processes which effects the rate at which a coastal feature is developing (e.g. reduction in erosion rate (Beneficial)).
Low	Variation in physical processes which maintains the coastal feature (e.g. localised change in sediment pathway which does not destabilise bank).
Negligible	Imperceptible variation in physical process (e.g. in the order of natural variability).
No change	No loss or alteration of characteristics, features or elements; no observable impact either adverse or beneficial.

6.5.2.5 The criteria for defining sensitivity in this chapter are outlined in Table 6.9 below.

Table 6.9: Definition of terms relating to the sensitivity of the receptor.

Sensitivity	Definition
Very High	Coastal feature forms vital part of a wider scale system which is scarce and non-recoverable.
High	Coastal feature forms part of a wider scale system and is non-recoverable.
Medium	Coastal feature has limited potential for re-creation.
Low	Coastal features of local scale and recoverable.
Negligible	Coastal feature adaptable to changes in physical processes.

6.5.2.6 The significance of the effect upon physical processes is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 6.10. Where a range of significance of effect is presented in Table 6.10, the final assessment for each effect is based upon expert judgement.

6.5.2.7 For the purposes of this assessment, any effects with a significance level of minor or less have been concluded to be not significant in terms of The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.

Table 6.10: Matrix used for the assessment of the significance of the effect.

Sensitivity of Receptor	Magnitude of Impact				
	No Change	**Negligible**	**Low**	**Medium**	**High**
Negligible	No change	Negligible	Negligible or Minor	Negligible or Minor	Minor
Low	No change	Negligible or Minor	Negligible or Minor	Minor	Minor or Moderate
Medium	No change	Negligible or Minor	Minor	Moderate	Moderate or Major
High	No change	Minor	Minor or Moderate	Moderate or Major	Major
Very High	No change	Minor	Moderate or Major	Major	Major

6.6 Key parameters for assessment

6.6.1 Maximum design scenario

6.6.1.1 The MDS identified in Table 6.11 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the project description provided in volume 1, chapter 3: Project description of the PEIR. Effects of greater adverse significance are not predicted to arise should any other development scenario, (e.g. different infrastructure layout), to that assessed here be taken forward in the final design scheme.

6.6.1.2 The results of the physical processes study, particularly the numerical modelling output detailed in volume 4, annex 6.1: Physical processes technical report of the PEIR, will be used to support and inform the following PEIR chapters:

- Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR
- Volume 2, chapter 8: Fish and shellfish ecology of the PEIR
- Volume 2, chapter 9: Marine mammals of the PEIR
- Volume 2, chapter 13: Marine archaeology of the PEIR
- Volume 2, chapter 14: Other sea users of the PEIR.

Table 6.11: Maximum Design Scenario considered for the assessment of potential impacts on physical processes.

[a] C=construction, O=operations and maintenance, D=decommissioning

Potential impact	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	**Construction phase** Site preparation: Sandwave clearance: Sandwave clearance activities undertaken over an approximate 12-month duration within the wider four-year construction programme. • Wind turbines and Offshore Substation Platform (OSP) foundations: sandwave clearance has been calculated on the basis of wind turbine foundations and an assumption of clearance at up to 60% of locations. Spoil volume per location has been calculated on the basis of 41 locations supporting the largest suction bucket four legged jacket foundation with an associated base diameter of 205m to an average depth of 7.5m. For OSP foundations the greatest clearance volume relates to four installations with gravity base foundations, each with a slab base diameter of 52.5m and with a scour protection diameter of 89.1m. This equates to a total spoil volume of 10,149,455m^3 and a volume of 247,548m^3 per wind turbine location. • Inter-array cables: sandwave clearance along 250km of cable length, with a width of 104m, to an average depth of 5.1m. Total spoil volume of 11,843,641m^3 • Interconnector cables: sandwave clearance along 36km of cable length, with a width of 104m, to an average depth of 5.1m. Total spoil volume of 3,060,814m^3 • Removal of up to 46km of disused cables. Foundation installation: • Undertaken over an approximate 12 month duration • Wind turbines: installation of up to 68 monopiles of 16m diameter, drilled to a depth of 60m at a rate of up to 0.73m/h. Two monopiles installed concurrently. Spoil volume of 13,460m^3 per pile • OSPs: installation of one OSP with foundations consisting of two 16m monopiles, drilled to a depth of 60m at a rate of up to 0.73m/h. Two monopiles installed concurrently. Spoil volume of 13,460m^3 per pile. Cable installation: • Inter-array cables: Installation via trenching of up to 500km of cable, with a trench width of up to 3m and a depth of up to 3m. Total spoil volume of 2,250,000m^3. Installed over a period of approximately12 months • Interconnector cables: installation via jetting of up to 60km of cable, with a trench width of up to 3m and a depth of up to 3m. Total spoil volume of 270,000m^3. Installed over a period of approximately four-months **Operations and maintenance phase** • Project lifetime of 35 years • Inter-array cables: repair of up 8km of cable in one event every three years. Reburial of up to 20km of cable in one event every five years • Interconnector cables: repair of up to 20km of cable in each of three events every 10 years. Reburial of up to 3km of cable in one event every five years **Decommissioning phase** • Scour and cable protection will remain *in situ*. If suction caissons are removed using the overpressure to release them then suspended sediment concentration will be temporarily increased • Inter-array and interconnector cables will be removed and disposed of onshore	**Construction phase** Site preparation: • The volume of material to be cleared 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. These details are not fully known at this stage, however based on the available data, it is anticipated that the sandwaves requiring clearance in the array area are likely to be in the range 15m in height. • Site clearance activities may be undertaken using a range of techniques, the suction hopper dredger will result in the greatest increase in suspended sediment and largest plume extent as material is released near the water surface during the disposal of material. • Boulder clearance activities will result in minimal increases in suspended sediment concentrations and have therefore not been considered in the assessment. Foundation installation: • Installation of foundations via augured (drilled) operations results in the release of the largest volume of sediment. The greatest volume of sediment disturbance by drilling at individual foundation locations and across the site as a whole is associated with the largest diameter monopile for wind turbines. The selected OSP scenario represents the greatest volume of sediment to be released for a drilling event. • The greatest drilling rate represents the maximum level of increase in suspended sediment concentration. Cable installation: • Cable routes inevitably include a variety of seabed material and in some areas 3m depth may not be achieved or may be of a coarser nature which settles in the vicinity of the cable route. The assessment therefore considers the upper bound in terms of suspended sediment and dispersion potential. • Cables may be buried by ploughing, trenching or jetting with jetting mobilising the greatest volume of material to increase suspended sediment concentrations. **Operations and maintenance phase** • The greatest foreseeable number of cable reburial and repair events is considered to the MDS for sediment dispersion. **Decommissioning phase** • 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.

Potential impact	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Impacts to the tidal regime due to presence of infrastructure. Impacts to the wave regime due to presence of infrastructure. Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry. Impacts to temperature and salinity stratification due to the presence of infrastructure.	✓	✓	✓	**Construction phase** • During the construction phase the potential changes to the receptor will be gradual as the presence of infrastructure increases reaching the MDS outlined below in the operations and maintenance phase. The MDS in terms of the presence of infrastructure would be on the completion of construction, during the operations and maintenance phase. **Operations and maintenance phase** • Wind turbines: 68 installations with four-legged suction bucket foundations, each jacket leg with a diameter of 5m, spaced 48m apart, and each bucket with a diameter of 16m. Scour protection to a height of 2.5m. Total footprint of 10,816 m^2 per wind turbine • OSPs: four installations with gravity base foundations, each with a 14m diameter at the surface, a slab base diameter of 52.5m and with scour protection to a height of 2.6m. Total footprint of 6,236m^2 per OSP • Inter-array cables: cable protection (armouring) along 50km of the cable, with a height of up to 3m and up to 10m width. Up to 67 cable crossings, each crossing has a height of up to 4m, a width of up to 32m and a length of up to 60m • Interconnector cables: cable protection along 12km of the cable, with a height of up to 3m and up to 10m width. Up to ten cable crossings, each crossing has a height of up to 3m, a width of up to 20m and a length of up to 50m **Decommissioning phase** • During the decommissioning phase the potential changes to the receptor would gradually decrease from the operational MDS as structures are removed and cut below the seabed. • Scour and cable protection will remain *in situ* and continue to influence tidal regime.	Physical processes are comprised of tides, waves and sediment transport and these aspects are integrated (i.e. without the influence of tides and waves there would be no sediment transport) as outlined below: • The tidal regime is influenced by changes in bathymetry due to the placement of scour protection and the obstruction of tidal flow due to wind turbine structures within the water column • The wave climate is influenced by obstruction within the water column however changes in bathymetry would only cause effects in shallow water • The sediment transport regime is affected by obstructions in the sediment transport pathways and also potential changes to the littoral currents which drive this process (i.e. those factors which also affect tide and wave climate) • Stratification is governed by the factors controlling mixing therefore the effects on tide and wave climate are common to stratification A holistic approach has therefore been applied to assessing the MDS. The greatest surface blockage to influence wave climate is from the wind turbines with the largest four-legged suction bucket foundations. The four legs provide a slightly smaller obstruction to tidal flows at each wind turbine site than gravity base foundations however the gravity base obstruction is concentrated towards to the lower section of the water column where tidal currents are weaker and influence of conveyance is therefore reduced. Suction bucket foundations have the largest footprint at each wind turbine in terms of scour protection and provide the greatest influence on bathymetry. The devices also have a greater footprint over the site as a whole rather than the more numerous smaller design options. The greatest overall in-water column blockage to influence tidal flow and wave climate from the OSPs is the maximum number of OSPs (four) with gravity base foundations. These parameters also present the largest overall footprints to affect changes in bathymetry and sediment transport pathways.

6.6.2 Impacts scoped out of the assessment

6.6.2.1 On the basis of the baseline environment and the description of development outlined in volume 1, chapter 3: Project description of the PEIR, a number of impacts are proposed to be scoped out of the assessment for physical processes. These impacts are outlined, together with a justification for scoping them out, in Table 6.12.

Table 6.12: Impacts scoped out of the assessment for physical processes.

Potential impact	Justification
Changes to bathymetry due to depressions left by jack-up vessels.	The potential for jack-up vessel spud-cans to affect the sediment regime has been scoped out of the assessment. Jack-up footprint depressions would likely only persist temporarily after jack-up operations have been completed and these would infill over time. Monitoring at the Barrow offshore wind farm showed depressions were almost entirely infilled 12 months after construction (BOWind, 2008).
Changes to sediment transport due to depressions left by jack-up vessels.	Changes to bathymetry and hydrography are intrinsically linked to sediment transport. When jack-up barges are removed the source of scour is also eradicated. The gradual infilling is not anticipated to significant implications for the sediment regime, due to the scale and nature.
Scour of seabed sediments during the construction and operations and maintenance phases.	Interaction between the waves and current and the Morgan Generation Assets generation infrastructure has the potential to cause localised scouring of seabed sediment. Scour protection will be a measure adopted as part of the project to prevent scour from occurring. The scour protection measures will be subject to engineering design to ensure they prevent scour from occurring and will be installed in concert with infrastructure. Therefore, it is proposed that scour of seabed sediments is scoped out of the physical processes Environmental Statement chapter.

6.7 Measures adopted as part of the Morgan Generation Assets.

6.7.1.1 For the purposes of the EIA process, the term 'measures adopted as part of the project' is used to include the following measures (adapted from IEMA, 2016):

- Measures included as part of the project design. These include modifications to the location or design envelope of the Morgan Generation Assets Project which are integrated into the application for consent. These measures are secured through the consent itself through the description of the development and the parameters secured in the DCO and/or marine licences (referred to as primary mitigation in IEMA, 2016).
- Measures required to meet legislative requirements, or actions that are generally standard practice used to manage commonly occurring environmental effects and are secured through the DCO requirements and/or the conditions of the marine licences (referred to as tertiary mitigation in IEMA, 2016).

6.7.1.2 A number of measures adopted as part of the Morgan Generation Assets have been proposed to reduce the potential for impacts on physical processes (see Table 6.13). As there is a secured commitment to implementing these measures, they are considered inherently part of the design of the Morgan Generation Assets and have therefore been considered in the assessment presented in section 6.8 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures).

Table 6.13: Measures adopted as part of the Morgan Generation Assets.

Measures adopted as part of the Morgan Generation Assets	Justification	How the measure will be secured
Primary measures: Measured included as part of the project design		
Scour Protection	There is the potential for scouring of seabed sediments to occur due to interactions between metocean regime (waves and currents) and foundations or other seabed structures. This scouring can develop into depressions around the structure. The use of scour protection around offshore structures and foundations will be employed, as described in detail in volume 1, chapter 3: Project description of the PEIR. The scour protection has been included in the modelled scenarios used within the impact assessment.	Committed with the project design (see volume 1, chapter 3: Project description of the PEIR)
Cable burial	Development and adherence to a Cable Specification and Installation Plan which will include cable burial where possible and cable protection. To minimise potential impact from the cables and removal of cables a commitment to bury cables where possible has been made in accordance with the specific policies set out in the North West Inshore and North West Offshore Coast Marine Plans (MMO, 2021).	Committed with the project design (see volume 1, chapter 3: Project description of the PEIR)
Material arising from drilling and/or sandwave clearance will be deposited in close proximity to the works	To retain material within sediment cell and maintain sediment transport regimes.	Committed with the project design (see volume 1, chapter 3: Project description of the PEIR)
Tertiary measures: Measures required to meet legislative requirements, or adopted standard industry practice		
N/A	N/A	N/A

6.7.1.3 Where significant effects have been identified, further mitigation measures (referred to as secondary mitigation in IEMA, 2016) have been identified to reduce the significance of effect to acceptable levels following the initial assessment. These are measures that could further prevent, reduce and, where possible, offset any adverse effects on the environment. These measures are set out, where relevant, in section 6.8 below.

6.8 Assessment of significant effects

6.8.1.0 The impacts of the construction, operations and maintenance, and decommissioning phases of the Morgan Generation Assets have been assessed on physical processes. The potential impacts arising from the construction, operations and maintenance and decommissioning phases of the Morgan Generation Assets are listed in Table 6.11, along with the MDS against which each impact has been assessed.

6.8.1.1 A description of the potential effect on physical processes receptors caused by each identified impact is given in the following sections. The assessment is focussed on, but not limited to, areas designated for features related to physical processes, (i.e. the West of Walney MCZ and the West of Copeland MCZ). Further information on the MCZs is provided in Marine Conservation Zone (MCZ) Assessment Report whilst impact assessments relating to important habitats are detailed in the respective chapters, particularly

- Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR
- Volume 2, chapter 8: Fish and shellfish ecology of the PEIR
- Volume 2, chapter 9: Marine mammals of the PEIR.

6.8.1 Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.

6.8.1.1 Increased suspended sediment concentrations may arise due to seabed preparation involving sandwave clearance, the installation of the wind turbines and OSP foundations, the installation and/or maintenance of cables and associated decommissioning activities. This impact is relevant to the construction, operations and maintenance, and decommissioning phases of the Morgan Offshore Wind Farm and may cause indirect impacts to receptors.

6.8.1.2 The following scenarios were investigated:

- Site preparation activities – sand wave clearance to facilitate wind turbine, OSP and cable installation
- Drilled pile installation – across the range of hydrodynamic conditions
- Inter-array and inter-connector cable installation – for a zone of sandy seabed sediment

6.8.1.3 Modelling was undertaken related to the MDS as outlined in Table 6.11 with the detail of the assessment provided in volume 4, annex 6.1: Physical processes technical report of the PEIR.

Construction phase

Magnitude of impact

6.8.1.4 The project design includes the provision of site preparation/sandwave clearance activities which have the potential to increase suspended sediment concentrations in the construction phase with associated deposition. Sandwave clearance was calculated for 60% of the wind turbine and OSP foundations at a width of 205m and a depth of 7.5m. The MDS for sandwave clearance for cable installation was along a 250km length of the inter array cable with a width of 104m, to an average depth of 5.1m. Similarly, sandwave clearance at the same depth and width may be required along 36km of the interconnector with modelling assuming a clearance dredging rate of 10,000 m^3/h and a 3% spill of material during the dredging phase.

6.8.1.5 In practice, plough dredging which mobilises a much smaller amount of sediment into suspension at the seabed and has reduced sediment plume concentrations and extents compared to other types of dredging activities may be undertaken. However, the modelling simulated the use of a suction hopper dredger with a phasing representative of the scale of the sandwaves; dredging, and then depositing material within the cable corridor as it progressed along the route, resulting in higher quantification of sedimentation compared to plough dredging.

6.8.1.6 The installation of infrastructure within the Morgan Offshore Array Area may lead to increased suspended sediment concentrations and associated deposition. For increased SSC plumes, the MDS is for the drilled installation of up to 68 monopiles of 16m diameter. Included is the installation of the largest single OSP with foundations consisting of two 16m monopiles, drilled to a depth of 60m. Up to two monopiles may be installed concurrently.

6.8.1.7 The modelled scenarios examined a range of locations across the Morgan Array Area with two concurrent drilling operations at adjacent locations. The drilled pile installations are anticipated to generate plumes with a suspended sediment level of <50mg/l. These levels would be localised and only persist for a short period. Concentrations within the wider plume envelope are much lower, typically <1mg/l a short distance from the discharge locations. Following the cessation of drilling the turbidity levels reduce within a few hours as tidal currents reduce. Some of the finer material associated with the drilling process is re-suspended during successive tides as it is redistributed but turbidity levels remain low. The sedimentation beyond the immediate drilling location is indiscernible (less than 0.1mm). This is due to the relatively slow drilling rate (0.73m/hour), allowing the fine sediment to be widely dispersed while the larger material settles at the release point due to the limited current speed.

6.8.1.8 For the installation of inter-array cables (500km) and interconnector cables (60km) a trench of up to 3m in width and 3m in depth with a triangular cross section may be excavated. For the inter-array cable installation, the sediment plumes are much larger than those for the pile installation. The reason for this is twofold, firstly there is a large amount of sediment mobilised (98,400m^3 of material was mobilised during the two day simulation along the 21.9km modelled route) and secondly there was elevated tidal currents on successive tides which remobilised material over the extended period of installation. Peak plume concentrations are highest at around 500mg/l (at the release site) with the sediment settling during slack water becoming resuspended in the form of an amalgamated plume. Sedimentation of 50mm depth occurs at the trench site, with sediment depths reducing moving away from the trench but remaining in the sediment cell and retained in the sediment transport system.

6.8.1.9 Following the completion of the works the turbidity levels return to baseline within a couple of tidal cycles. It would however be anticipated that spring tides following the works may mobilise and redistribute unconsolidated seabed material deposited at the end of the construction phase; this material will therefore be incorporated into the existing transport regime. Following installation, the native seabed material settles close to where it is mobilised and remains in situ. This would be expected as the baseline modelling indicated that sediment transport potential is limited across the Morgan Array Area. The sedimentation is concentrated along the installation route as material effectively returns to the vicinity from where it was disturbed. Sedimentation depths of <0.5mm arise beyond the immediate vicinity of the trench the day after drilling cessation and therefore would be indistinguishable from the existing seabed sediment.

6.8.1.10 The impact is predicted to be of local spatial extent, short term duration, intermittent and with high reversibility. West of Walney MCZ and the West of Copeland MCZ are both designated for seabed sediment type, therefore direct impacts would be related to changes resulting wholly from construction activities such as sandwave clearance or trenching within designated areas which could potentially change the nature of the seabed. Indirect impacts would be defined as those occurring via the pathways by which the nature of the seabed may be changed. For example, deposition of sediment during slack tide as a result of activities which mobilise sediment within the tidal excursion from the designation.

6.8.1.11 It is predicted that the impact won’t affect any designations or features of importance directly as construction activities will not be undertaken within the West of Walney MCZ or the West of Copeland MCZ. There is the potential during certain conditions, namely flood tides coupled with wind from the southwest, that during construction activities in the east of the Morgan Array Area, sediment plumes may extend to the western edge of the West of Walney MCZ and southern tip of the West of Copeland MCZ. However, prior to reaching these locations, significant dispersion will have occurred with concentrations being well below 1mg/l and the deposition arising from these levels of concentration is de minimis. Therefore, the Morgan Generation Assets construction may affect receptors indirectly within two MCZs. The magnitude is considered to be **negligible** for the receptors within the West of Walney MCZ and the West of Copeland MCZ.

Sensitivity of the receptor

6.8.1.12 The Morgan Generation Assets does not directly overlap with designated zones, but two MCZs do overlap within the physical processes study area, as illustrated in Figure 6.4.

6.8.1.13 The West of Copeland MCZ is designated for protected features such as, subtidal coarse sediment, subtidal sand and subtidal mixed sediments. These subtidal sediments may provide habitats which support a wide range of associated biological communities. The assessment of impacts on these communities is presented in Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR.

6.8.1.14 The sedimentation identified as part of the Morgan Generation Assets assessment is localised and composed of native material therefore the structure and function of the designated features is of low vulnerability and recoverable. The sensitivity of the receptor to changes as a result of seabed preparation, foundation installation and cable installation is therefore considered to be **low**.

6.8.1.15 The protected features within the West of Walney MCZ are subtidal sand, subtidal mud and sea-pen and burrowing megafauna communities. The assessment of impacts on the communities is presented in Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR. The physical processes sediment features would recover from sedimentation as it is localised and composed of native material therefore the composition and function of the features is of low vulnerability and recoverable. The sensitivity of the receptor to changes as a result of seabed preparation, foundation installation and cable installation is therefore considered to be **low**.

Significance of the effect

6.8.1.16 During the installation of the wind turbines in the Morgan Array Area, the peak SSC of sediment plumes is <50mg/l. Plumes do not persist or result in discernible sedimentation. These increased sediment concentrations do not extend as far east as the West of Walney MCZ and the West of Copeland MCZ.

6.8.1.17 Inter-array cable and inter-connector cable installation creates plumes with SSCs on average <50-500mg/l, highest during the release (of material) phase however these plume concentrations do not persist in the designated sites due to their distance from construction activities. Sedimentation is typically <50mm beyond the immediate vicinity of the installation and less than one tenth of this value in the wider domain and would therefore not affect features beyond the development area (i.e. limited to the Morgan Generation Assets). The SSC plumes may extend to the two neighbouring designated sites on the flood tide however sediment concentrations are dispersed to well below background levels at these locations and sedimentation levels are de minimis.

6.8.1.18 Overall, the magnitude of the impact is deemed to be **negligible,** and the sensitivity of the receptor is considered to be **low**. Considering a negligible magnitude of impact combined with a low sensitivity of the receptor where impacts are limited in both temporal and spatial extent the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms. For intertidal and coastal areas, the magnitude of impacts are negligible giving rise to effects of negligible significance.

Operations and maintenance phase

Magnitude of impact

6.8.1.19 Operations and maintenance activities within the Morgan Generation Assets may lead to increases in SSC and associated sediment deposition.

6.8.1.20 The MDS for cable maintenance is for up to 8km of inter-array cable repair comprising one event every three years and a reburial event of up to 20km once every five years (Table 6.11). For the interconnector cable, the MDS is repair of 20km of cable with three events every ten years and reburial events of up to 3km of cable in one event every five years. Repairs would be undertaken using similar methods as those for cable installation activities (i.e. trenching/jetting, with trench width up to 3m and trench depth up to 3m).

6.8.1.21 The worst case for the length of the repair or reburial activity may be up to 20km; therefore, the magnitude of the impacts would be a fraction of those for the construction phase. The sediment plumes and sedimentation footprints would be dependent on which section of the cable is being repaired however the entire length has been quantified under the construction phase scenario discussed above.

6.8.1.22 The impact is predicted to be of local spatial extent, short term duration, intermittent and with high reversibility. As, seen in the construction phase assessment, it is predicted that the impact won't affect any designations or features of importance directly whilst affecting other receptors within two MCZs indirectly to a much lesser degree than the construction phase. The magnitude is, therefore, considered to be **negligible** for the receptors within the West of Walney MCZ and the West of Copeland MCZ.

Sensitivity of receptor

6.8.1.23 The sensitivity of receptors to changes in suspended sediments concentration and sedimentation remains the same as for all construction phases. The significance of the effects will however be reduced as the works are limited to intermittent, discrete repair activities.

6.8.1.24 The West of Walney MCZ and West of Copeland MCZ would recover from the sedimentation which may occur due to maintenance activities. The material released is native to the sediment cell and the minimal sedimentation would be localised. The sensitivity of the receptor to changes as a result of seabed preparation, foundation installation and cable installation is therefore considered **low** and is impacted to a much lesser degree than the construction phase.

Significance of effect

6.8.1.25 Overall, for all the physical processes receptors the magnitude of the impact is deemed to be **negligible**, and the sensitivity of the receptor is considered to be **low**. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

6.8.1.26 Following decommissioning, increases in suspended sediments and potential impact on the physical features would be of lesser magnitude than both the construction phase and the operations and maintenance phase with scour and cable protection remaining *in situ*. In the case of piled foundations, there is no significant disturbance of the seabed during decommissioning as piles are cut off. Increases in SSC due to the removal of inter-array and interconnector cables would be similar to those experienced during the construction phase, as retrieval would be undertaken using similar techniques to installation. As per the MDS (Table 6.11), SSC would also increase temporarily if suction caissons were removed using overpressure to release. The increase in suspended sediments and the potential impact on physical features may persist during decommissioning, however they are localised in nature.

6.8.2 Impacts to the tidal regime due to presence of infrastructure.

6.8.2.1 The presence of infrastructure may lead to changes to the tidal regime during the operations and maintenance phase of the Morgan Generation Assets. This impact is also relevant to the construction phase and following decommissioning associated with residual infrastructure. Modelling was undertaken using the MDS as outlined in Table 6.11 including the presence of scour protection as outlined in the project description (volume 1, chapter 3: Project description of the PEIR). The detail of the numerical modelling underpinning the assessment is provided in volume 4, annex 6.1: Physical processes technical report of the PEIR. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Construction phase

6.8.2.2 As the assessment was carried out with and without the presence of infrastructure, it can be inferred that during the construction phase there will be gradual changes to tidal regime as infrastructure is introduced into the environment. This would result in changes and therefore potential impacts, ranging from the baseline environment (no presence of infrastructure) to the operations and maintenance phase (MDS), which are assessed in the following section.

Operations and maintenance phase

Magnitude of impact

6.8.2.3 The presence of infrastructure within the Morgan Array Area may lead to changes in tidal regime and the associated potential impacts along adjacent shorelines during the operations and maintenance phase of the Morgan Generation Assets. The MDS in terms of hydrographic impacts is for up to 68 wind turbines with 4-legged suction bucket foundations for each jacket leg at 5m diameter spaced 48m apart, and each bucket with a diameter of 16m. Scour protection at each bucket foundation of 2.5m in height and extending 20m covering a total footprint of 10,816m^2.

6.8.2.4 Additionally, the MDS includes four OSP installations with gravity base foundations each with a diameter of 14m at the surface and a slab base 52.5m diameter at the bed. Associated scour protection extends from the slab base by 18.3m at a height of 2.6m giving rise to 6,236m^2 footprint per unit. The modelled scenario presented in volume 4, annex 6.1: Physical processes technical report of the PEIR used an alternate arrangement for the inclusion of the OSPs within the modelled scenario.

6.8.2.5 The parameters in terms of seabed footprint and water column obstruction are similar between each wind turbine unit, as modelled, and each of the four OSP units. Therefore, it is appropriate to infer the impacts on tidal flows due to each of the OSPs would be of the same extent and order of magnitude as those modelled wind turbine sites and to occur at the OSP locations.

6.8.2.6 The results of the modelling indicated that peak tidal flows are redirected in the immediate proximity of structures by a maximum variation of 4cm/s which constitutes as less than 3% of the peak flow and reduces significantly with distance from the structures. These changes are also limited to the immediate Morgan Generation Assets which may have a direct impact on the hydrodynamic regime and persist for the entire lifecycle of the Morgan Generation Assets. However, they would be imperceptible from natural variations beyond the immediate vicinity of the Morgan Array Area and would be reversible on decommissioning. The limited nature of these changes would not significantly influence the tidal regime which underpins sediment transport.

6.8.2.7 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. West of Walney MCZ and the West of Copeland MCZ are designated for seabed sediment characteristics therefore in terms of changes to tidal flow they are not directly affected. However, if changes to tidal flow form a pathway by which these sediments are altered, for example by changes to sediment supply or erosion, then they may be indirectly affected. Under certain circumstances, namely at times of peak current speeds during flood tides with storms approaching from the southwest, changes in littoral currents may extend to the western edge of the West of Walney MCZ and the West of Copeland MCZ. However these values amount to changes of less than ±0.025% of the preconstruction tidal current speed and would be indistinguishable from natural variations, and the resulting influence on sediment transport characteristics would be very slight. The West of Walney MCZ and the West of Copeland MCZ may be impacted indirectly and the magnitude is considered to be **negligible**.

Sensitivity of the receptor

6.8.2.8 No overlap occurs between designated sites and Morgan Generation Assets however the West of Walney MCZ and the West of Copeland MCZ is designated for several protected features such as subtidal coarse sediment, subtidal sand and subtidal mixed sediments supporting burrowing species and megafauna. The potential impacts on the benthic communities are assessed in Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR. Due to the localised and limited changes in tidal regime, the West of Walney MCZ and the West of Copeland MCZ features are of low vulnerability and recoverable. The sensitivity of the receptor to changes in tidal regime infrastructure is therefore considered to be **low**.

Significance of the effect

6.8.2.9 Overall, the magnitude of the impact is deemed to be **negligible,** and the sensitivity of the receptor is considered to be **low**. Considering both a negligible magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

6.8.2.10 Following decommissioning, changes to tidal regime would be of lesser magnitude than the operations and maintenance phase, as no structures would remain in the water column to influence tidal currents, with only the scour and cable protection retained within the context of the MDS.

6.8.2.11 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect West of Walney MCZ and the West of Copeland MCZ receptors indirectly. The magnitude is therefore, considered to be **negligible**.

Sensitivity of receptor

6.8.2.12 As with the operations and maintenance phase, in response to localised changes in tides, the West of Walney MCZ and West of Copeland MCZ features are deemed to be of low vulnerability and recoverable. The sensitivity of this is therefore, considered to be **low**.

Significance of effect

6.8.2.13 Overall, the magnitude of the impact is deemed to be **negligible,** and the sensitivity of the receptor is considered to be **low**. Considering both a negligible magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

6.8.3 Impacts to the wave regime due to presence of infrastructure.

6.8.3.1 Introducing infrastructure may lead to changes to the wave regime principally during the operations and maintenance phase of the Morgan Generation Assets. Also, relevant to a lesser degree is the construction phase and decommissioning associated with residual infrastructure. Modelling was undertaken using the MDS as outlined in Table 6.11 including the presence of scour protection as outlined in the project description (volume 1, chapter 3: Project description of the PEIR). The detail of the numerical modelling underpinning the assessment is provided in volume 4, annex 6.1: Physical processes technical report of the PEIR. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Construction phase

6.8.3.2 Similar to the above assessment on the tidal regime, modelling was carried out with and without the presence of infrastructure. During the construction phase there will be gradual changes to the wave regime as infrastructure is introduced into the environment. This would result in changes and therefore potential impacts ranging from the baseline environment (no presence of infrastructure) to the operations and maintenance phase (MDS), which are assessed in the following section.

Operations and maintenance phase

Magnitude of impact

6.8.3.3 The presence of infrastructure within the Morgan Array Area may lead to changes in wave regime during the operations and maintenance phase of the Morgan Generation Assets. The MDS in terms of hydrographic impacts is for up to 68 wind turbines with 4-legged suction bucket foundations for each jacket leg at 5m diameter spaced 48m apart, and each bucket with a diameter of 16m. Scour protection at each bucket foundation of 2.5m in height and extending 20m covering a total footprint of 10,816m^2.

6.8.3.4 Additionally, the MDS includes four OSP installations with gravity base foundations, each with a diameter of 14m at the surface and a slab base 52.5m diameter at the bed. Associated scour protection extends from the slab base by 18.3m at a height of 2.6m giving rise to 6,236m^2 footprint per unit. The modelled scenario presented in volume 4, annex 6.1: Physical processes technical report of the PEIR used an alternate arrangement for the inclusion of the OSPs within the modelled scenario.

6.8.3.5 The modelled OSP parameters included three structures of 3m diameter at the water surface for each unit which is a reduction on the 14m diameter single structure proposed. Modelling at the wind turbine locations however included four structures each 16m in diameter therefore it may be inferred that the impact on wave climate at the OSP sites would be marginally larger than that modelled but much smaller than experienced at the wind turbine locations.

6.8.3.6 Examination of a 1in1 year storm from the west (of greatest influence of approaching storms) shows the deflection of waves by the structures result in a reduction in the lee and increases where the waves had been deflected either side of each structure. Changes in the wave height were in the order of 3cm equating to <1% of the baseline significant wave height. For a 1in20 year storm event, the pattern is similar however the change in wave height at the structures during a storm event is 3.5cm and due to the larger baseline associated with the return period the overall impact on the wave climate is less obvious.

6.8.3.7 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. West of Walney MCZ and the West of Copeland MCZ are designated for seabed sediment characteristics therefore in terms of changes to wave climate they are not directly affected. However, if the changes form a pathway by which these sediments are altered, for example by changes to sediment supply or erosion, then they may be indirectly affected. Under certain circumstances changes in wave climate may extend to the periphery of the neighbouring MCZs.

6.8.3.8 During a 1in20 year storm from 270º the change in significant wave height on the southwest edge of the West of Walney MCZ may be circa 5mm, similarly, for a 1in20 year storm from 210º the change in significant wave height at the south end of the West of Copeland MCZ is circa 6mm. In each case this represents a reduction of less than 0.1% from the preconstruction wave climate and would be indistinguishable from natural variations and the resulting influence on sediment transport characteristics would be de minimis. The West of Walney MCZ and the West of Copeland MCZ may be impacted indirectly and the magnitude is considered to be **negligible**.

Sensitivity of receptor

6.8.3.9 No overlap occurs between designated sites and Morgan Generation Assets however within 8km of the Morgan Array Area are the West of Walney MCZ and the West of Copeland MCZ, designated for several protected features such as subtidal coarse sediment, subtidal sand and subtidal mixed sediments supporting burrowing species and megafauna. The potential impacts on the benthic communities are assessed in Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR. Due to the localised and limited changes in wave climate, the West of Walney MCZ and the West of Copeland MCZ features are of low vulnerability and recoverable. The sensitivity of the receptor to changes in wave regime because of the presence of infrastructure is therefore considered to be **low**.

Significance of effect

6.8.3.10 Overall, the magnitude of the impact is deemed to be **negligible,** and the sensitivity of the receptor is considered to be **low**. Considering both a negligible magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

6.8.3.11 Following decommissioning, changes to wave regime would be of lesser magnitude than the operations and maintenance phase, as no structures would remain in the water column to influence wave climate, with only the scour and cable protection retained within the context of the MDS.

6.8.3.12 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will indirectly affect West of Walney MCZ and the West of Copeland MCZ receptors. The magnitude is therefore, considered to be **negligible**.

Sensitivity of receptor

6.8.3.13 As with the operations and maintenance phase, in response to localised changes in wave climate, the West of Walney MCZ and the West of Copeland MCZ features are deemed to be of low vulnerability and recoverable. The sensitivity of this is therefore, considered to be **low**.

Significance of effect

6.8.3.14 Overall, the magnitude of the impact is deemed to be **negligible,** and the sensitivity of the receptor is considered to be **low**. Considering both a negligible magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

6.8.4 Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.

6.8.4.1 During the operations and maintenance phase the presence of infrastructure may alter sediment transport and sediment transport pathways leading to changes in the Morgan Generation Assets physical processes study area and associated potential impacts to physical features and bathymetry. The construction and decommissioning phases will be impacted to a lesser degree. During the construction phase infrastructure is introduced gradually, whilst in the decommissioning phase, only those impacts associated with residual infrastructure are present. Modelling was undertaken using the MDS as outlined in Table 6.11 including the presence of scour protection as outlined in the project description (volume 1, chapter 3: Project description of the PEIR). The detail of the numerical modelling underpinning the assessment is provided in volume 4, annex 6.1: Physical processes technical report of the PEIR. The magnitude of the impact is detailed in this section along with the assessment of the effect of changes to physical processes on relevant receptors.

Construction phase

6.8.4.2 During the construction phase there will be gradual changes to sediment transport and sediment transport pathways as infrastructure is introduced into the environment, with changes and therefore potential impacts ranging from the baseline environment (no presence of infrastructure) to the operations and maintenance phase (MDS) assessed in the following section.

Operations and maintenance phase

Magnitude of impact

6.8.4.3 The presence of infrastructure within the Morgan Array Area may lead to changes in sediment transport and sediment transport pathways during the operations and maintenance phase of the Morgan Generation Assets. The MDS in terms of hydrographic impacts is for up to 68 wind turbines with 4-legged suction bucket foundations for each jacket leg at 5m diameter spaced 48m apart, and each bucket with a diameter of 16m. Scour protection at each bucket foundation of 2.5m in height and extending 20m covering a total footprint of 10,816m^2.

6.8.4.4 Additionally, the MDS includes four OSP installations each with gravity base foundations each with a diameter of 14m at the surface and a slab base 52.5m diameter at the bed. Associated scour protection extends from the slab base by 18.3m at a height of 2.6m giving rise to 6,236m^2 footprint per unit. The modelled scenario presented in volume 4, annex 6.1: Physical processes technical report of the PEIR used an alternate arrangement for the inclusion of the OSPs within the modelled scenario.

6.8.4.5 The parameters in terms of seabed footprint and water column obstruction are similar between each wind turbine unit, as modelled, and each of the four OSP units. Therefore, it is appropriate to infer the impacts on sediment transport due to each of the OSPs would be of the same extent and order of magnitude as those modelled wind turbine sites and to occur at the OSP locations.

6.8.4.6 Sediment transport is driven by a combination of tidal currents and wave conditions, the magnitude of these has been individually quantified as described above. For a 1in1 year storm approaching from 210°, during the flood tide the wave climate is in concert with tidal flow reducing the tidal flow on the lee side of the structure further. However, during the ebb flow, the wave climate and tidal flow are in opposition reducing the magnitude of the littoral current. With the presence of infrastructure, wave climate causes a small reduction in the magnitude of flow whilst there is little difference between the magnitude of littoral current flow and the tidal flows. Changes in magnitude compared to baseline current flow are ±5% which would not be sufficient to disrupt sediment features.

6.8.4.7 Residual currents are effectively the driver of sediment transport and therefore any changes to residual currents would have a direct impact on sediment transport which would persist for the lifecycle of the Morgan Generation Assets. However, if the presence of the foundation structures does not have a significant influence on either tide or wave conditions (see impact assessments presented above for changes in tidal and wave regime) they cannot therefore have a significant effect on the sediment transport regime. For completeness, the residual current and sediment transport was simulated with the foundations in place. The maximum change in residual current and sediment transport is circa ±10% which is largely sited within close proximity to the wind turbine foundation structures (i.e. as a result of the scour protection). Changes in the residual current and sediment transport reduce with increasing distance from the wind turbines towards baseline levels.

6.8.4.8 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. West of Walney MCZ and the West of Copeland MCZ are both designated for seabed sediment type, therefore direct impacts would be related to changes resulting wholly from construction activities such as placement of infrastructure or scour protection within designated areas which could potentially change the nature of the seabed. Indirect impacts would be defined as those occurring via the pathways by which the nature of the seabed may be changed. For example, changes in sediment transport drivers or pathways which may affect sediment characteristics within the designated area.

6.8.4.9 It is predicted that the impact won't affect any designations or features of importance directly as construction activities will not be undertaken within the West of Walney MCZ or the West of Copeland MCZ. Under certain circumstances, with more extreme storms approaching from the southwest, changes in residual currents may extend to western edge of the West of Walney MCZ and the southern tip of the West of Copeland MCZ. However these values amount to changes of less than ±1% of the preconstruction values for a 1in20 year storm from 270º and would be indistinguishable from natural variations. The resulting influence on sediment transport characteristics would be minimal. The West of Walney MCZ and the West of Copeland MCZ may be impacted indirectly and the magnitude is considered to be **negligible**.

Sensitivity of receptor

6.8.4.10 No overlap occurs between designated sites and Morgan Generation Assets, however, within 8km of the Morgan Array Area are the West of Walney MCZ and the West of Copeland MCZ designated for several protected features such as, subtidal coarse sediment, subtidal sand and subtidal mixed sediments supporting burrowing species and megafauna. The potential impacts on the benthic communities are assessed in Volume 2, chapter 7: Benthic subtidal and intertidal ecology of the PEIR. Due to the localised and limited changes in the littoral currents which drives sediment transport, the West of Walney MCZ and the West of Copeland MCZ features are of low vulnerability and recoverable. The sensitivity of the receptor to changes in sediment transport pathways because of the presence of infrastructure is therefore considered to be **low**.

Significance of effect

6.8.4.11 Overall, the magnitude of the impact is deemed to be **negligible** and the sensitivity of the receptor is considered to be **low**. Considering both a low magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

6.8.4.12 Following decommissioning, changes to the sediment transport and sediment pathways would be of lesser magnitude than the operations and maintenance phase, as no structures would remain in the water column to influence the littoral currents above bed level, with only the scour and cable protection remaining *in situ*.

6.8.4.13 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will indirectly affect the West of Walney MCZ and the West of Copeland MCZ receptors. The magnitude is therefore, considered to be **negligible**.

Sensitivity of receptor

6.8.4.14 As with the operations and maintenance phase, in response to localised changes in the sediment transport pathways, the West of Walney MCZ and the West of Copeland MCZ features are deemed to be of low vulnerability and recoverable. The sensitivity of this receptor is therefore, considered to be **low**.

Significance of effect

6.8.4.15 Overall, the magnitude of the impact is deemed to be **negligible,** and the sensitivity of the receptor is considered to be **low**. Considering both a negligible magnitude of impact combined with a low sensitivity of the receptor coupled with the limited spatial extent of the impact the effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

6.8.5 Impacts to temperature and salinity stratification due to the presence of infrastructure.

6.8.5.1 Within the physical processes study area most of the water column remains thoroughly mixed due to the occurrence of sufficiently intense tidal mixing throughout the year. It has been noted that stratification of the water column can occur in estuaries and specifically in Morecambe Bay, as fresh water associated with river discharge is less dense than the saline offshore environment. In order to disrupt temperature and salinity stratification in Morecambe Bay a change in hydrography would be required in this region, an example being increased tidal currents or wave climate resulting in additional mixing.

6.8.5.2 The modelling studies undertaken for the Morgan Generation Assets detailed in volume 4, annex 6.1: Physical processes technical report of the PEIR demonstrated that potential changes in tidal currents and wave climate do not extend into these areas located beyond the physical processes study area therefore there will be no impact on thermal stratification.

6.8.6 Future monitoring

6.8.6.1 Overall, no effects which are significant in EIA terms have been identified therefore, in terms of physical processes, no specific monitoring is recommended beyond those related to undertaking maintenance activities outlined in the project description, volume 1, chapter 3: Project description of the PEIR. These include routine inspections of inter-array and interconnector cables to ensure the cables are buried to an adequate depth and not exposed. We anticipate that geophysical surveys will be required as a condition of the deemed marine licence.

6.9 Cumulative effect assessment methodology

6.9.1 Methodology

6.9.1.1 The CEA takes into account the impact associated with the Morgan Generation Assets together with other projects and plans. 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 3, annex 5.1: Cumulative effects screening matrix of the PEIR). Each project has been considered on a case by case basis for screening in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

6.9.1.2 The physical processes CEA methodology has followed the methodology set out in volume 1, chapter 5: EIA methodology of the PEIR. As part of the assessment, all projects and plans considered alongside the Morgan Generation Assets have been allocated into 'tiers' reflecting their current stage within the planning and development process, these are listed below.

6.9.1.3 A tiered approach to the assessment has been adopted, as follows:

- Tier 1
  - Under construction
  - Permitted application
  - Submitted application
  - Those currently operational that were not operational when baseline data were collected, and/or those that are operational but have an ongoing impact (for example, with associated maintenance activities)
- Tier 2
  - Scoping report has been submitted and is in the public domain
- Tier 3
  - Scoping report has not been submitted and is not in the public domain
  - Identified in the relevant Development Plan
  - Identified in other plans and programmes.

6.9.1.4 This tiered approach is adopted to provide a clear assessment of the Morgan Generation Assets alongside other projects, plans and activities.

6.9.1.5 The specific projects, plans and activities scoped into the CEA, are outline in Table 6.14. In accordance with The Planning Inspectorate (PINS) advice, where other projects are expected to be completed before construction of the proposed NSIP and the effects of those projects are fully determined, effects arising from them are considered as part of the baseline and are considered as part of both the construction and operational assessment.

Table 6.14: List of other projects, plans and activities considered within the CEA.

Project/Plan	Status	Distance from the Morgan Array Area (km)	Description of project/plan	Dates of construction (if applicable)	Dates of operation (if applicable)	Overlap with the Morgan Generation Assets
Tier 1- Offshore Wind Projects and Associated Cables						
Walney extension 3	Operational	7.55	Maintenance activities at Walney extension 3	N/A	28/11/2014- 28/11/2039	Project Maintenance Phase overlaps with Proposed Development Construction and Operations and Maintenance Phases.
Walney extension 4	Operational	7.55	Maintenance activities at Walney extension 4	N/A	28/11/2014- 28/11/2039	Project Maintenance Phase overlaps with Proposed Development Construction and Operations and Maintenance Phases.
Walney 2	Operational	11.90	Maintenance activities at Walney 2	N/A	01/11/2007- 01/11/2032	Project Maintenance Phase overlaps with Proposed Development Construction and Operations and Maintenance Phases.
West of Duddon Sands	Operational	15.2	Maintenance activities at West of Duddon Sands	N/A	23/09/2008- 23/09/2033	Project Maintenance Phase overlaps with Proposed Development Construction and Operations and Maintenance Phases.
Walney 1	Operational	15.54	Maintenance activities at Walney 1	N/A	01/11/2007- 01/11/2032	Project Maintenance Phase overlaps with Proposed Development Construction and Operations and Maintenance Phases.
Ormonde Energy Limited	Operational	23.29	Maintenance activities at Ormonde Energy Limited	N/A	01/01/2011- 01/01/2036	Project Maintenance Phase overlaps with Proposed Development Construction and Operations and Maintenance Phases.
Barrow Offshore Wind Limited	Operational	30.03	Maintenance activities at Barrow Offshore Wind Limited	N/A	01/03/2003- 01/03/2028	Project Maintenance Phase overlaps with Proposed Development Construction Phases.
Disposal Sites						
Walney Extension pontoon/jetty dredging and disposal	Operational	15.15	A marine licence is being sought for dredging and associated disposal activities for the Walney Extension Offshore Wind Farm operations and maintenance base at the Port of Barrow.	N/A	07/02/2019- 06/02/2029	Project Operations Phase overlaps with Proposed Development Construction Phases.
Tier 2- Offshore Wind Projects and Associated Cables						
Mona Offshore Wind Project	Scoping submitted	5.5	Mona Offshore Wind Project	01/01/2026-31/12/2029	01/01/2030-31/12/2065	Project Construction Phase overlaps with Proposed Development Construction Phase. Project Operations and Maintenance Phase overlaps with Proposed Development Operations and Maintenance Phase.
Morecambe Offshore Windfarm Generation Assets	Scoping submitted	11.24	Morecambe Offshore Wind Farm	01/01/2028-31/12/2029	01/01/2030-31/12/2065	Project Construction Phase overlaps with Proposed Development Construction Phase. Project Operations and Maintenance Phase overlaps with Proposed Development Operations and Maintenance Phase.
Morgan/ Morecambe Transmission Assets (scoping search area)	Scoping submitted	11.24	Morgan Generation Assets and Morcambe offshore wind farm transmission assets	01/01/2028-31/12/2029	01/01/2030-31/12/2065	Project Construction Phase overlaps with Proposed Development Construction Phase. Project Operatiosn and Maintenance Phase overlaps with Proposed Development Operations and Maintenance Phase.

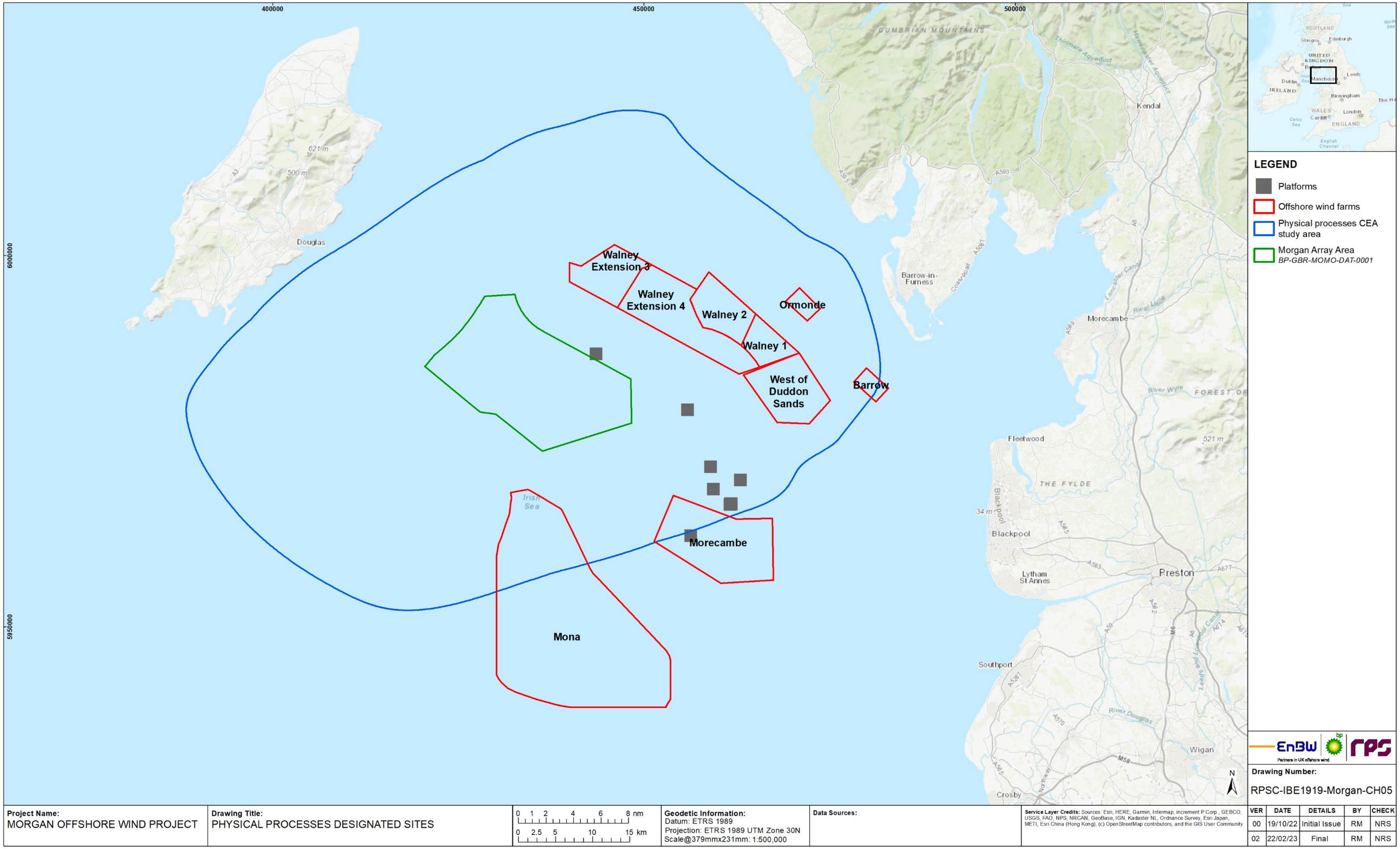

Figure 6.5: Other projects, plans and activities screened into the cumulative effects assessment for Morgan Generation Assets.

6.9.2 Maximum design scenario

6.9.2.1 The MDS identified in Table 6.15 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative effects presented and assessed in this section have been selected from the Project Design Envelope provided in volume 1, chapter 3: Project description of the PEIR as well as the information available on other projects and plans, in order to inform a 'MDS'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the Project Design Envelope (e.g. different wind turbine layout), to that assessed here, be taken forward in the final design scheme.

Table 6.15: Maximum design scenario considered for the assessment of potential cumulative effects on physical processes.

[a] C=construction, O=operations and maintenance, D=decommissioning

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	MDS as described for the Morgan Generation Assets Table 6.11 assessed cumulatively with the following other projects/plans: **Tier 1** **Construction Phase** • Maintenance of Walney Extension 3 offshore wind farm • Maintenance of Walney Extension 4 offshore wind farm • Maintenance of Walney 2 offshore wind farm • Maintenance of West of Duddon Sands offshore wind farm • Maintenance of Walney 1 offshore wind farm • Maintenance of Ormonde offshore wind farm • Maintenance of Barrow offshore wind farm • Use of Walney Extension pontoon/jetty dredging and disposal site **Operations and Maintenance Phase** • Maintenance of Walney Extension 3 offshore wind farm • Maintenance of Walney Extension 4 offshore wind farm • Maintenance of Walney 2 offshore wind farm • Maintenance of West of Duddon Sands offshore wind farm • Maintenance of Walney 1 offshore wind farm • Maintenance of Ormonde offshore wind farm • Maintenance of Barrow offshore wind farm • Use of Walney Extension pontoon/jetty dredging and disposal site **Decommissioning Phase** • Use of Walney Extension pontoon/jetty dredging and disposal site **Tier 2** **Construction Phase** • Tier 1 Projects • Construction of Mona Offshore Wind Project • Construction of Morecambe Offshore Windfarm Generation Assets • Construction of the Morgan/Morecambe Transmission Assets **Operations and Maintenance Phase** • Tier 1 Projects • Operations and maintenance of Mona Offshore Wind Project • Operations and maintenance of Morecambe Offshore Windfarm Generation Assets • Operations and maintenance of Morgan/Morecambe Transmission Assets **Decommissioning Phase** • Tier 1 Projects • Mona Offshore Wind Project residual structures	Outcome of the CEA will be greatest when the greatest number of other schemes are considered in combination. Including schemes and developments within the CEA study area to capture the potential overlap of impacts during the construction, operations and maintenance and decommissioning phases. Activities from schemes that potentially increase suspended sediment concentrations during the temporal overlap with the Morgan Generation Assets phases have been included as these may create a cumulative impact on physical features/ receptors.

Potential cumulative effect	Phase[a]			Maximum Design Scenario	Justification
	C	O	D		
				• Morecambe Offshore Windfarm residual structures **Tier 3** **Construction Phase** • Tier 2 Projects **Operations and Maintenance Phase** • Tier 2 Projects **Decommissioning Phase** • Tier 2 Projects	
Impacts to the tidal regime due to presence of infrastructure. Impacts to the wave regime due to presence of infrastructure. Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.	✓	✓	✓	**Tier 2** **Construction Phase** • Tier 1 Projects • Construction of Mona Offshore Wind Project • Construction of Morecambe Offshore Windfarm Generation Assets • Construction of the Morgan/Morecambe Transmission Assets **Operations and Maintenance Phase** • Tier 1 Projects • Operations and maintenance of Mona Offshore Wind Project • Operations and maintenance of Morecambe Offshore Windfarm Generation Assets • Operations and maintenance of Morgan/Morecambe Transmission Assets **Decommissioning Phase** • Tier 1 Projects • Mona Offshore Wind Project residual structures • Morecambe Offshore Windfarm residual structures **Tier 3** **Construction Phase** • Tier 2 Projects **Operations and Maintenance Phase** • Tier 2 Projects **Decommissioning Phase** • Tier 2 Projects	

6.10 Cumulative effects assessment

6.10.1.0 A description of the significance of cumulative effects upon physical processes receptors arising from each identified impact is given below.

6.10.1 Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.

6.10.1.1 Increased suspended sediment concentrations may arise due to seabed preparation involving sandwave clearance, the installation of the wind turbines and OSP foundations, the installation and/or maintenance of cables and associated decommissioning activities. Should the other projects cited take place concurrently with the Morgan Generation Assets (construction or operations and maintenance), there is potential for cumulative increased turbidity levels.

Construction phase

Magnitude of impact

6.10.1.2 The magnitude of the increase in suspended sediment concentrations arising from seabed preparation involving sandwave clearance, the installation of the wind turbines, OSP foundations and cables has been assessed as low for the Morgan Generation Assets alone, as described in section 6.8.

6.10.1.3 The construction phase of the Morgan Generation Assets coincides with the maintenance phase of the Barrow offshore wind farm, Ormonde offshore wind farm, Walney 1 offshore wind farm, Walney 2, Walney Extension 3, Walney Extension 4 and West of Duddon Sands offshore wind farm. These activities are likely to be of a similar nature to those associated with the Morgan Generation Assets, such as repair and reburial of inter-array and interconnector cables. Maintenance activities may result in increased suspended sediment concentration, however these activities would be of limited spatial extent and frequency and unlikely to interact with sediment plumes from the Morgan Generation Assets.

6.10.1.4 The cumulative impact assessment also considers sea disposal of dredged material at the Walney Extensions offshore wind farm, located 15.15km from the Morgan Generation Assets. If the construction phase activities and dredge material disposal coincided both resultant plumes would be advected on the tidal currents, they would travel in parallel, and not towards one another, and are unlikely to interact.

6.10.1.5 During the construction phase of the Morgan Generation Assets there is the potential for cumulative impacts with two proposed offshore wind farm installations (Mona and Morecambe) including the transmission assets combined for Morgan/Morecambe wind farms. Construction activities may result in increased suspended sediment concentration; however, these activities would be of limited spatial extent and frequency and unlikely to interact with sediment plumes from the Morgan Generation Assets as they would be advected on the tidal currents and would travel in parallel.

6.10.1.6 The cumulative effect is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect no designated sites directly whilst affecting the West of Walney MCZ and the West of Copeland MCZ important sediment features and associated fauna indirectly. The magnitude is therefore, considered to be **negligible**.

Sensitivity of the receptor

6.10.1.7 The West of Walney MCZ and the West of Copeland MCZ features are deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.1.8 Overall, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance (not significant in EIA terms).

Operations and maintenance phase

Magnitude of impact

6.10.1.9 The magnitude of the increase in suspended sediment concentrations arising from maintenance activities during operations and maintenance phase, has been assessed as negligible for the Morgan Generation Assets alone, as described in section 6.8.

6.10.1.10 The operations and maintenance phase of the Morgan Generation Assets coincides with the maintenance phase of the Barrow offshore wind farm, Ormonde offshore wind farm, Walney 1 offshore wind farm, Walney 2, Walney Extension 3, Walney Extension 4 and West of Duddon Sands offshore wind farm. Maintenance activities may result in increased suspended sediment concentrations; however these activities would be of limited spatial extent and frequency and are unlikely to interact with sediment plumes from the Morgan Generation Assets. With resultant plumes from the Morgan Generation Assets being smaller in scale than during the construction phase potential cumulative impacts are less likely to occur during this operations and maintenance phase.

6.10.1.11 Potential cumulative impacts may relate to maintenance of inter-array and interconnector cables or wind turbine infrastructure. However, maintenance activities are both intermittent and a smaller scale than that of the construction phase and therefore any potential cumulative impacts are less likely to occur and be on a smaller scale.

6.10.1.12 The cumulative impact assessment considers the proposed development of Mona Offshore Wind Project, Morecambe Offshore Windfarm Generation Assets and the Morgan/Morecambe Transmission Assets with potential maintanence for this infrastructure coinciding with the operations and maintanence phase of Morgan Generation Assets. Maintenance activities are both intermittent and a smaller scale than that of the construction phase and therefore any potential cumulative impacts are less likely to occur and will be on a smaller scale.

6.10.1.13 The cumulative effect is predicted to be of local spatial extent, short term duration, intermittent and high reversibility. It is predicted that the impact will affect no designated sites directly whilst affecting the West of Walney MCZ and the West of Copeland MCZ important sediment features and associated fauna indirectly. The magnitude is therefore, considered to be **negligible**.

Sensitivity of the receptor

6.10.1.14 The West of Walney MCZ and the West of Copeland MCZ features are deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.1.15 Overall, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance (not significant in EIA terms).

Decommissioning phase

6.10.1.16 The magnitude of the increase in suspended sediment concentrations arising from decommissioning activities has been described in section 6.8 as having a lesser impact than the construction phase. The SSC would however increase temporarily as inter-array and interconnector cables are retrieved and if suction caissons were removed using overpressure to release. The increase in suspended sediments and the potential impact on physical features may persist during decommissioning, however they are localised in nature.

6.10.1.17 All the Tier 1 offshore wind farms discussed above may already have been decommissioned due to similar operational lifespan with only residual infrastructure remaining on the seabed. Offshore wind farms decommissioned prior to the Morgan Generation Assets would not cause a cumulative increase in suspended sediment concentrations.

6.10.1.18 Decommissioning of the Morecambe Offshore Windfarm Generation Assets and Mona Offshore Wind Project will most likely occur on the same projected timeline as the Morgan Generation Assets. Decommissioning activity may result in increased suspended sediment concentrations however this would be localised and of a lesser magnitude than the construction phase. Residual structures remaining from the decommissioning of the Mona Offshore Wind Project and Morecambe Offshore Windfarm Generation Assets would not have a cumulative impact on suspended sediment concentrations.

Sensitivity of the receptor

6.10.1.19 The West of Walney MCZ and the West of Copeland MCZ features are deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.2 Overall, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of negligible significance (not significant in EIA terms).

6.10.3 Impacts to the tidal regime due to presence of infrastructure.

6.10.3.1 The presence of infrastructure may lead to changes to the tidal regime principally during the operations and maintenance phase of the Morgan Generation Assets. This impact is also relevant to the construction phase and following decommissioning associated with residual infrastructure.

Construction phase

6.10.3.2 Assessment of the Morgan Generation Assets was carried out with and without the presence of infrastructure. We can infer that during the construction phase there will be gradual changes to tidal regime. With changes occurring from the baseline environment (no presence of infrastructure) to the operations and maintenance phase (MDS).

Operations and maintenance phase

Magnitude of impact

6.10.3.3 The presence of infrastructure within the Morgan Array Area may lead to changes in tidal regime during the operations and maintenance phase of the Morgan Generation Assets. The magnitude of increased infrastructure leading to changes in the tidal regime the operations and maintenance phase, has been assessed as low for the Morgan Generation Assets alone as described in section 6.8.

6.10.3.4 The proposed development of the Mona Offshore Wind Project may be in operation during the operations and maintenance phase of the Morgan Generation Assets. The Mona Offshore Wind Project array is 5.5km from the Morgan Array Area. The modelling carried out for Morgan Generation Assets concluded that the impact on tidal regime was low when considering the development alone. Changes are observed in close proximity to the turbine structures with tides returning to near baseline levels beyond the Morgan Array Area. Additionally changes in flow patterns are aligned with tidal flow and therefore, no overlap is expected to create cumulative changes in the tidal regime between the two wind farm developments.

6.10.3.5 On similar project timelines to the Morgan Generation Assets project, the operation of the Morecambe Offshore Windfarm Generation Assets alongside the Morecambe/Morgan Transmission Assets are expected to coincide with the operations and maintenance phase of the Morgan Generation Assets. The impact of Morgan Generation Assets on the tidal regime has been modelled on its own, with a low magnitude of impact discussed in section 6.8. As highlighted above the increase in infrastructure will not cause a cumulative change on the tidal regime as the impacts caused by the turbines are localised and return to near baseline levels just beyond the infrastructure. An overlap of these changes in the tidal flow is not expected as they are limited to the proximity Morgan Array Area and are aligned with tidal flow.

6.10.3.6 The cumulative effect is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect no designated sites directly whilst affecting the West of Walney MCZ and the West of Copeland MCZ important sediment features and associated fauna indirectly. The magnitude is therefore, considered to be **negligible**.

Sensitivity of the receptor

6.10.3.7 The cumulative effects of the presence of infrastructure from multiple offshore wind farm developments *in situ*, operating and maintained concurrently does not further impact the important features of the West of Walney MCZ and the West of Copeland

MCZ, more than a single development due to the impacts of infrastructure typically being restricted to the vicinity of the developments.

6.10.3.8 The West of Walney MCZ and the West of Copeland MCZ is deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.3.9 Overall, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

6.10.3.10 The Tier 1 offshore wind farm developments will have been decommissioned, with only residual infrastructure remaining (such as scour protection) and would have a negligible magnitude of impact on tidal regime; the effects of which would not overlap with other developments.

6.10.3.11 With a similar lifespan to the Morgan Generation Assets, Mona Offshore Wind Project and Morecambe Offshore Windfarm Generation Assets may be or have been decommissioned during the decommissioning phase of Morgan Generation Assets. Residual structures left on the seabed from decommissioning will not cause a cumulative impact on changes to the tidal regime and will result in a lesser magnitude of impact than that described in the operations and maintenance phase.

6.10.3.12 The cumulative effect is predicted to be of local spatial extent, long term duration and high reversibility. It is predicted that the impact will affect the West of Walney MCZ and the West of Copeland MCZ indirectly with a **negligible** magnitude.

Sensitivity of the receptor

6.10.3.13 The cumulative effects of the decommissioned wind farm infrastructure from multiple offshore wind farm developments does not further impact the designated sites, more than a single development due to the impacts of decommissioning typically reserved to the vicinity of the developments.

6.10.3.14 The cumulative effects of the decommissioning of the Morgan Generation Assets and the Mona Offshore Wind Project with any infrastructure remaining *in situ* does not further impact the designated sites, more than a single development due to the impacts of decommissioning typically restricted to the vicinity of the developments.

6.10.3.15 The West of Walney MCZ and the West of Copeland MCZ is deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.3.16 Overall, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

6.10.4 Impacts to the wave climate due to presence of infrastructure.

6.10.4.1 Introducing infrastructure may lead to changes to the wave regime principally during the operations and maintenance phase of the Morgan Generation Assets. Also, relevant to a lesser degree is the construction phase and following decommissioning associated with residual infrastructure.

Construction phase

6.10.4.2 Assessment of the Morgan Generation Assets was carried out with and without the presence of infrastructure we can infer that during the construction phase there will be gradual changes to tidal regime. With changes occurring from the baseline environment (no presence of infrastructure) to the operations and maintenance phase (MDS).

Operations and maintenance phase

Magnitude of impact

6.10.4.3 The presence of Morgan Generation Assets infrastructure may lead to changes in wave regime during the operations and maintenance phase of the Morgan Generation Assets. The magnitude of changes in the wave regime has been assessed as low for the Morgan Generation Assets alone as described in section 6.8.

6.10.4.4 The offshore wind farm closest to Morgan Generation Assets is the proposed Mona Offshore Wind Project located to the south of the Morgan Array Area. The proposed development of the Mona Offshore Wind Project comprising of 68 turbines may be in operation during the operations and maintenance phase of the Morgan Generation Assets. The Mona Array Area is 5.5km from the Morgan Array Area. The modelling carried out for Morgan Generation Assets concluded that the impact on the wave regime was low when considering the development alone. Changes are observed in close proximity to the turbine structures with changes to wave climate decreasing rapidly with distance from the infrastructure. Under storm conditions from the north the change in wave climate due to the Morgan Generation Assets may extend to the limit of the Mona Offshore Wind Project however at this distance the change is diminutive (i.e. circa 0.2% reduction in significant wave height during a 1in20 storm from the north).

6.10.4.5 On similar project timelines, the operation of the Round 4 Morecambe Offshore Windfarm Generation Assets alongside the Morecambe/Morgan Transmission Assets are expected to coincide with the operations and maintenance phase of the Morgan Generation Assets. The impact of Morgan Generation Assets on the wave regime has been modelled on its own, with a low magnitude of impact discussed in section 6.8. As highlighted above the increase in infrastructure will not cause a cumulative change on the wave regime as the impacts caused by the turbines are localised and return to baseline levels just beyond the infrastructure and an overlap of these changes in the wave regime is not predicted.

6.10.4.6 Storms approaching from the north may influence the wave climate in the Morgan Array Area to a small degree. The changes in wave climate due to storms from the southwest and west interacting with Morgan Array infrastructure do not extend to the Morecambe site due to the influence of Anglesey. The limited frequency and fetch length would reduce the likelihood of storms from the east giving rise to a change in wave climate in the Morgan Array Area due to the presence of the Morecambe Offshore Windfarm Generation Assets.

6.10.4.7 The cumulative effect is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the West of Walney MCZ and the West of Copeland MCZ features indirectly with a **negligible** magnitude.

Sensitivity of the receptor

6.10.4.8 The cumulative effects of the presence of infrastructure from multiple offshore wind farm developments, operating and maintained concurrently does not further impact the West of Walney MCZ and the West of Copeland MCZ features, more than a single development due to the impacts of infrastructure typically restricted to the vicinity of the developments.

6.10.4.9 The West of Walney MCZ and the West of Copeland MCZ are deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.4.10 Overall, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

6.10.4.11 The Tier 1 offshore wind farm developments will have been decommissioned with only residual infrastructure remaining (such as scour protection) and would have a negligible magnitude of impact on wave climate; the effects of which would not overlap with other developments.

6.10.4.12 With a similar lifespan to the Morgan Generation Assets, Mona Offshore Wind Project and Morecambe Offshore Windfarm Generation Assets may be or have been decommissioned during the decommissioning phase of the Morgan Generation Assets. Residual structures left on the seabed from decommissioning will not cause a cumulative impact on changes to the wave regime and will result in a lesser magnitude of impact than that described in the operations and maintenance phase.

6.10.4.13 The cumulative effect is predicted to be of local spatial extent, long term duration and high reversibility. It is predicted that the impact will affect the West of Walney MCZ and the West of Copeland MCZ indirectly with a **negligible** magnitude.

Sensitivity of the receptor

6.10.4.14 The cumulative effects of the decommissioning of the wind farm infrastructure from multiple offshore wind farm developments does not further impact the West of Walney MCZ and the West of Copeland MCZ, more than a single development due to the impacts of decommissioning typically reserved to the vicinity of the developments.

6.10.4.15 The West of Walney MCZ and the West of Copeland MCZ are deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.4.16 Overall, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

6.10.5 Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.

6.10.5.1 During the operations and maintenance phase the presence of infrastructure may alter the sediment transport and sediment transport pathways leading to changes in the Morgan Generation Assets area. The construction phase and following decommissioning associated with residual infrastructure is relevant but changes are gradual and to a lesser extent in these phases.

Construction phase

6.10.5.2 Assessment of the Morgan Generation Assets was carried out with and without the presence of infrastructure and we can infer that during the construction phase there will be gradual changes to sediment transport and sediment transport pathways. With changes occurring from the baseline environment (no presence of infrastructure) to the operations and maintenance phase (MDS).

Operations and maintenance phase

Magnitude of impact

6.10.5.3 The presence of Morgan Generation Assets infrastructure may lead to changes in sediment transport and sediment transport pathways during the operations and maintenance phase of the Morgan Generation Assets. The magnitude of changes in sediment transport and sediment transport pathways during the operations and maintenance phase, has been assessed as low for the Morgan Generation Assets alone as described in section 6.8.

6.10.5.4 The proposed development of the Mona Offshore Wind Project may be in operation during the operations and maintenance phase of the Morgan Generation Assets. The Mona Array Area is 5.5km from the Morgan Array Area. The modelling carried out for Morgan Generation Assets concluded that the impact on the sediment transport and sediment transport pathways was low when considering the development alone. Changes are observed in close proximity to the turbine structures with changes to sediment transport and sediment transport pathways decreasing rapidly with distance from the infrastructure. Under storm conditions from the north the change in sediment transport and sediment transport pathways due to the Morgan Generation Assets may extend to the limit of the Mona Generation Assets however at this distance the change is diminutive (i.e. circa 0.2% reduction in significant wave height during a 1in20 storm from the north).

6.10.5.5 On similar project timelines, the construction and operation of the Round 4 Morecambe Offshore Windfarm Generation Assets alongside the Morecambe/Morgan Transmission Assets are expected to coincide with the operations and maintenance phase of the Morgan Generation Assets. The impact of Morgan Generation Assets on the sediment transport and sediment transport pathways has been modelled on its own, with a low magnitude of impact discussed in section 6.8. As highlighted above the increase in infrastructure will not cause a cumulative change on the sediment transport regime as the impacts caused by the turbines are localised and return to baseline levels just beyond the infrastructure. An overlap of these changes in the sediment transport and sediment transport pathways is not expected as they are limited to the immediate vicinity of the Morgan Array Area.

6.10.5.6 The cumulative effect is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the West of Walney MCZ and the West of Copeland MCZ indirectly with a **negligible** magnitude.

Sensitivity of the receptor

6.10.5.7 The cumulative effects of the presence of infrastructure from multiple offshore wind farm developments, operating concurrently does not further impact the West of Walney MCZ and the West of Copeland MCZ, more than a single development due to the impacts of infrastructure being restricted to the immediate vicinity of the developments.

6.10.5.8 The West of Walney MCZ and the West of Copeland MCZ are deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.5.9 Overall, the magnitude of the cumulative impact is deemed to be low, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Decommissioning phase

Magnitude of impact

6.10.5.10 The Tier 1 offshore wind farm developments will have been decommissioned with only residual infrastructure remaining (such as scour protection) and would have a negligible magnitude of impact on sediment transport, the effects of which would not extent to the other developments.

6.10.5.11 With a similar lifespan to the Morgan Generation Assets, Morecambe and Mona offshore wind farms may be or have been decommissioned during the decommissioning phase of Morgan Generation Assets. Residual structures left on the seabed from decommissioning will not cause a cumulative impact on changes to the sediment transport and sediment transport pathways and will result in a lesser magnitude of impact than that described in the operations and maintenance phase.

6.10.5.12 The cumulative effect is predicted to be of local spatial extent, long term duration and high reversibility. It is predicted that the impact will affect the West of Walney MCZ and the West of Copeland MCZ indirectly with **negligible** magnitude.

Sensitivity of the receptor

6.10.5.13 The cumulative effects of the decommissioning of the wind farm infrastructure from multiple offshore wind farm developments does not further impact the West of Walney MCZ and the West of Copeland MCZ more than a single development due to the impacts of decommissioning being restricted to the vicinity of the developments.

6.10.5.14 The West of Walney MCZ and the West of Copeland MCZ is deemed to be of low vulnerability and recoverable. The sensitivity of the receptor is therefore, considered to be **low**.

Significance of effect

6.10.5.15 Overall, the magnitude of the cumulative impact is deemed to be negligible, and the sensitivity of the receptor is considered to be low. The cumulative effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

6.11 Transboundary effects

6.11.1.1 A screening of transboundary impacts has been carried out and has identified that there was no potential for significant transboundary effects with regard to physical processes from the Morgan Generation Assets upon the interests of other states.

6.12 Inter-related effects

6.12.1.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the Morgan Generation Assets (construction, operations and maintenance, and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three phases (e.g. subsea noise effects from piling, operational turbines, vessels and decommissioning).
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on physical processes, such as sediment plumes, may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects may be short term, temporary or transient effects, or incorporate longer term effects.

6.12.1.2 A description of the likely interactive effects arising from the Morgan Generation Assets on physical processes is provided in volume 2, chapter 15: Inter-related effects of the PEIR.

6.13 Summary of impacts, mitigation measures and monitoring

6.13.1.1 Information on physical processes within the physical processes study area was collected through detailed desktop review of existing studies and datasets and supported by numerical modelling.

- Table 6.16 presents a summary of the potential impacts, measures proposed to be adopted as part of the project and residual effects in respect to physical processes. The impacts assessed include:
  - Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features
  - Changes to tidal regime, wave climate and sediment transport due to presence of infrastructure and the associated potential impacts along adjacent shorelines
- Overall, it is concluded that there will be no significant effects arising from the Morgan Generation Assets during the construction, operations and maintenance or decommissioning phases
- Table 6.17 presents a summary of the potential cumulative impacts, mitigation measures and residual effects. The cumulative impacts assessed include:
  - Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features
  - Changes to tidal currents, wave climate, littoral currents and sediment transport
- Overall, it is concluded that there will be no significant cumulative effects from the Morgan Generation Assets alongside other projects/plans
- No potential transboundary impacts have been identified in regard to effects of the Morgan Generation Assets.

Table 6.16: Summary of potential environmental effects, mitigation and monitoring.

[a] C=construction, O=operations and maintenance, D=decommissioning

Description of impact	Phase[a] C	O	D	Measures adopted as part of the project	Magnitude of impact	Sensitivity of the receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	N/A	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Impacts to the tidal regime due to presence of infrastructure.	✓	✓	✓	Scour Protection	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Impacts to the wave regime due to presence of infrastructure.	✓	✓	✓	Scour Protection	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.	✓	✓	✓	Scour Protection	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A

Table 6.17: Summary of potential cumulative environmental effects, mitigation and monitoring.

[a] C=construction, O=operations and maintenance, D=decommissioning

Description of effect	Phase[a] C	O	D	Measures adopted as part of the project	Magnitude of impact	Sensitivity of the receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Tier 1										
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	N/A	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Impacts to the tidal regime due to presence of infrastructure.	✓	✓	✓	Scour Protection	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Impacts to the wave regime due to presence of infrastructure.	✓	✓	✓	Scour Protection	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.	✓	✓	✓	Scour Protection	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A

Description of effect	Phase[a] C	O	D	Measures adopted as part of the project	Magnitude of impact	Sensitivity of the receptor	Significance of effect	Further mitigation	Residual effect	Proposed monitoring
Tier 2										
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	N/A	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Impacts to the tidal regime due to presence of infrastructure.	✓	✓	✓	Scour Protection	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Impacts to the wave regime due to presence of infrastructure.	✓	✓	✓	Scour Protection	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Impacts to sediment transport and sediment transport pathways due to presence of infrastructure and associated potential impacts to physical features and bathymetry.	✓	✓	✓	Scour Protection	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A
Tier 3										
Increase in suspended sediments due to construction, operations and maintenance and/or decommissioning related activities, and the potential impact to physical features.	✓	✓	✓	N/A	C: Negligible O: Negligible D: Negligible	C: Low O: Low D: Low	Negligible Negligible Negligible	N/A	N/A	N/A

6.14 Next steps

6.14.1.1 As part of the Morgan Generation Assets project one year of metocean data has been collected within the Morgan Array Area. The data gathered subsequent to undertaking the modelling will be reviewed to verify the assumptions made within the context of the physical process modelling and may be used to further validate numerical models. Additionally, the completed geotechnical and geophysical surveys are undergoing analysis. This includes further processing of geophysical surveys and particle size analysis of seabed sediment grab samples. Following completion of this process data will be reviewed to substantiate that assertions made within the context of the physical process modelling and assessment are valid. For example, that seabed sediment classification and composition datasets derived from British Geological Survey geo-index applied in the desktop study are in line with survey samples collected.

6.14.1.2 The outcome of the analysis will be incorporated into the physical processes study and a revised assessment may be undertaken if necessary for the preparation of the physical processes chapter of the Environmental Statement.

6.15 References

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