15. Marine and coastal physical processes

15.1 Introduction

15.1.1 This chapter presents a preliminary assessment of the likely significant effects relating to marine and coastal physical processes arising from the Moorside Project (**Figure 15.1**). Of particular relevance to this chapter is the potential for modification to existing patterns of sediment transport and related changes in coastal morphology as a consequence of the construction of a Beach Landing Facility (BLF), Marine OffLoading Facility (MOLF) and Circulating Water System (CWS) infrastructure. The MOLF includes a jetty, two breakwaters and related localised dredging. The assessment of change to marine and coastal physical processes is of relevance to other environmental receptors, which are described in the following sections of the PEIR, notably:

- Marine Water and Sediment Quality **(Chapter 16)**;
- Marine Ecology **(Chapter 17)**; and
- Radiological **(Chapter 20)**.

15.1.2 These linkages between marine and coastal physical processes and other marine topics are summarised in **Figure 15.2**.

15.1.3 A review of the development proposals for the Accommodation Sites, Additional Sites, Moorside Site Railway and sites for the Highway Improvements confirms that they are entirely land based and therefore will not result in any changes to marine and coastal physical processes. Accordingly, these sites have not been considered further with regards to marine and coastal physical processes. This chapter considers only development activities at the Moorside Site.

15.2 Limitations of the PEIR

General

15.2.1 The assessment has focussed on the construction and operational phases for the Moorside Site. As discussed at **Chapter 2**, decommissioning of the MPS itself will be included within the ES, but at a high level, given that these activities will take place around 60 years after operations commence, and they will be covered by a discrete EIA of the activities at that time. With respect to the decommissioning of the Moorside Project, potential effects associated with decommissioning of the BLF, MOLF and CWS are likely to be similar or less than to the effects arising from the construction phase. It is not anticipated that additional receptors would be affected beyond those identified for the construction phase assessment as this assessment has assumed a reasonable worst case. It is anticipated that the decommissioning works would be of shorter duration and would occupy more limited footprints than those currently assumed for construction of the relevant facilities.

Subject to further design and delivery details, and for the purposes of this PEIR, a worst case scenario has been applied, i.e. it has been assumed that the effects would be the same (rather than less) as those identified for the construction phase.

Technical

15.2.2 The assessments presented within this chapter are made in the absence of full quantitative supporting analysis (e.g. numerical modelling) as this work is being progressed over the remainder of 2016. Details of the proposed methodology are provided in **Section 15.7**. Instead, the assessments rely on expert professional judgment. These judgements may be revised within the Environmental Statement (to be submitted as part of the application for a DCO for the Moorside Project in 2017), following more detailed analysis and refinements in engineering design.

15.2.3 Details of the marine infrastructure required for the construction and operation of the MPS are provided in **Chapter 2**, **Project Description** and summarised in **Section 15.8**. Detailed engineering drawings and construction methodologies are not available at this time therefore the impact assessment is based upon reasonable worst case assumptions and expert judgement using the design details presented at this time.

15.3 Policy and legislative context

15.3.1 The following planning policy and guidance has been used to inform this preliminary assessment:

- Policy (National and Local):
  - Overarching NPS for Energy (EN-1) (Reference 1: Department of Energy and Climate Change (DECC)) (NPS EN-1). NPS EN-1 states in Section 5.5 'Coastal change' that:

    "*Where relevant, applicants should undertake coastal geomorphological and sediment transfer modelling to predict and understand impacts and help identify relevant mitigating or compensatory measures (paragraph 5.5.6)*".
  - Paragraph 5.5.7 states that "*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 implications of the proposed project on strategies for managing the coast as set out in Shoreline Management Plans*

(SMPs)…any relevant Marine Plans…and capital programmes for maintaining flood and coastal defences;
- *The effects of the proposed project on marine ecology, biodiversity and protected sites;*
- *The effects of the proposed project on maintaining coastal recreation sites and features; and*
- *The vulnerability of the proposed development to coastal change, taking account of climate change, during the project's operational life and any decommissioning period."*

- In addition to the above, it is stated that *"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"* (paragraph 5.5.8).
- Finally, "*The applicant should be particularly careful to identify any effects of physical changes on the integrity and special features of Marine Conservation Zones (MCZs), candidate marine Special Areas of Conservation (cSACs), coastal SACs and candidate coastal SACs, coastal Special Protection Areas (SPAs) and potential Sites of Community Importance (SCIs) and Sites of Special Scientific Interest (SSSI)*" (paragraph 5.5.9).
- NPS for Nuclear Power Generation (EN-6) (Reference 2: DECC) (NPS EN-6). NPS EN-6 states at paragraph 3.8.2 that "*The Nuclear AoS identified that the construction of new coastal and fluvial defences and possible marine landing jetties/docks necessary to support the nuclear power station could affect coastal processes, hydrodynamics and sediment transport processes at coastal and estuarine sites. These impacts could lead to coastal erosion or accretion. There could also be changes to offshore features such as submerged banks and ridges and marine ecology.*"
- NPS EN-6 paragraphs 3.8.3 and 3.8.5 state that:

  "*In light of the findings of the Nuclear AoS, applicants should assess the site's geology, soils and geomorphological processes in order to understand the ongoing natural ecological, coastal and geomorphic processes. This will include identifying impacts on coastal processes, intertidal deposition and soil development processes that maintain terrestrial/coastal and/or marine habitats*".

  "*In applying the policy on mitigation set out in Section 5.5 of EN-1, and having taken account of the effects of climate change over the lifetime of the project (including any decommissioning period), the [Secretary of State] should be satisfied that the application will include measures where necessary to mitigate the effects of, and on, coastal change."*
- The National Planning Policy Framework (NPPF) (Reference 3: Department for Communities and Local Government (DCLG)). The NPPF identifies that. Paragraphs 100 and 106 of the NPPF identify that:

"Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere".

"*Local planning authorities should reduce risk from coastal change by avoiding inappropriate development in vulnerable areas or adding to the impacts of physical changes to the coast".*

In addition to the above, paragraph 168 of the NPPF states that:

"Shoreline Management Plans should inform the evidence base for planning in coastal areas. The prediction of future impacts should include the longer term nature and inherent uncertainty of coastal processes (including coastal landslip), and take account of climate change".

The UK Marine Policy Statement is the framework for preparing Marine Plans and taking decisions affecting the marine environment. Adopted by the UK Government, the Scottish Government, the Welsh Government and the Northern Ireland Executive, the Marine Policy Statement is intended to help achieve the shared UK vision for clean, healthy, safe, productive and biologically diverse oceans and seas. The Marine Policy Statement aims to enable an appropriate and consistent approach to marine planning across UK waters, and to ensure the sustainable use of marine resources and strategic management of marine activities from renewable energy to nature conservation, fishing, recreation and tourism. The Marine Policy Statement recognises that the primary environmental considerations include morphological changes, hydrological effects, increase in turbidity and changes to natural sedimentary systems. The MMO has started developing a marine plan for the North West Region (within which the Moorside Project would be located) and is currently consulting on the Statement of Public Participation and the Sustainability Appraisal Scoping Report. Decision-making needs to have appropriate regard to the policies in the Marine Policy Statement.

- North West England and North Wales Shoreline Management Plan (SMP) 2 (Reference 4: Halcrow) dated July 2010.

  The SMP 2 provides a large-scale assessment of the risks associated with erosion and flooding at the coast. It also presents policies to help manage these risks to people and to the developed, historic and natural environment in a sustainable manner. SMPs form an important part of the Department for Environment, Food and Rural Affairs (Defra) strategy for managing risks due to flooding and coastal erosion; and

- The Copeland Local Plan (2013 - 2028) (Reference 5: Copeland Borough Council).

  Policy ENV2 on Coastal Management, supports energy generating developments that require a coastal location along the undeveloped

coast, provided that the potential impacts on biodiversity, landscape and heritage assets are carefully assessed against the benefits. Where negative impacts are likely, these must be mitigated against and compensated for. The policy also states that the Council will work with partners to manage the risks associated with coastal erosion and flooding and ensure that all new development is located outside areas identified as being at risk.

Policy ENV3 states that the Council will seek to improve the conditions of designated sites and enhance, extend, restore and create priority habitats.

- Guidance:
  - The British Energy Estuarine and Marine Studies (BEEMS) guidance for the Nuclear New Build Programme;
  - General advice on assessing potential impacts of and mitigation for human activities on MCZ features, using existing regulation and legislation (Reference 6: Joint Nature Conservation Committee (JNCC) and Natural England);
  - The Marine Management Organisation MCZ and Marine Licensing assessment process (Reference 7: MMO); and
  - UK Technical Advisory Group on the Water Framework Directive: Guidance on Morphological Alterations and the Pressures and Impacts Analyses (Reference 8: UK Technical Advisory Group (UKTAG)).

15.4 Data gathering methodology

Study area

15.4.1 The study area within which baseline conditions and potential effects have been considered is shown in **Figure 15.1**. To aid the assessment process, the study area has been sub-divided into two zones (**Figure 15.1**):

- Far-field. Defined as the wider coastal and offshore area surrounding the Moorside Site over which effects may potentially occur; and
- Near-field. Defined as the coastal and offshore area within the boundary of the Moorside Site, covering the proposed area of the BLF, MOLF and CWS.

15.4.2 The spatial extent of the study area has been defined on the basis of:

- High level details regarding the location of the BLF, MOLF and CWS (**Chapter 2**, **Project Description**);
- Consultations with statutory consultees; and
- A precautionary "enveloping" approach in order to ensure the spatial extent of all likely potential direct and indirect effects is covered.

15.4.3 The northerly and southerly limits of the far-field are primarily determined on the basis of existing process understanding available from the North West England and North Wales Shoreline Management Plan 2 (Reference 4: Halcrow). The westerly (offshore) limit to the study area is more loosely defined. However, it is considered to be located sufficiently far to the west to describe baseline marine and coastal physical processes and seabed conditions which may be relevant to inform the impact assessment carried out for this and other topics, particularly those considering the impacts of thermal and chemical discharge plumes.

Desk study

15.4.4 In order to determine the requirement for new survey work, a desk study has been undertaken which reviewed the availability (and suitability) of existing marine and coastal physical environmental data. A wide range of existing datasets and reports were considered and a detailed list of these is presented in the Moorside Development, EIA Scoping Document (Reference 9: AMEC Environment & Infrastructure UK Ltd), in particular:

- Data collected as part of the Northwest Regional Coastal Monitoring Programme (NWSRCMP);
- Data from other ongoing regional monitoring initiatives, including:
  - Water levels (National Tide and Sea Level Facility (NTSLF) UK National Tide Gauge Network);
  - Waves (Centre for Environment, Fisheries and Aquaculture Science (Cefas) Wavenet);
  - Inter-tidal elevations (Environment Agency LiDAR); and
  - Physical water column data for salinity, temperature and suspended solids (EA water sampling).
- Data collected to inform past and ongoing operations at the Sellafield Site; and
- Modelling outputs from the Cell Eleven tide and sediment study (CETaSS), developed to support the North West England and North Wales Shoreline Management Plan 2 (Reference 4: Halcrow).

15.4.5 The analysis of the above demonstrated that enough secondary data was available to provide a broad description of marine and coastal physical processes across the far-field. However, the available datasets were found to be less informative at the project scale (i.e. near-field) and were considered to be insufficient to fully address EIA requirements. Accordingly, a programme of surveys was commissioned to address the identified data gaps. These data gaps included (amongst other things):

- A lack of detailed wave and current (full depth profile) data from the Moorside Site as well as concurrent measurements of turbidity to help

inform process understanding of the conditions under which sediment mobilisation and transport occurs; and

- The absence of high resolution seabed bathymetry data and accompanying information on seabed texture/substrate.

Survey work

15.4.6 Three surveys have been commissioned to address the data gaps identified for the marine and coastal physical processes topic. These are summarised below, with survey locations and coverage shown in **Figure 15.1**:

- Oceanographic survey (commenced by Titan Environmental Surveys Ltd in June 2014 and now complete). Commissioned to define advective properties of the local waterbody for plume dispersion and to inform understanding of the hydrodynamic conditions driving sediment transport:
  - Water levels, currents, waves (from four Acoustic Wave and Current (AWAC) devices), suspended sediment concentrations (via optical backscatter (OBS) and water sampling methods), Conductivity, Temperature and Depth (CTD) profiles and a drogue survey (24 releases from six locations).
- Bathymetric and geophysical survey (Phase 1 undertaken by Gardline Group in 2014; Phase 2 currently underway). Commissioned to improve understanding of seabed conditions including the presence of mobile bedforms as well as the seabed texture/roughness:
  - Multibeam Echo Sounding (MBES), side-scan and seismic survey.
- Inter-tidal and sub-tidal survey (completed by Amec Foster Wheeler in 2015). Commissioned to provide detailed Particle Size Analysis of mapped beach/seabed sediments to inform modelling of potential changes to sediment transport:
  - Particle Size Analysis data from grab samples collected across inter-tidal (at a total of 33 locations) and sub-tidal (at a total of 35 locations) within and nearby to the Moorside Site.

Consultation

15.4.7 Further to the details outlined in **Chapter 3, EIA Methodology**, regarding the consultation that has taken place to date, it should be noted that consultation received from the following organisations has been used to inform the scope of the assessment:

- Marine Management Organisation;
- Environment Agency;
- Natural England:
- The Crown Estate;

- Sellafield Ltd.;
- Cumbria County Council;
- Copeland Borough Council;
- Friends of the Lake District; and
- Lake District National Park Authority.

15.4.8 The North West Inshore Fisheries and Conservation Authority (NWIFCA) have management duties for MCZs and as such, are of relevance to the assessment of marine and coastal physical processes. NWIFCA has been consulted with regards to fisheries (**Chapter 10**, **Socio Economics** and **Chapter 17**, **Marine Ecology**) and any comments of relevance to marine and coastal physical processes have been noted.

15.4.9 **Table 15.1** provides details of the issues which have been raised during these consultations, and a response on how they are being considered in the EIA process.

Table 15.1 Consultation responses received

Issue raised	Consultees	Response
Scope of assessment: Consideration should be given to the potential for changes in waves, currents, tides (including surge events), sediment transport and inter-tidal/seabed morphology resulting from the MOLF and CWS intakes/outfalls.	MMO Natural England Environment Agency Cumbria County Council Copeland Borough Council Friends of the Lake District	Quantitative assessment of potentially significant effects is in the process of being undertaken as full design details emerge. Consideration of changes to the hydrodynamic, wave, sediment transport and morphological regimes will be considered in full within the ES, using numerical modelling, analytical/empirical techniques as well as the existing evidence base. Further details of the proposed methodology are provided in **Section 15.7**.
Scope of assessment: Consideration should be given to the potential for changes in coastal morphology including any increased risk of erosion to the railway line and to the south of the Moorside Site, at Drigg	MMO	An assessment of the potential for increased erosion of the coast (including to the railway embankment) will be undertaken within the ES, including consideration of climate change. To increase the visibility of this assessment within the ES, the 'coast and associated infrastructure' has been included as a separate receptor in **Section 15.5** and in **Table 15.6**.
Scope of assessment: Consideration should be given to the potential effects on seabed morphology associated with scour and scour protection. (The potential for global scour should also be investigated.)	MMO Natural England Copeland Borough Council	Scour will be considered within the ES using standard empirical techniques for the assessment of scour (Reference 10: Whitehouse).

Issue raised	Consultees	Response
Scope of assessment: Consideration should be given to any direct and indirect changes associated with dredging operations (both capital and maintenance), including any disposal of dredged material.	MMO Cumbria County Council	The detailed information as to the exact volumes and locations for dredging is being refined and, as such, a full assessment of these works (in terms of the potential for changes in suspended sediment concentrations and associated changes in bed level) will be carried out and presented within the ES. The dredge assessment will investigate the advection and dispersion of sediment plumes using the existing ABPmer hydrodynamic model developed to inform the water quality assessment. Results from the dredging assessment will also be used to inform other topics including **Chapter 17**, **Marine Ecology**. An appropriate method for assessing the dredge disposal will be finalised and discussed with Regulators once the exact nature and volume of material is known.
Scope of assessment: The ES should assess the range of sediment types likely to be affected by the proposed scheme, the behaviour (formation, movement and dispersal) of any fluid mud layers present over the spring-neap tidal cycle; and the behaviour of mobile sand/other geomorphological features over time.	MMO	Details regarding the intended scope of assessment are provided in **Section 15.5**. These will be considered in full within the ES, using numerical modelling, analytic/empirical techniques as well as the existing evidence base.
Scope of assessment: consideration should be given to component features of designated sites as well as wider changes to the marine physical environment in non-designated areas.	MMO	Numerical modelling will be used to assess the spatial extent of potential change to the water column, seabed morphology and substrate. This information will subsequently be used to determine the potential for change to individual morphological features, as well as to the wider seabed and coast.

Issue raised	Consultees	Response
Scope of assessment: the spatial extent and scope of works within the Other Sites are yet to be confirmed. It is therefore not possible to agree that construction and operational activity on the additional scoping land would not -affect the marine and coastal physical environment.	Environment Agency Natural England	Further details are now available with regards to the Accommodation Sites and Additional Sites. A review of these design details confirms that these sites have no potential for interaction with marine and coastal physical processes.
Scope of assessment: the Marine and Coastal Physical Environment currently does not include an assessment of flood risk to the proposed development associated with tidal and coastal sources and following a breach in any formal or informal flood defences.	Cumbria County Council MMO	A Flood Risk Assessment (FRA) will be undertaken and submitted with the DCO Application in 2017. This will utilise numerical modelling to consider extreme water levels associated with both tidal and non-tidal processes (up to 1:10,000 year return period).
Interaction with other topics: Changes to the marine and coastal environment caused by the proposed development could affect other aspects of the environment, such as transport, biodiversity, the freshwater environment, landscape, socio-economics and recreation. Such interactions should be considered in the assessment. Cross references should be made to other chapters in the ES where this information is provided, particularly the biodiversity and freshwater chapters.	Cumbria County Council	The potential for interaction with other topics and cumulative impacts (**Section 15.10**) will be considered throughout the assessment process and cross references to relevant chapters made where relevant. See also **Chapter 22**, **Interrelationships**. Anticipated topic linkages are summarised in **Section 15.1** and in **Figure 15.2**.
Design information: Further design definition is required to establish potential effects e.g. details on where the intake and outfalls will be located, type of structure present on the seabed, location of, and facilities expected at the MOLF/breakwaters. The realistic worst case aspects of the design should be determined using a Rochdale Envelope Approach.	MMO Natural England Copeland Borough Council Friends of the Lake District	Overarching design details are available related to the BLF, MOLF, and the CWS. From these it has been possible to make broad assumptions regarding the likely Realistic Worst Case (RWC) using the information available. These assumptions are defined in the 'Preliminary assessment of residual effects' section and have been used to help determine the preliminary assessment results presented in **Table 15.6**.

Issue raised	Consultees	Response
Assessment approach: Adequate detail on the modelling approach and assessment to be carried out should be provided to ensure a) confidence in the modelling, b) how near shore sediment transport will be addressed. **Definitions of receptor sensitivity, value and magnitude of change should be provided, as well as justification for each judgment made in the assessment.**	MMO Copeland Borough Council Cumbria County Council	The specifications of the technical assessments will be fully finalised to align with final detailed design information. The assessment methodology will then be discussed with relevant consultees prior to undertaking the quantitative analyses and assessment.
Reporting: The ES should provide full details of modelling and monitoring methodologies, including Zone of Influence (ZoI) and impact pathways, within the ES and should consider the full geographic extent of effect of the proposals. **Models should be adequately calibrated, validated and sensitivity tested against any assumptions used. Additional information is also required regarding the calibration standards which will be used for the model and quality assurance procedures required for ISO compliance.** **Site specific surveys (including methodology and applied standards) and background data which are relied upon in the assessment should be appended to the ES.**	MMO Natural England Copeland Borough Council Cumbria County Council	Full details of all model calibration/validation reporting as well as project specific surveys undertaken in support of the assessment work will be provided with the ES. These will include: ABPmer Moorside hydrodynamic model calibration/validation report. Bathymetric/geophysical survey report (for the 2014 Gardline survey and 2016 Fugro survey); Oceanographic survey report (for the 2015/2016 Titan survey); and Inter-tidal/sub tidal sediment survey (for the 2015 Amec FW survey). The methodology applied to develop the ABPmer hydrodynamic model, as well as the degree to which the model meets agreed calibration/validation standards will also be documented in detail within the ES.

Issue raised	Consultees	Response
Climate change: Potential changes due to natural variations in marine and coastal processes (e.g. during extreme weather events and as a result of climate change) should be considered. This should include particular consideration of the effects of climate change on sea level rise, wave height and direction to help determine how the MOLF will cope with changes to longshore drift and possible erosion in the 60-100 years of operation and decommissioning. Potential changes to the course of the River Ehen should also be considered as a response to changes in river flow over the lifetime of the project.	MMO Natural England Copeland Borough Council Lake District National Park Friends of the Lake District	Climate change will be considered within the assessment. Where possible, this will be carried out in a quantitative manner using outputs from UKCP09 (Reference 11: Lowe et al.). If interim information becomes available from the on-going update of this guidance (UKCP18), this will also be used where applicable.
Cumulative Effects: The potential for cumulative impacts should be considered and built into the modelling to be undertaken.	Planning Inspectorate	The potential for widespread cumulative effects is presently considered to be low. However, this will be confirmed within the ES, following a detailed review of the final list of relevant development and related level of detail available for non-Moorside Projects. A preliminary assessment of cumulative effects is set out below in **Section 15.10** of this chapter.

15.5 Scope of the assessment

Potential receptors

15.5.1 Although waves, current, tides and associated patterns of sediment transport may be altered by the installation and presence of infrastructure (MOLF and CWS structures), they largely represent 'pathways' as opposed to 'receptors'. These pathways control short and long-term net morphological change, both at the coast and at the seabed. Instead, it is typically morphological features (such as dunes and estuaries) that form the key receptors in the marine and coastal physical processes domain. Accordingly, the following are identified as marine and coastal physical processes receptors (see **Figure 15.1** for location details):

- Designated geomorphological features within the Cumbria Coast MCZ:
  - Inter-tidal sand and muddy sand, high energy inter-tidal rock (including scars), moderate energy infra-littoral rock, peat and clay exposures.
- Designated geomorphological features within the Drigg Coast SAC:
  - Mud/sand flats, saltmarsh, estuaries and dunes.
- Hydromorphological elements of Cumbria Coast Water Body and Esk Transitional Water Body (depth variation, structure and substrate of the seabed and structure of the inter-tidal zone.)
- The coastline and associated infrastructure
  - Including the Cumbrian Coast railway line embankment between St Bees and the Ravenglass Estuary.

15.5.2 Importantly, the assessment of potential effects to designated sites focuses upon the potential for significant modification of the naturally occurring geomorphology that could indirectly impact the habitats that they support. Any resultant impacts on marine ecology are considered separately, within **Chapter 17**, **Marine Ecology**.

15.5.3 Whilst the receptors listed above will be the focus of the Marine and Coastal Physical Processes Environmental Statement chapter for the DCO submission, details of the potential extent of changes to the wider marine environment across the study area will be included in a technical appendix to the Environmental Statement. This will include discussion of the potential for change to:

- Waves;
- Water levels (including surge);
- Currents (tidal and non-tidal);
- Sediment transport;
- Seabed and coastal morphology; and

- Seabed/inter-tidal substrate.

15.5.4 A Flood Risk Assessment (FRA) is being carried out for the Moorside Project which will consider both terrestrial and marine flooding elements. The FRA will be provided as part of the DCO Application in 2017.

15.5.5 Localised dredging is anticipated as part of the construction works. The detailed information as to the exact volumes and locations for dredging is being refined and, as such, a full assessment (in terms of the potential for changes in suspended sediment concentrations and associated changes in bed level) will be carried out and presented within the ES.

15.5.6 It is anticipated that all phases of the development may be associated with some noise and vibration effects. For example, piling during construction of the MOLF and operation of the circulating water system. The magnitude of noise and vibration effects will be described in **Chapter 5**, **Noise and Vibration**, whilst the potential for associated effects upon marine ecological receptors will be described in **Chapter 17**, **Marine Ecology**.

15.5.7 Finally, the effects of existing radioactive sediments being mobilised as a result of construction activities at the Moorside Site are covered in in **Chapter 16**, **Marine Water and Sediment Quality** and **Chapter 21, Radiological**, with **Chapter 16** covering the baseline understanding and **Chapter 21** the potential effects.

Spatial and temporal scope

15.5.8 The detailed assessment of likely significant effects (which will be reported in the ES that will accompany NuGen's application for a DCO for the Moorside Project in 2017) is being undertaken with consideration to potential changes to marine and coastal physical processes that could occur within the geographical extent of the study area (**Figure 15.1**). Consideration will be given to the potential for significant effects to occur during the construction period (approximately a decade), operational period (circa 60 years) and decommissioning period.

Potentially significant effects

15.5.9 All of the receptors identified for this topic could potentially be affected by construction, operation and decommissioning activities associated with the Moorside Project. These could occur either directly (e.g. due to emplacement of structures directly onto the receptor) or indirectly (e.g. through the modification of sediment transport pathways).

15.6 Environmental measures incorporated into the proposed development

15.6.1 Details of environmental measures that have been incorporated into the overall design of the Moorside Project are set out in **Chapter 2**, **Project Description**, of this PEIR. Specific measures relating to this environmental

topic and how these have been targeted to specific marine and coastal receptors are set out in **Table 15.2**. Where environmental measures are currently unknown, or uncertain, they are not included within **Table 15.2**. Further measures may be included in the EIA and reported on in the ES as they are designed and confirmed.

Table 15.2 Rationale for incorporation of environmental mitigation

Potential receptor	Predicted changes and potential effects	Incorporated mitigation
Moorside Site only		
Designated morphological features within the Cumbria Coast MCZ Designated morphological features within the Drigg Coast SAC Hydromorphological elements of Cumbria Coast Water Body and Esk Transitional Water Body The coastline and associated infrastructure	Localised interruption of sediment transport and patterns of nearshore/inshore wave propagation, potentially leading to morphological change at the coast and at the seabed.	It is envisaged that the inclusion of a piled jetty within the MOLF will greatly reduce the direct blockage of sediment transport in comparison to an enclosed structure. The extent of wave refraction and diffraction will also be much less, lessening any changes to the rate/direction of sediment transport. Intake and outfall tunnels will be beneath the seabed surface. This will remove the potential for interaction with waves and associated sediment transport processes.

15.7 Assessment methodology

Methodology for prediction of effects

15.7.1 The overarching approach for the assessment of effect significance is set out in **Chapter 3**, **EIA Methodology**, and combines judgments of receptor value/significance with an assessment of the magnitude of change. Topic specific criteria for receptors value/significance and magnitude of change are described in this section and in **Table 15.3 and Table 15.4**. There are no industry-specific definitions relating to the magnitude of change to Marine and Coastal Physical Process receptors. Instead, these have been determined using expert judgment and are consistent with those used in similar nationally significant infrastructure project coastal process studies. The proposed assessment approaches for determining the magnitude of change are consistent with industry guidance, in particular the BEEMS guidance for the UK Nuclear New Build Programme.

15.7.2 In terms of receptor value and sensitivity, all of the designated geomorphological elements within the Cumbria Coast MCZ and Drigg Coast SAC have been defined as having a 'High' value/sensitivity rating. This is because

these elements are internationally important features, although they have some capacity to adapt to environmental change (**Table 15.3**). The coastline and associated infrastructure has also been assigned a high value/sensitivity rating since the receptor has medium to high socio-economic importance. This is primarily associated with the Cumbrian Coast railway line which is in very close proximity to the shore along much of the coast. The hydromorphological elements of the Cumbria Coast Water Body and Esk Transitional Water Body are defined as having 'Medium' value/sensitivity. This is because although hydromorphological changes have the potential to influence compliance with the Water Framework Directive (WFD), the seabed is a dynamic environment and has some capacity to accommodate change.

15.7.3 Criteria that are being used to assess the magnitude of change to identified receptors are set out in **Table 15.4**.

Table 15.3 Criteria used to determine value and sensitivity

Value and Sensitivity	Definition
Very high	Receptor of international importance or of high or very high socio-economic importance. Receptor likely to be rare with minimal potential for substitution. Receptor likely to have no capacity to accommodate the proposed form of change.
High	Receptor designated and/or of national to international importance. May also be of medium to high socio-economic importance. Likely to be relatively rare and may also be of high socio-economic importance. Receptor likely to have low to moderate capacity to accommodate the proposed form of change.
Medium	Receptor designated and/or of regional to national importance. Receptor likely to have moderate capacity to accommodate the proposed form of change.
Low	Receptor not designated but of local to regional importance. Receptor likely to have moderate to high capacity to accommodate the proposed form of change.
Very low	Receptor of local importance with high capacity to accommodate the proposed form of change.

Table 15.4 Criteria used to determine the magnitude of change

Magnitude	Definition
Very high	Permanent, irreversible changes over the near- and far-field that are of a scale that will change key characteristics of the morphological features of interest.
High	Permanent, irreversible changes over the near-field or temporary (i.e. months to years) changes over the far-field that are of a scale that will change key characteristics of the morphological features of interest.
Medium	Noticeable, temporary changes which are confined to the near-field and that are of a scale that will change key characteristics of the morphological features of interest.

Magnitude	Definition
Low	Temporary or permanent changes that are confined to the footprint of the development and immediate near-field surroundings.
Very low	Changes either within the near- or far-field which are not discernible from background conditions.

15.7.4 In order to assess the magnitude of change relative to the baseline (existing) coastal environment, a combination of approaches is being adopted:

- Expert knowledge with reference to the 'evidence base', including guidance such as that provided by BEEMS, outcomes from BEEMS for other nuclear power stations as well as previous assessments and monitoring undertaken in relation to or during the construction and operation of other, analogous coastal/offshore developments.
- Use of analytical and/or other standard empirical equations to describe the relationship between (for example) hydrodynamic forcing and sediment transport, settling and mobilisation characteristics of sediment particles released during construction activities and scour.
- Application of sophisticated numerical modelling tools, as required, to determine the potential magnitude of changes to the marine environment. Details of the modelling methodologies are being discussed with the relevant consultees and will be included in the ES.

15.7.5 These techniques are being used to assess:

- Direct disturbance to backshore, foreshore and sub-tidal seabed areas during construction of marine infrastructure (construction phase);
- Changes to coastal/seabed morphology at/nearby to the intake/outfall tunnel opening (construction phase);
- Changes to coastal/seabed morphology due to modifications of the hydrodynamic and wave regime caused by the MOLF (construction and operation phases);
- Changes to coastal/seabed morphology due to localised scour (including global scour) around infrastructure (construction and operation phases); and
- Changes to coastal/seabed morphology due to localised modifications of the hydrodynamic and wave regime caused by offshore intake/outfall structures at the tunnel opening (operation phase).

15.7.6 The realistic worst case characteristics of the preferred design in terms of impacts upon Marine and Coastal Physical Processes will be considered. This method is in accordance with the requirements of the Rochdale Envelope approach to environmental assessment (Reference 12: Planning Inspectorate). In essence, the 'Rochdale' or Design Envelope is a series of projected maximum extents to the Project for which the significant effects are assessed. The detailed design of the Project can then vary within this envelope while

ensuring that the EIA outcomes remain robust. Thus, this approach also provides a conservative method to understanding the potential impacts of the Moorside Project.

Significance evaluation methodology

15.7.7 For each of the potential issues identified above, the assessment of the magnitude of change to individual receptors has been combined with the judgments of receptor value/sensitivity to determine the significance of effect. This has been achieved using the significance evaluation matrix set out in **Table 15.5**.

Table 15.5 Significance evaluation matrix

		Magnitude of change				
		Very high	**High**	**Medium**	**Low**	**Very low**
Sensitivity	**Very high**	**Major** (Significant)	**Major** (Significant)	**Major** (Significant)	**Major** (Significant)	**Moderate** (Potentially Significant)
	High	**Major** (Significant)	**Major** (Significant)	**Major** (Significant)	**Moderate** (Potentially Significant)	**Minor** (Not Significant)
	Medium	**Major** (Significant)	**Major** (Significant)	**Moderate** (Potentially Significant)	**Minor** (Not Significant)	**Negligible** (Not Significant)
	Low	**Major** (Significant)	**Moderate** (Potentially Significant)	**Minor** (Not Significant)	**Negligible** (Not Significant)	**Negligible** (Not Significant)
	Very low	**Moderate** (Potentially Significant)	**Minor** (Not Significant)	**Negligible** (Not Significant)	**Negligible** (Not Significant)	**Negligible** (Not Significant)

Note: Significant effects are those identified as 'Major'. 'Moderate' effects have the potential to be significant, but this depends on the environmental topic and the use of professional judgment.

15.8 Preliminary assessment of residual effects

Baseline conditions

15.8.1 **Figure 15.3** provides a summary of system understanding for marine and coastal physical processes. On the basis of the newly collected survey data (June 2015 to March 2016) and existing available information, it is found that:

- The Moorside Site is located in a hyper-tidal setting, with a mean spring tidal range in excess of 7 m. Peak north-northwesterly currents (roughly parallel to the shore), occur at or very shortly after (i.e. ~1 hr) high water,

whilst the peak south-southeasterly flow along the frontage occurs at or just after low water;

- Tidal currents are of weak to moderate strength, with peak depth averaged flows typically around 0.6 m/s;
- Tidal asymmetry generally causes a weak residual northwesterly drift of material held in suspension within the Moorside Site. However, non-tidal influences (especially wind and wave driven currents) can interrupt this generalized pattern;
- Net bedload transport of sand sized material is very limited under tidal forcing alone and the direction of transport is likely to be spatially variable across the study area. However, non-tidal influences (i.e. winds and waves) are known to result in greatly enhanced flow speeds (>1 m/s);
- Littoral sediment transport at the coast is very weak but is generally understood to be towards the north (Reference 4: Halcrow). However, localised reversals to this pattern occur and other process mechanisms, especially wind driven transport, are understood to play an important role in the longshore movement of material;
- The coastal frontage within the Moorside Site is largely an expanse of sandy beach although bedrock and rocky reef is also found in patches across the littoral and sub-littoral zone. The sub-tidal seabed is typically characterised by the presence of mud or muddy sand. No evidence for the presence of fluid mud layers has been found from either the project-specific oceanographic survey or from existing publications/datasets reviewed as part of the desk study;
- Within offshore areas of the Moorside Site, the seabed is generally featureless and characterised by very low (i.e. <1°) slope gradients. However, the nearshore area is more irregular, with low elevation (i.e. <2 m) mounds and ridges present, as well as active rippled bedform features; and
- The beach and nearshore areas within the Moorside Site are generally found to be stable with limited intra- and inter-annual change observed.

15.8.2 Further details will be presented within the ES, once the survey programme (**Section 15.4**) has been completed. The ES will also include information on surge water levels and anticipated changes to the marine physical environment as a consequence of climate change.

Predicted residual effects and their significance

15.8.3 As stated in **Section 15.2**, the assessments presented in the evaluation tables rely on expert judgment. This expert judgment approach takes into consideration both an understanding of the baseline environment, the sensitivity/value of the receptors and the anticipated magnitude of change which at present is principally determined from experience obtained from analogous developments located elsewhere. These judgements may be revised

within the ES (to be submitted as part of the application for a DCO for the Moorside Project in 2017). The ES assessments will be informed by more detailed analysis and refinements in engineering design.

15.8.4 The assessments presented in **Table 15.6** incorporate the mitigation measures outlined in **Table 15.2**. These mitigation measures include the decision to use a piled (i.e. 'open') design for the MOLF.

15.8.5 As previously stated, a review of the development proposals for the Accommodation Sites, Additional Sites, Moorside Site Railway and site for the Highways Improvements confirms that they are entirely land based and therefore will not result in any changes to marine and coastal physical processes. Accordingly, **Table 15.6** only considers development activities at the Moorside Site.

15.8.6 The following assumptions have been used to carry out the assessment of potential residual effects presented in **Table 15.6**. Within the assessment, potential impacts have been considered in respect to specific source terms from the various infrastructure components to help ensure that all key source-pathway-receptors are addressed (i.e. for the MOLF impacts are considered in relation to the Jetty, Breakwaters and Dredging):

- A BLF will be constructed during the initial phases of the construction programme which is expected to incorporate localised infrastructure across the foreshore.
- A MOLF of approximately 1.6 km in length during the construction of the MPS, consisting of a piled , breakwaters and localised dredging, Elements of the MOLF (outer trestle and breakwater) will be decommissioned at the end of the construction phase with the shorter MOLF and inshore breakwater remaining during the operational phase;
- Two intake and two outfall, each with a maximum footprint of 200 m x 200 m. These are anticipated to be located several kilometres offshore, in water depths >10 m LAT, and may require localised seabed preparation works;
- Caissons may be used to facilitate construction of the intakes and outfalls. The maximum size of each caisson will be similar to the footprint of the intake and outfall locations (i.e. 200 m x 200 m); and

15.8.7 With respect to the decommissioning of the Moorside Project, potential effects associated with decommissioning of the MOLF are likely to be similar or less than to the effects arising from the construction phase. It is not anticipated that additional receptors would be affected beyond those identified for the construction phase assessment as this assessment has assumed a reasonable worst case. It is anticipated that the decommissioning works would be of shorter duration and would occupy more limited footprints than those currently assumed for construction of the relevant facilities. Subject to further design and delivery details, and for the purposes of this PEIR, a worst case scenario has been applied, i.e. it has been assumed that the effects would be the same (rather than less) as those identified for the construction

phase. Decommissioning is therefore not considered further in the assessment tables below that address the construction and operational phases.

Table 15.6 Development at the Moorside Site: Summary of predicted residual effects

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Construction (including decommissioning of longer MOLF and outer breakwater)					
Cumbria Coast MCZ (Inter-tidal sand and muddy sand, high energy inter-tidal rock, moderate energy infra-littoral rock, peat and clay exposures)					
Source: BLF Effect: (Direct) localised disturbance of inter-tidal/areas associated with the construction, operation and decommissioning of the BLF	Likely	High	low	Moderate (Potentially Significant)	Temporary localised disturbance of the inter-tidal will occur, however, the intertidal area is actively re-worked by waves so magnitude of change considered low.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: MOLF Breakwaters Effect: (Indirect) changes to morphology of the MCZ due to modifications of the hydrodynamic and wave regime	Likely	High	Medium	Major (Significant)	The breakwaters would create a zone of calmer water in the vicinity of the MOLF. This reduction in wave energy could alter the rate and direction of sediment transport at the seabed/within the littoral zone, leading to a change in morphology and substrate over time. Localised modifications of tidal currents and blockage of bedload sediment transport could also result in a change to seabed morphology and substrate. However, the magnitude of change will be re-evaluated once the numerical modelling has been undertaken, with the significance of effect revised accordingly in the ES that is submitted in 2017.
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of the MCZ due to modifications of the hydrodynamic and wave regime	Likely	High	Low	Moderate (Potentially Significant)	Modification of the hydrodynamic/wave regime is expected to be relatively limited for the piled aspects of the MOLF. Associated changes in longshore sediment transport are therefore also expected to be relatively small, leading to a low magnitude of change to the seabed/inter-tidal areas. However, the magnitude of change will be dependent upon the density of the piles supporting the MOLF.
Source: MOLF (piled elements and dredge pockets) Effect: (Direct) loss (or alteration) of inter-tidal area within the MCZ	Likely	High	Low	Moderate (Potentially Significant)	Loss/disturbance of inter-tidal will largely be restricted to the footprint of the MOLF/dredge pockets, resulting in a low magnitude of change to the MCZ.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of the MCZ due to localised scour around piles	Likely	High	Low	Moderate (Potentially Significant)	Scour effects are expected (Reference 10: Whitehouse) to be restricted to within a distance of a few metres around the piles.
Source: Caissons around intakes/outfalls Effect: (Indirect) changes to morphology of the MCZ due to modifications of the hydrodynamic and wave regime	Unlikely	High	Very low	Minor (Not Significant)	It is envisaged that (temporary) caisson structures will be used to construct each of the four CWS intake/outfalls. These may cause short term and localised changes to hydrodynamic and wave conditions. However, any changes to the hydrodynamic/wave regime are not expected to extend to the coast and therefore no morphological change is expected.
Source: Dredging activity Effect: (Indirect) localised changes to bed level/substrate within the MCZ associated with dredging works	Likely	High	Low	Moderate (Potentially Significant)	Localised dredging is anticipated to be required prior to construction of the MOLF and Circulating Water System (CWS). As well as direct disturbance of the seabed, dredging may also result in indirect localised and short term changes in bed level and substrate associated with the settling out of material from suspended sediment plumes.
Source: MOLF Effect: (Indirect) changes to morphology of the MCZ due to sediment disturbance both during the construction and decommissioning of the MOLF.	Likely	High	Very low	Minor (Not Significant)	The installation and removal of piles may result in indirect localised and short term changes in bed level and substrate associated with the settling out of material from suspended sediment plumes.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Drigg Coast SAC (Mud/sand flats, saltmarsh, estuaries and dunes)					
Source: MOLF Breakwaters Effect: (Indirect) changes to morphology of the SAC due to modifications of the hydrodynamic and wave regime	Unlikely	High	Very low	Minor (Not Significant)	Changes in the rate/direction of longshore sediment transport arising from alterations to the wave climate could potentially lead to changes in inter-tidal morphology and substrate at locations away from the Moorside Site coastal frontage. The magnitude of change and associated probability of this occurring will be dependent upon the design of the breakwaters, in particular the size and shape. However, given (i) the distance to the Drigg Coast SAC; and (ii) the absence of a (clear) longshore sediment transport pathway connecting the Drigg Coast SAC to the Moorside Site, the magnitude of change to the SAC is expected to be very low.
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of the SAC due to modifications of the hydrodynamic and wave regime	Unlikely	High	Very low	Minor (Not Significant)	Modification of the hydrodynamic/wave regime is expected to be limited for a piled MOLF and changes in longshore sediment transport are therefore also expected to be similarly limited. Given (i) the distance to the Drigg Coast SAC; and (ii) the absence of a (clear) longshore sediment transport pathway connecting the Drigg Coast SAC to the Moorside Site, the magnitude of change to the SAC is expected to be very low.
Source: Caissons around intakes/outfalls Effect: (Indirect) changes to morphology of the SAC due to modifications of the hydrodynamic and wave regime	Unlikely	High	Very low	Minor (Not Significant)	It is envisaged that temporary structure(s) may be in place at the tunnel breakout locations. These may cause short term and localised changes to hydrodynamic and wave conditions. However, any changes to the hydrodynamic/wave regime are not expected to extend to the coast and therefore no morphological change is expected.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: Dredging activity Effect: (Indirect) localised changes to bed level/substrate within the SAC associated with dredging works	Unlikely	High	Very low	Minor (Not Significant)	Localised dredging is anticipated to be required prior to construction of the MOLF and Circulating Water System (CWS). As well as direct disturbance of the seabed, dredging may also result in indirect localised and short term changes in bed level and substrate associated with the settling out of material from suspended sediment plumes. However, these changes are not expected to be detectable as far away as the SAC.
Hydromorphological elements of Cumbria Coast Water Body and Esk Transitional Water Body (Depth variation, structure and substrate of the bed and structure of the inter-tidal zone)					
Source: BLF Effect: (Direct) localised disturbance of inter-tidal/areas associated with the construction, operation and decommissioning of the BLF	Likely	Medium	low	Minor (Not Significant)	Temporary localised disturbance of the inter-tidal will occur, however, the intertidal area is actively re-worked by waves so the magnitude of change considered to be low.
Source: MOLF Breakwaters Effect: (Indirect) changes to morphology of inter-tidal/sub-tidal areas due to modifications of the hydrodynamic and wave regime	Likely	Medium	Low	Minor (Not Significant)	Breakwaters would create a zone of calmer water in the vicinity of the MOLF. This reduction in wave energy could alter the rate and direction of sediment transport at the seabed/within the littoral zone, leading to a change in morphology and substrate over time. Localised modifications of tidal currents and blockage of bedload sediment transport could also result in a change to seabed morphology and substrate.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of inter-tidal/sub-tidal areas due to modifications of the hydrodynamic and wave regime	Likely	Medium	Low	Minor (Not Significant)	Modification of the hydrodynamic/wave regime is expected to be limited for a piled MOLF. Associated changes in longshore sediment transport are therefore also expected to be small, leading to a low magnitude of change to the seabed/inter-tidal areas.
Source: Dredging activity Effect: (Indirect) localised changes to bed level/substrate associated with dredging works	Likely	Medium	Low	Minor (Not Significant)	Localised dredging is anticipated to be required prior to construction of the MOLF and Circulating Water System (CWS). As well as direct disturbance of the seabed, dredging may also result in indirect localised and short term changes in bed level and substrate associated with the settling out of material from suspended sediment plumes.
Source: MOLF (piled elements and dredge pockets) Effect: (Direct) loss (or alteration) of inter-tidal and sub-tidal seabed	Likely	Medium	Low	Minor (Not Significant)	Loss/disturbance of inter-tidal will largely be restricted to the footprint of the MOLF and dredge pockets, resulting in a low magnitude of change.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of the inter-tidal/seabed due to localised scour around piles	Likely	Medium	Low	Minor (Not Significant)	Scour effects are expected (Reference 10: Whitehouse) to be restricted to within a distance of a few metres around piles.
Source: Caissons around intakes/outfalls Effect: (Indirect) changes to morphology of inter-tidal/sub-tidal areas due to modifications of the hydrodynamic and wave regime	Likely	Medium	Low	Minor (Not Significant)	It is envisaged that temporary structure(s) may be in place at the tunnel breakout locations. These may cause short term and localised changes to hydrodynamic and wave conditions. However, any changes to the hydrodynamic/wave regime are expected to be extremely localised and are not expected to extend to the coast and therefore no morphological change is expected.
Source: Dredging activity Effect: (Indirect) localised changes to bed level/substrate associated with dredging works	Likely	Medium	Very low	Minor (Not Significant)	Localised dredging is anticipated to be required prior to construction of the MOLF and Circulating Water System (CWS). As well as direct disturbance of the seabed, dredging may also result in indirect localised and short term changes in bed level and substrate associated with the settling out of material from suspended sediment plumes.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: MOLF Effect: (Indirect) changes to morphology of the seabed/inter-tidal due to sediment disturbance both during the construction and decommissioning of the MOLF.	Likely	Medium	Very low	Negligible (Not Significant)	The installation and removal of piles may result in indirect localised and short term changes in bed level and substrate associated with the settling out of material from suspended sediment plumes.
The coastline and associated infrastructure					
Source: BLF Effect: (Direct) localised disturbance of inter-tidal/areas associated with the construction, operation and decommissioning of the BLF	Likely	High	low	Moderate (Potentially Significant)	Temporary localised disturbance of the inter-tidal will occur, however, the intertidal area is actively re-worked by waves so the magnitude of change is considered to be low.
Source: MOLF (Piled elements and dredge pockets) Effect: (Direct) loss (or alteration) of inter-tidal area	Likely	High	Low	Moderate (Potentially Significant)	Loss/disturbance of inter-tidal will largely be restricted to the footprint of the MOLF, resulting in a low magnitude of change.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: MOLF Breakwaters (Indirect) increase in erosion of the coast/ railway embankment due to modification of the hydrodynamic and/or wave regime	Likely	High	Medium	Major (Significant)	The MOLF has the potential to directly alter the hydrodynamic/wave regime resulting in modification of the energy reaching the coast. A change in energy could modify existing patterns of erosion. These changes in hydrodynamic/wave conditions may also result in changes in sub-tidal/inter-tidal morphology which could also lead to further changes in the amount of energy reaching the coast, and thus local changes to the coastline. However, the magnitude of change will be re-evaluated once the numerical modelling has been undertaken, with the significance of effect revised accordingly in the ES that is submitted in 2017.
Source: MOLF (piled elements) (Indirect) increase in erosion of the coast/railway embankment due to modification of the hydrodynamic and/or wave regime	Likely	High	Low	Moderate (Potentially Significant)	The MOLF has the potential to directly alter the hydrodynamic/wave regime resulting in modification of the energy reaching the coast. A change in energy could modify existing patterns of erosion. These changes in hydrodynamic/wave conditions may also result in changes in sub-tidal/inter-tidal morphology which could also lead to further changes in the amount of energy reaching the coast, and thus local changes to the coastline. However, the magnitude of change will be re-evaluated once the numerical modelling has been undertaken, with the significance of effect revised accordingly in the ES that is submitted in 2017.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Operation					
Cumbria Coast MCZ (Inter-tidal sand and muddy sand, high energy inter-tidal rock, moderate energy infra-littoral rock, peat and clay exposures)					
Source: MOLF Breakwaters Effect: (Indirect) changes to morphology of the MCZ due to modifications of the hydrodynamic and wave regime	Likely	High	Medium	Major (Significant)	Breakwaters would create a zone of calmer water in the vicinity of the MOLF. This reduction in wave energy could alter the rate and direction of sediment transport at the seabed/within the littoral zone, leading to a change in morphology and substrate over time. Localised modifications of tidal currents and blockage of bedload sediment transport could also result in a change to seabed morphology and substrate. However, the magnitude of change will be re-evaluated once the numerical modelling has been undertaken, with the significance of effect revised accordingly in the ES that is submitted in 2017.
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of the MCZ due to modifications of the hydrodynamic and wave regime	Likely	High	Low	Moderate (Potentially Significant)	Modification of the hydrodynamic/wave regime is expected to be limited for a piled MOLF. Associated changes in longshore sediment transport are therefore also expected to be small, leading to a low magnitude of change to the seabed/inter-tidal areas. (However, the magnitude of change will be dependent upon the density of the piles supporting the MOLF.)
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of the MCZ due to localised scour around piles	Likely	High	Very low	Minor (Not Significant)	Scour effects are expected to be restricted to within a distance of a few metres around infrastructure (especially piles). It is also anticipated that the majority of scour will occur during the construction phase, with an equilibrium scour depth achieved either prior to or early within the operational phase.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: Intakes/outfalls Effect: (Indirect) changes to morphology of the MCZ due to modifications of the hydrodynamic and wave regime	Unlikely	High	Very low	Minor (Not Significant)	Modification of the hydrodynamic/wave regime is expected to be localised and any associated changes to the seabed are not expected to extend to the Cumbria Coast MCZ.
Source: Dredging activity Effect: (Indirect) localised changes to bed level/substrate within the MCZ associated with maintenance dredging works	Likely	High	Low	Moderate (Potentially Significant)	Maintenance dredging may be required to maintain appropriate water depths in the MOLF berth pockets. Dredging may result in indirect localised and short term changes in bed level and substrate associated with the settling out of material from suspended sediment plumes. However, the magnitude of change will be re-evaluated once the numerical modelling has been undertaken, with the significance of effect revised, as appropriate, in the ES that is submitted in 2017.
Drigg Coast SAC (Mud/sand flats, saltmarsh, estuaries and dunes)					
Source: MOLF Breakwaters Effect: (Indirect) changes to morphology of the SAC due to modifications of the hydrodynamic and wave regime	Unlikely	High	Very low	Minor (Not Significant)	Changes in the rate/direction of longshore sediment transport arising from alterations to the wave climate could potentially lead to changes in inter-tidal morphology and substrate at locations away from the Moorside Site frontage. The magnitude of change and associated probability of this occurring will be dependent upon the design of the breakwaters, in particular its size and shape. However, given (i) the distance to the Drigg Coast SAC; and (ii) the absence of a (clear) longshore sediment transport pathway connecting the Drigg Coast SAC to the Moorside Site, the magnitude of change to the SAC is expected to be very low.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of the SAC due to modifications of the hydrodynamic and wave regime	Unlikely	High	Very low	Minor (Not Significant)	Modification of the hydrodynamic/wave regime is expected to be limited for a piled MOLF and changes in longshore sediment transport are therefore also expected to be similarly limited. Given (i) the distance to the Drigg Coast SAC; and (ii) the absence of a (clear) longshore sediment transport pathway connecting the Drigg Coast SAC to the Moorside Site, the magnitude of change to the seabed/inter-tidal areas is expected to be very low.
Source: Intakes/outfalls Effect: (Indirect) changes to morphology of the SAC due to modifications of the hydrodynamic and wave regime	Unlikely	High	Very low	Minor (Not Significant)	Modification of the hydrodynamic/wave regime is expected to be localised and any associated changes to the seabed are not expected to extend to the Drigg Coast SAC.
Hydromorphological elements of Cumbria Coast Water Body and Esk Transitional Water Body (Depth variation, structure and substrate of the bed and structure of the inter-tidal zone)					
Source: MOLF Breakwaters Effect: (Indirect) changes to morphology of inter-tidal/sub-tidal areas due to modifications of the hydrodynamic and wave regime	Likely	Medium	Low	Minor (Not Significant)	Breakwaters would create a zone of calmer water in the vicinity of the MOLF. This reduction in wave energy could alter the rate and direction of sediment transport at the seabed/within the littoral zone, leading to a change in morphology and substrate over time. Localised modifications of tidal currents and blockage of bedload sediment transport could also result in a change to seabed morphology and substrate.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of inter-tidal/sub-tidal areas due to modifications of the hydrodynamic and wave regime	Likely	Medium	Low	Minor (Not Significant)	Modification of the hydrodynamic/wave regime is expected to be limited for a piled MOLF. Associated changes in longshore sediment transport are therefore also expected to be small, leading to a low magnitude of change to the seabed/inter-tidal areas.
Source: MOLF (piled elements) Effect: (Indirect) changes to morphology of the inter-tidal/seabed due to localised scour around piles	Likely	Medium	Very low	Negligible (Not Significant)	Scour effects are expected to be restricted to within a distance of a few metres around infrastructure (especially piles). It is also anticipated that the majority of scour will occur during the construction phase, with an equilibrium scour depth achieved either prior to or early within the operational phase.
Source: intakes/outfalls Effect: (Indirect) changes to morphology of inter-tidal/sub-tidal areas due to modifications of the hydrodynamic and wave regime	Unlikely	Medium	Very low	Negligible (Not Significant)	Modification of the hydrodynamic/wave regime is expected to be highly localised and any associated changes to the seabed are expected to be similarly limited.

Receptor and summary of predicted effects	Probability	Sensitivity/ value of receptor	Magnitude of change	Significance of effect	Rationale
Source: Dredging activity Effect: (Indirect) localised changes to bed level/substrate associated with maintenance dredging works	Likely	Medium	Low	Minor (Not Significant)	Maintenance dredging may be required to maintain appropriate water depths in the MOLF berth pockets. Dredging may result in indirect localised and short term changes in bed level and substrate associated with the settling out of material from suspended sediment plumes.
The coastline and associated infrastructure					
Source: MOLF Breakwaters (Indirect) increase in erosion of the coast/railway embankment due to modification of the hydrodynamic and/or wave regime	Likely	High	Medium	Major (Significant)	The MOLF has the potential to directly alter the hydrodynamic/ wave regime resulting in modification of the energy reaching the coast. A change in energy could modify existing patterns of erosion. These changes in hydrodynamic/wave conditions may also result in changes in sub-tidal/inter-tidal morphology which could also lead to further changes in the amount of energy reaching the coast and thus local changes to the coastline. However, the magnitude of change will be re-evaluated once the numerical modelling has been undertaken, with the significance of effect revised accordingly in the ES that is submitted in 2017.
Source: MOLF (piled elements) (Indirect) increase in erosion of the coast/railway embankment due to modification of the hydrodynamic and/or wave regime	Likely	High	Low	Moderate (Potentially Significant)	The MOLF has the potential to directly alter the hydrodynamic/wave regime resulting in modification of the energy reaching the coast. A change in energy could modify existing patterns of erosion. These changes in hydrodynamic/wave conditions may also result in changes in sub-tidal/inter-tidal morphology which could also lead to further changes in the amount of energy reaching the coast and thus local changes to the coastline. However, the magnitude of change will be re-evaluated once the numerical modelling has been undertaken, with the significance of effect revised accordingly in the ES that is submitted in 2017.

15.9 Preliminary assessment of the Moorside Project as a whole

15.9.1 As previously stated in **Section 15.1**, a review of the development proposals for the Accommodation Sites, Additional Sites, Moorside Site Railway and sites for the Highways Improvements confirms that they are entirely land based and therefore will not result in any changes to marine and coastal physical processes. Accordingly, for this preliminary assessment only the Moorside Site has been considered. As such, consideration of the likely significant effects of the Moorside Project as a whole is delivered by virtue of the preliminary assessment set out above in relation to the Moorside Site.

15.10 Preliminary assessment of cumulative effects with other developments

Scope of the assessment

15.10.1 As outlined in **Section 3.4**, an exercise has been undertaken to determine which other (non-Moorside Project) developments should be considered in the context of their ability to result in cumulative environmental effects with any development of the Moorside Project Sites.

15.10.2 Of the other developments described in **Section 3.4**, listed in **Table 3.4** and considered in the context of **Table 3.9** in terms of Marine and Coastal Physical Processes effects, it is considered appropriate at this stage not to consider the following projects on the basis that they are located outwith the ZoI identified in **Table 3.8**:

2. National Grid – North West Coast Connections (National Grid);
3. West Cumbria Mining Project (coal mine) (West Cumbria Mining);
5. West Cumbria Water Supply Pipeline (United Utilities);
6. Walney Extension Wind Farm (Dong Energy);
7. Barrow-in-Furness Site (BAE Systems);
8. Ulverston Biopharmaceutical Manufacturing Facility (GSK);
9. Heysham New Nuclear Power Station (EDF Energy); and
10. Tidal Lagoon West Cumbria (Tidal Lagoon Power).

15.10.3 However, it should be noted that the situation with respect to the above developments will be kept under review during the preparation of the EIA, pending the availability of information from the respective developers regarding their own marine and coastal physical processes ZoIs.

15.10.4 Of the remaining other developments considered in **Table 3.9**, these are briefly discussed in the context of their likely interaction with respect to marine and coastal physical processes in the sub-sections below.

1. Sellafield Site Decommissioning (Sellafield Ltd/Nuclear Decommissioning Authority)

15.10.5 It is considered unlikely that the Sellafield Site Decommissioning project will have the potential to interact with development at the Moorside Site. This is because decommissioning activities are not expected to impact the marine environment. However, should NuGen be made aware that the Sellafield Site Decommissioning is expected to involve any inter-tidal/seabed disturbance activities associated with removal of existing marine infrastructure, the potential for cumulative effects will be assessed and will be reported on in the ES that is submitted in 2017. The most likely cumulative effect is anticipated to be the potential for suspended sediment plumes associated with Moorside Site construction activities to interact with those associated with decommissioning of Sellafield marine infrastructure - should the latter be required.

4. Low Level Waste Repository, Drigg (LLWR Ltd)

15.10.6 As is the case with Sellafield Site Decommissioning, the extensions to the Low Level Waste Repository (LLWR) at Drigg are not expected to have the potential to interact with development at the Moorside Site, since it is understood that the consented works have no marine element.

15.11 Consideration of additional mitigation

15.11.1 At this stage, all of the mitigation measures, which are anticipated will be required, are incorporated into the development proposals and are considered in the assessment of effects outlined in **Section 15.8**. However, if it emerges during the preparation of the ES that further measures are required the relevant details will be presented in the ES. In particular, this may be relevant when considering the potential for an increase in erosion associated with the MOLF and breakwaters. Subject to the outcome of the more detailed assessment to be included in the ES in 2017 (which will incorporate numerical modelling analyses), the provision of coastal defence structures may be proposed as an additional mitigation measure.

15.12 References

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