Cyngor Gwynedd

Barmouth North Promenade FAS

ES Chapter 12 Marine and Coastal Physical Processes

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12. Marine and Coastal Physical Processes

12.1 Introduction

12.1.1 This chapter provides an assessment of the likely significant effects on the Marine and Coastal Physical Processes that may arise from the construction, operation and maintenance of Barmouth North Promenade Flood Defence Scheme (hereafter referred to as the 'Proposed Development').

12.1.2 This chapter has considered the scoping report submitted by Cyngor Gwynedd (Ymgynghoriaeth Gwynedd Consultancy (YGC)), engagement with statutory consultees, and scoping opinions received from Cyngor Gwynedd and Natural Resources Wales (NRW) on 30 April 2024 and 19 April 2024 respectively.

12.1.3 This chapter details the legislation, policy and guidance that is relevant to the Marine and Coastal Physical Processes, a summary of engagement undertaken, the methodology of assessment, and the embedded environmental design measures. This is followed by an assessment of likely significant effects of the Proposed Development on Marine and Coastal Physical Processes, taking account of the embedded environmental design measures, and the need for any additional mitigation is then considered along with any proposals for enhancement design measures. This chapter concludes with a summary of likely significant residual effects.

12.1.4 The Marine and Coastal Physical Processes chapter provides a general site description, placing the site within the regional geographical and environmental context and giving an overview of regional coastal processes. This informs the setting of the proper spatial maximum zone of influence for potential impacts of the proposed works which has been considered in this chapter.

12.1.5 Marine and Coastal Physical Processes receptors include:

- Tidal levels
- Extreme water and surge levels
- Waves
- Beach and coastal erosion
- Sediment Transport

12.1.6 This chapter is supported by the following appendices, all contained in Volume 3:

- Appendix 12.1 - ABPmer (2019), Barmouth North Promenade, Wave modelling, extremes analysis and overtopping, ABPmer Report No. R.3105. A report produced by ABPmer for Arup, May 2019 (referred herein R3105).
- Appendix 12.2 - ABPmer (2019), Barmouth North Promenade, Coastal Processes, ABPmer Report No. R.3096. A report produced by ABPmer for Arup, February 2019 (referred herein R3096).
- Appendix 12.3 - ABPmer (2021), Barmouth North Promenade, Shoreline modelling - risk reduction assessment, ABPmer Report No. R.3589. A report produced by ABPmer for Arup, April 2021.
- Appendix 12.4 - ABPmer (2024), Barmouth North Promenade D&C, Consideration of revised water level estimates, Ref 5501/TN01. A report produced by ABPmer for Arup, Oct 2024.

- Appendix 12.5 - Coastal Processes Technical Note by Arup. Appendix A: ABPmer (2024), Barmouth North Promenade D&C, Coastal Process and Option Review, Ref R.4718. A report produced by ABPmer for Arup, Dec 2024.
- Appendix 12.6 - Barmouth Beach Blown Sand Management Options Report prepared for Gwynedd Council KPAL Report No: 19100 27 October 2016, Pye, K., Blott, S., 2016.

12.1.7 This chapter is supported by the following figures, all contained in ES Volume 4:

- Figure 12.1 Coastal Processes: Zone of Influence
- Figure 12.2 Coastal Processes: Zone of Influence and Protected Areas

12.1.8 This chapter should be read in conjunction with:

- ES Chapter 6 Biodiversity and Protected Sites
- ES Chapter 7 Climate Change
- ES Chapter 8 Community Considerations
- ES Chapter 9 Cultural Heritage
- ES Chapter 10 Flooding and Water Quality
- ES Chapter 13 Seascape and Landscape and Visual
- ES Chapter 15 Cumulative and In-Combination Effects

12.2 Legislation, Policy and Guidance

12.2.1 This section identifies the legislation, policy, guidance and other documentation that has informed the assessment of likely significant effects on the Marine and Coastal Physical Processes. This section is supported by the ES Volume 3, Appendix 1.1 Policy Context, which outlines overarching legislation and policy relevant to the Proposed Development.

12.3 Legislation

12.3.1 Table 12-1 lists the legislation relevant to this topic and the assessment of the likely significant effects.

Table 12-1 List of Relevant Legislation

Legislation	Relevance to Assessment
The Environment (Wales) Act 2016	Section 6 under Part 1 of the Act introduced an enhanced duty (the S6 duty) for public authorities in the exercise of functions in relation to Wales. The S6 duty requires that public authorities must seek to maintain and enhance biodiversity so far as consistent with the proper exercise of their functions and in so doing promote the resilience of ecosystems. In doing so, public authorities must have regard to the list of species and habitats published under Section 7, the State of Natural Resources Report. (SoNaRR) and any relevant Area Statement(s).
Well-being of Future Generation (Wales) Act 2015	Well-being goal: Capacity to adapt to climate change Indicator 32 ‘Reducing flood risk to homes and businesses’

12.4 National Policy and Strategies

12.4.1 Table 12-2 lists the relevant planning policy and strategies, with paragraphs of relevance to the Marine and Coastal Physical Processes assessment.

Table 12-2 List of Relevant National Policy

National Policy & Paragraph Number	Summary of Policy Requirement and Relevance
Planning Policy Wales (PWW) Edition 12	**Section Coastal Change** Policies 6.5.14 to 6.5.20 have been considered in this assessment.
Welsh National Marine Plan	**SOC_08: Resilience to coastal change and flooding** Proposals should demonstrate how they are resilient to coastal change and flooding over their lifetime.
	SOC_09: Effects on coastal change and flooding Proposals should demonstrate how they: • avoid significant adverse impacts upon coastal processes; and • minimise the risk of coastal change and flooding; Proposals that align with the relevant Shoreline Management Plan(s) and its policies are encouraged.
	SOC_11: Resilience to climate change Proposals should demonstrate that they have considered the impacts of climate change and have incorporated appropriate adaptation measures, taking into account Climate Change Risk Assessments for Wales. Proposals that contribute to climate change adaptation and/or mitigation are encouraged.
	ENV_01: Resilient marine ecosystems Proposals should demonstrate how potential impacts on marine ecosystems have been taken into consideration and should, in order of preference: a. avoid adverse impacts; and/or b. minimise impacts where they cannot be avoided; and/or c. mitigate impacts where they cannot be minimised. If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding. Proposals that contribute to the protection, restoration and/or enhancement of marine ecosystems are encouraged.
	ENV_02: Marine Protected Areas Proposals should demonstrate how they: • avoid adverse impacts on individual Marine Protected Areas (MPAs) and the coherence of the network as a whole; • have regard to the measures to manage MPAs; and • avoid adverse impacts on designated sites that are not part of the MPA network
	ENV_06: Air and water quality Proposals should demonstrate that they have considered their potential air and water quality impacts and should, in order of preference: a. avoid adverse impacts; and/or b. minimise adverse impacts where they cannot be avoided; and/or c. mitigate adverse impacts where they cannot be minimised. If significant adverse impacts cannot be avoided, minimised or mitigated, proposals must present a clear and convincing case for proceeding.
West of Wales Shoreline Management Plan 2 (SMP2)– St Anne's Head to Great Orme	The West of Wales Shoreline Management Plan 2 (SMP2) is a strategic, non-statutory policy document that sets out a long-term framework for managing coastal risks along the region's shoreline. It assesses coastal processes, flood and erosion risks, and the environmental, social, and economic implications of different management approaches. SMP2 gives guidance on driving sustainable coastal defence strategies while balancing the need for protection with the natural dynamics of the coastline.

National Policy & Paragraph Number	Summary of Policy Requirement and Relevance
	Section 6.2 Summary of SMP2 Policy Units Table Coastal Area D – Summary SMP2 preferred policies for Policy Units PU11.14 to PU11.16
UK Marine Policy Statement	**Section 2.6.7 Climate change adaptation and mitigation** Policies 2.6.7.1 to 2.6.7.9 (Pages 23 and 24) have been considered in this assessment.
	Section 2.6.8 Coastal change and flooding Policies 2.6.8.1 to 2.6.8.6 (Pages 24 and 25) have been considered in this assessment.
	Section 3.1 Marine protected areas Policies 3.1.1 to 3.1.8 (Pages 27 and 28) have been considered in this assessment.
TAN 14: Coastal Planning (1998)	*TAN 14: Coastal Planning* provides guidance on managing development in coastal areas, emphasizing the need to account for coastal erosion, flooding, and long-term changes. It highlights the importance of the SMP in shaping development decisions and avoiding areas that require costly engineering interventions. The document stresses the need for environmental protection, ensuring that development does not disrupt coastal habitats or exacerbate risks like coastal squeeze.
TAN 15: Development, Flooding, and Coastal Erosion (2022)	*TAN 15: Development, Flooding, and Coastal Erosion* provides guidance on assessing and managing risks from flooding and coastal erosion in development planning. The guidance supports sustainable development by encouraging risk-aware planning and resilience to future flooding and coastal erosion impacts.

12.5 Local Policy and Strategies

12.5.1 The relevant local planning policy plans and strategies to the Marine and Coastal Physical Processes assessment are listed in Table 12-3.

Table 12-3 List of relevant local policy, plans and strategies

Local Policy, Plan & Strategy	Relevant policy	Relevance to Assessment
Anglesey and Gwynedd Joint Local Development Plan 2011 - 2026 (2017)	Policy PS 6	Ensuring that the ability of landscapes, environments and species to adapt to the harmful effects of climate change is not affected, and that compensatory environments are provided if necessary;
	Policy ARNA 1	Proposals for new or replacement coastal defence schemes will only be permitted where it can be demonstrated that the works are consistent with the management approach for the frontage presented in the Shoreline Management Plan, and there will be no material adverse impact on the environment.
	Policy PS 19	The development is to conserve and enhance the natural environment and coastline and outlines that developments should consider relevant supplementary planning guidance including SPG Wildlife Sites and SPG Gwynedd Landscape Character.
	Policy AMG 4	Coastal Protection requires development to not cause harm to SACs and biodiversity areas.
	Policy AMG 5	The proposal is to protect and enhance locally important biodiversity and that developers produce an Ecological Assessment which highlights the relevant local biodiversity issues.

12.6 Standards and Guidance

12.6.1 The guidance and standards which relate to this topic are listed below.

- NRW Guidance Note GN13 - Scoping an Environmental Impact Assessment for Marine Developments (2017) [1].
- NRW Guidance Note GN19 - Completing a coastal or physical processes assessment for small-scale projects (2024) [2].
- NRW Guidance Note GN41 - (EIA) (2025) [3].
- Met Office UKCP18 Marine Report (2018) [4].

12.7 Stakeholder Engagement

EIA Scoping Opinion

12.7.1 An EIA Scoping Opinion was adopted by Cyngor Gwynedd/Gwynedd Council (supported by Ymgynghoriaeth Gwynedd Consultancy (YGC)) and Natural Resources Wales (NRW) on 30 April 2024 and 19 April 2024 respectively. The comments received in relation to Marine and Coastal Physical Processes are presented in Table 12-4 and Table 12-5 and details are included on how these have been addressed.

Engagement with NRW

12.7.2 A meeting with NRW Marine Advisory and Cyngor Gwynedd/Gwynedd Council was held on the 10 July 2025 where the key issues associated with coastal processes for the Proposed Development were described. Due consideration has been given to the NRW Guidance notes: GN19 - Completing a coastal or physical processes assessment for small-scale projects and GN41 Marine Physical Processes Guidance to inform Environmental Impact Assessment (EIA).

Table 12-4 Gwynedd Council comments on scope of the Marine and Coastal Physical Processes and the response

Scoping Opinion Comment	Response
We would agree that marine and coastal physical process is scoped into the assessment.	Marine and coastal physical processes are scoped into the assessment.
NRW have noted that as regards to Physical Processes a spatial maximum zone of influence for potential impacts of the proposed works has not been presented. A suitable spatial maximum zone of influence should be confirmed.	A suitable spatial maximum zone of influence is confirmed (see section 12.12).
NRW have stated that the scoping report submitted provides insufficient detail regarding potential direct and indirect impacts of the Construction, Operation and Decommission phases of the proposed works to Physical Processes.	Direct and indirect impacts of the Construction and Operation phases of the proposed works to Physical Processes are provided in sections Construction Effects and Operational and Maintenance Effects. The Proposed Development does not include decommissioning.
The Scoping Report notes that the Shoreline Management Plan relevant to the site is Hold the Line for epoch 1 while transitioning to Managed Realignment by epoch 2 and 3. The EIA must consider whether works are in line with the relevant SMP.	The EIA considers alignment of the works with the relevant SMP (see section 12.15).

Table 12-5 NRW comments on scope of the Marine and Coastal Physical Processes and the response

Scoping Opinion Comment	Response
We agree that marine and coastal physical process must be scoped into the assessment. A spatial maximum zone of influence for potential impacts of the proposed works has not been presented. This must be included with the EIA.	Marine and coastal physical processes are scoped into the assessment. A suitable spatial maximum zone of influence is confirmed (see section 12.12).
NRW also state that scoping report submitted provides insufficient detail regarding potential direct and indirect impacts of the Construction, Operation and Decommission phases of the proposed works to Physical Processes this must be addressed within the EIA"	Direct and indirect impacts of the Construction and Operation phases of the proposed works to Physical Processes are provided in sections Construction Effects and Operational and Maintenance Effects. The Proposed Development does not include decommissioning.
The Scoping Report notes that the Shoreline Management Plan relevant to the site is Hold the Line for epoch 1 while transitioning to Managed Realignment by epoch 2 and 3. The EIA must consider whether works are in line with the relevant SMP.	The EIA considers alignment of the works with the relevant SMP (see section 12.15).
There is guidance on NRW website surrounding when a coastal squeeze assessment may be necessary. We encourage you to review and follow the guidance.	Coastal Squeeze assessment eligibility requirements assessed in Section **Error! Reference source not found.**.

12.7.3 Comments were received from NRW dated 27 November 2025 as part of the Statutory Pre-Application Consultation – Town and Country Planning (Development Management Procedure) (Wales) Order 2012 as Amended. Consideration has been given to these comments, as summarised in Table 12-6.

Table 12-6 NRW comments as part of the Statutory Pre-Application Consultation

Statutory Pre-Application Consultation Comment	Response
NRW advised that a coastal squeeze assessment is submitted with planning application.	HRA Coastal Squeeze Addendum (doc ref BMTH-ARP-EBD-OFFSH-TN-OE-000003) has been produced to provide a Coastal Squeeze Assessment, considering the proposed policy change and section 12.16 amended to reflect the assessment.
NRW advised that the aeolian transport, impact of the revetment on dunes and the removal of the groynes impact on aeolian transport should be assessed.	These aspects have been considered in section *Sediment transport and beach morphology* including key conclusions in relation to the wind driven (aeolian) sand transport which have been extracted from the report Barmouth Beach Blown Sand Management Options Report prepared for Gwynedd Council KPAL Report No: 19100 27 October 2016, Pye, K., Blott, S., 2016 (Appendix 12.6.)
NRW advised clarifications of the baseline sediment transport model	Clarifications of the baseline sediment transport model have been added in section *Sediment Transport* including likely sand transport processes.

Statutory Pre-Application Consultation Comment	Response
NRW concluded that the provided zone of influence is reasonable; however, NRW advised that specific details should be given into the determination of the extent of the zone in this section. NRW advised that the 100m longshore extent was justified.	Numerical justification has been provided to determine the zone of influence in section 12.12 *Zone of influence*. It is noted that the 100m longshore extent has been modified to 15m as a result of the reduced extent of rock revetment which has been assessed to cause only localised effects.

Non-Statutory Engagement

12.7.4 Non-Statutory Stakeholder engagement has been undertaken with key stakeholders in relation to the Marine and Coastal Physical Processes. A summary of engagement undertaken is outlined below.

12.7.5 Stakeholder engagement was undertaken with NRW Marine Advisory and Cyngor Gwynedd/Gwynedd Council in a meeting held on the 10 July 2025 where the key issues dealing with coastal processes were described.

12.8 Methodology

Assessment Methodology

12.8.1 The EIA assessment methodology follows the NRW Guidance Note GN41 - Marine Physical Processes Guidance to inform Environmental Impact Assessment (EIA) (2025) for the determination of zone of influence and assessment of change and likely impacts. The EIA approach is based on the approach set out within ES Volume 2, Chapter 4 EIA approach applied to change and likely impacts identified.

12.8.2 The stages assessed in this chapter include the steps listed below.

- Conceptual understanding and characterisation of present and future baseline conditions including climate change allowances.
- Initial project description.
- Definition of maximum Zone of influence.
- Assessment of change and likely impacts.
- Assessment of significance:
  - Assigning value (or sensitivity) to receptors or resources.
  - Assigning magnitude of impact.
  - Assigning significance.
- Mitigation
- Residual effect
- Enhancements

12.9 Baseline

Current Baseline

12.9.1 This section sets out existing conditions and identifies potential receptors and their value, as per the methodology.

Description of the site elements affected by coastal processes

12.9.2 The Site location is set out in ES Chapter 2. The beach north of North Promenade is comprised of a shingle/cobble bank that fronts the railway line. Along North Promenade and to the south of North Promenade, the sediments are mainly comprised of sand with isolated pockets of shingle/cobbles along the upper foreshore.

12.9.3 A large beach with dynamic foredunes and embryo dunes lies to the south of Barmouth North Promenade at the Mawddach Estuary (see section Habitats and Ecology for wider ecological considerations).

12.9.4 Timber groynes are in place in front of the promenade to control the longshore movement of sediment, the groynes condition varies from north to south. However, these have been assessed as generally in poor condition and have very limited functionality with the exception of one refurbished groyne which seems to be retaining the coarser material in the upper part of the beach. In-between each of the groynes there are small pockets of sand-shingle beaches which become sandier in a southerly direction.

12.9.5 According to Appendix 12.2 Coastal Process and Option Review report by ABPmer, site visits undertaken in 2024 indicate that:

- Along the northern end of the frontage, the wall is undermined due to significant beach lowering has occurred against the sea wall.
- Coarse sediment (pebble/cobble) fillet exists along northern half the frontage blocked/trapped within a very slight ‘V’ in the seawall alignment.
- Reduced beach levels in central portion of frontage were observed.
- Along the southern section of the frontage (and extending along Barmouth, South Promenade), there is a significant coarse sediment in the and lower upper beach. The full extent of these shoals in the lower beach is unknown as sand material moves around, covering and exposing the coarse material in the process.
- Intermediate damage to the wall from past overtopping events seems to have occurred in the northern frontage where there is significant beach lowering,

12.9.6 Given the tidal range at Barmouth, the existing sea defences along North Promenade are exposed to the incident wave climate for significant periods over the tidal cycle, therefore exposing the defence to wave overtopping and hinterland flooding.

Metocean conditions

12.9.7 Water levels referenced in this section are extracted from the document: Consideration of revised water levels estimates, by ABPmer which can be found in ES Volume 3, Appendix 12.4.

Tidal Levels

12.9.8 Predicted tidal water levels to Admiralty Chart Datum (CD) and Ordnance Datum Newlyn (ODN) were obtained from Admiralty Total Tide by ABPmer and are presented in Table 12-7. The values presented are current and are representative of levels in 2025.

Table 12-7 Tidal water levels (Total Tide secondary port of Barmouth). See Appendix 12.4.

Reference Still Water Level	Chart Datum (mCD)	Ordnance Datum Newlyn (mODN)
Highest astronomical tide (HAT)	5.70	3.26
Mean high water springs (MHWS)	5.00	2.56
Mean high water neaps (MHWN)	3.70	1.26
Mean sea level (MSL)	2.72	0.28
Mean low water neaps (MLWN)	1.90	-0.54
Mean low water springs (MLWS)	0.70	-1.74
Lowest astronomical tide (LAT)	0.30	-2.14
Mean Spring Range	4.30m	
Mean Neap Range	1.80m	

12.9.9 During spring tides, the water level reaches the sea defence along most of the frontage, as can be seen in Graphic 12-1.

Graphic 12-1 Aerial Image of North Promenade showing coastline for different existing tidal levels (MHWN =1.3 mODN in blue, MHWS = 2.6 mODN in red, HAT 3.3 mODN in black), ODN Datum

Extreme Water Levels and Surge

12.9.10 The extreme still water levels for the current epoch were extracted from the Coastal Flood Boundary Dataset (CFBD, 2018) included in Appendix 12.4, at the dataset point closest to the Barmouth frontage (point 834). These water levels account for the impact of storm surges.

12.9.11 As the CFBD dataset provides water levels for the base year 2017, the extracted levels were adjusted to the 2025 using the UKCP18 (RCP8.5 70th %ile) Sea Level Rise (SLR) scenario and 95th %ile for sensitivity tests following the Welsh Government, (2022) Guidance “Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales”. More detail on the procedure can be found in Section 2.3 of Appendix 12.4, Refer to Table 12-8 for the extreme water levels in 2025.

Table 12-8 Extreme still water levels for the year 2025 derived from CFBD (2018) and UKCP18 RCP8.5 70th percentile projections

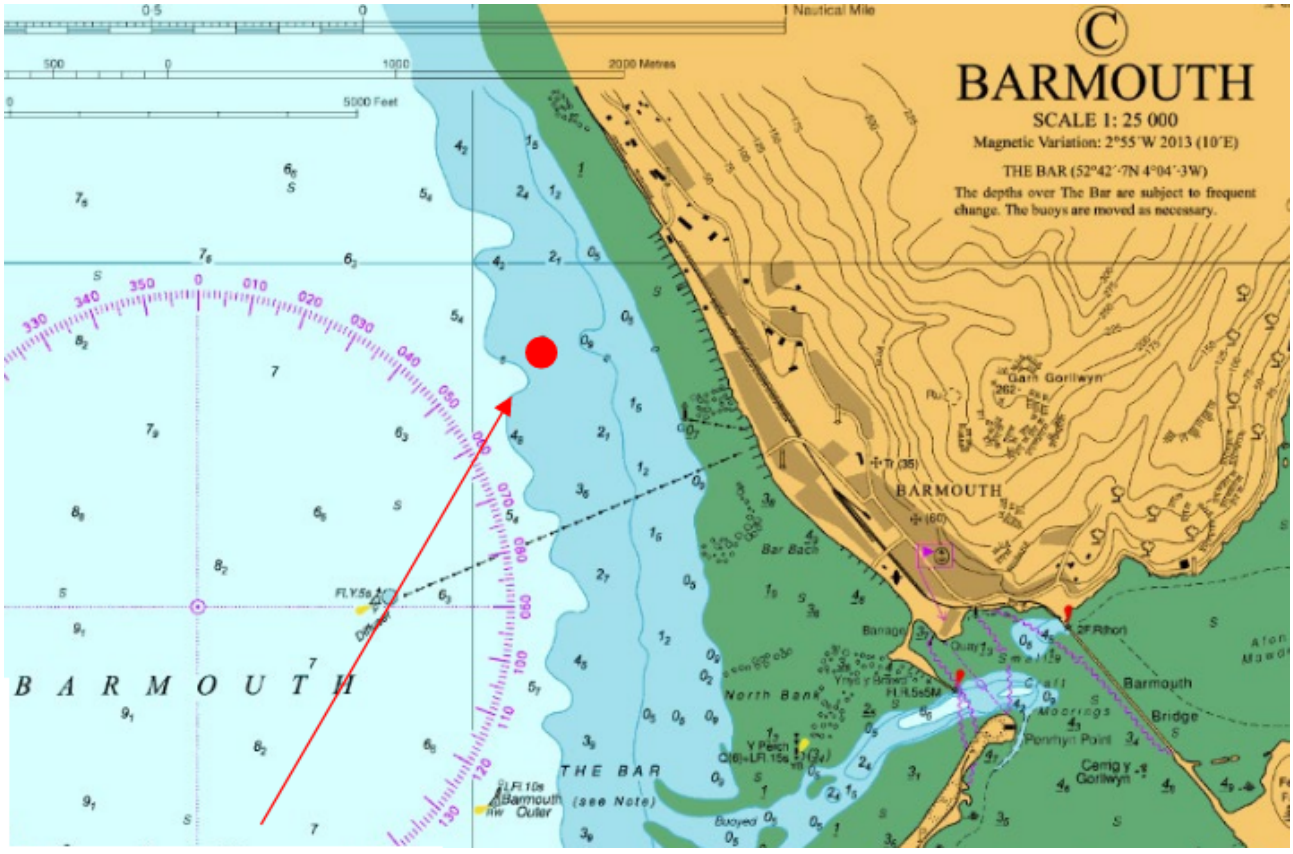
Return Period	AEP (%)	Epoch 2025 (mODN)
T1	63	3.50
T10	10	3.90
T50	2	4.17

Return Period	AEP (%)	Epoch 2025 (mODN)
T100	1	4.29
T200	0.5	4.41
T1000	0.1	4.70

Waves

12.9.12 Predicted extreme wave heights reaching the Barmouth frontage were derived from a regional wave model by ABPmer at OBC stage in 2019 described in ES Volume 3, Appendix 12.2. The results are based on a 39 year hindcast timeseries of wave heights and were subject to an Extreme Value Analysis and Joint Probability Analysis. The full methodology and assumptions behind the wave model are presented in Appendix 12.2.

12.9.13 The model extraction point, selected as representative of the entire beach extent, is located at an offshore position in front of Barmouth North Beach, along the -7 mODN contour (see Graphic 12-2).



Graphic 12-2 Wave extraction location (red circle) overlaid over admiralty chart

12.9.14 The results at the model extraction point for the year 2019 are presented in Table 12-9.

Table 12-9 Extreme significant wave height predictions at Barmouth frontage for the year 2019

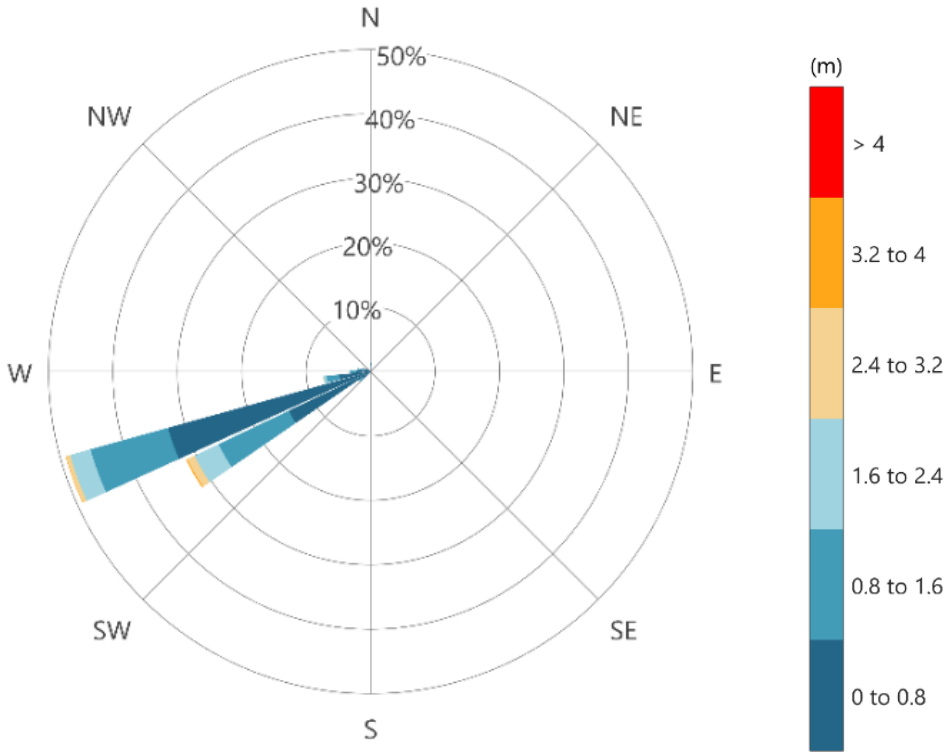
Return Period	AEP (%)	Epoch 2019 (mODN)
T1	63	3.67

Return Period	AEP (%)	Epoch 2019 (mODN)
T10	10	4.12
T50	2	4.24
T100	1	4.27
T200	0.5	4.29
T1000	0.1	4.32

12.9.15 To derive the maximum wave heights in the current year 2025, the Welsh national precautionary sensitivity ranges for offshore wave height can be applied, as per Welsh Government guidance. For the year 2025, an indicative 5% increase in offshore extreme wave height is proposed (refer to Table 10 in Appendix 12.4). However, it was considered appropriate for wind and wave increases to be considered as a sensitivity test rather than be included in the future 39 year hindcasts. To assess the sensitivity, wind speed and wave height at the model boundary were increased by 10% for the 2119 epoch.

12.9.16 The wave model results indicate that the dominant wave direction approaching the Barmouth frontage is from the southwest, with an average direction of 244°, as shown in Graphic 12-3. The narrow range of approaching wave directions observed in the figure is likely due to the prevailing offshore wave conditions and the presence of the northern headland, which limits wave energy from reaching the site from the north-westerly sectors.

12.9.17 Wave direction is largely unaffected by increases in water level, therefore the direction of waves in 2025 can be assumed to be unchanged. (Appendix 12.1)



Graphic 12-3 Wave roses showing significant wave height at circa -7 mODN for the year 2019

12.9.18 Other than the local shoals near the mouth of the Mawddach Estuary, the nearshore bathymetry directly offshore from the North Promenade frontage is relatively smooth and featureless. Therefore, the dominant wave energy approaches the frontage from a relatively consistent angle that is close to shore normal.

Coastal Processes

Historical Beach Evolution Trends

Desktop Study

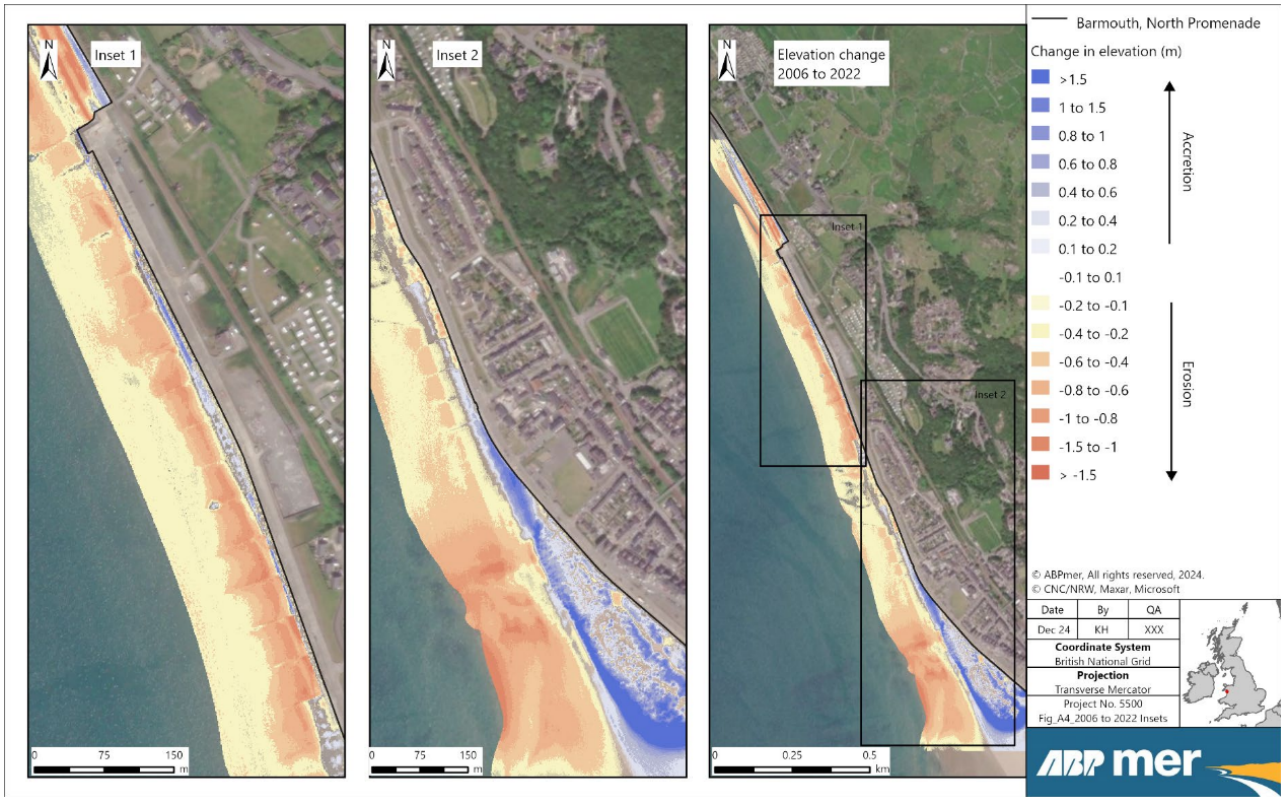
12.9.19 An overview of the historical evolution and changes of the coast along Barmouth and the Mawddach Estuary, based on the analysis of historical documents and photographs can be found in Section 4 of Appendix 12.2.

12.9.20 In summary, it was observed that following the construction of the 48 timber groynes and the sloping concrete structure in the 1930s, the northern part of Barmouth Beach experienced sediment loss and declining beach levels. This was already reported in the decade of the 1950s, leading to the strengthening of some sections of the wall in 1956 through the installation of sheet piles at the base of the structure. The southern part (dunes area) has seen profound changes including sediment accretion and rising beach levels, particularly since the construction of the causeway across the former Bar Bach channel in the early 1970s. This area has then experienced significant dune growth from the early 2000s.

LIDAR Study

12.9.21 Historical LiDAR surveys indicate a general trend of foreshore and beach lowering across North Barmouth Beach between 2006 and 2022. Over this 16-year period, the lower foreshore has decreased by approximately 0.4 m, while the upper foreshore has experienced a more significant reduction of around 0.8 m (Graphic 12-4). This lowering generally occurred around 15-60 m from the sea wall. Inshore and offshore of this bed level, changes are much less pronounced. For detailed figures and analysis, refer to Section 4.1 of Appendix 12.5.

12.9.22 There has been a greater level of erosion along the northern part of Barmouth South Promenade and a significant increase in the dunes. Along the Llanaber frontage, to the north of Barmouth North Promenade, there also appears to be lowering of the lower foreshore with some redistribution of coarse material along the upper beach.



Graphic 12-4 Changes in beach levels between LiDAR surveys in 2006 and 2022 – ABPmer (Appendix 12.5)

Sediment Transport

12.9.23 A baseline sediment transport model was developed by ABPmer in 2019 (refer to Section 3 of appendix 12.3). This was a longshore sediment transport model which modelled only the shingle portion of the beach as mobile material with the objective of assessing the stability of potential beach nourishment at the site. The shoreline evolution modelling predicted changes as a result of longshore sediment drift, and changes as a result of onshore-offshore transport were not represented in the model. This approach is considered appropriate as the study focused on coarse sediment that lies along the upper beach over a shallower slopping sandy foreshore which will be subject to longshore drift. The baseline model was run over a ~10-year period (2007–2016).

12.9.24 The sand flat platform where the shingle sits is subject to constant change as a result of cross-shore transport. There is a loss of sediment predicted in the wider area as part of natural erosion processes. This dynamic process will continue in the future and is not considered to be impacted by the proposed solution when compared with the baseline scenario.

12.9.25 The sediment transport model indicates limited shoreline change, reflecting the observed stability of the upper shingle/cobble beach. Sediment transport rates are generally low in relation to transport rates that can occur along an open coast subject to similar wave heights.

12.9.26 Where transport occurs, there is southerly net movement in the area north of North Promenade and northerly net movement along the southern section of North Promenade and northern Barmouth South frontage.

12.9.27 These low transport rates are influenced by several key factors:

- The wave climate is confined to a narrow, shore-normal sector, with waves becoming nearly perpendicular as they break on the upper beach, limiting longshore drift.
- The shingle/cobble is restricted to the upper beach, making it only susceptible to mobilization during certain tidal conditions.

Coastal Flooding

12.9.28 Coastal Flooding is linked with Marine and Physical Processes as the magnitude of defence overtopping is a function of water levels and wave overtopping. Methodology and results to determine the baseline coastal flooding are described in Chapter 10.

Habitats and Ecology

12.9.29 To the south, the Mawddach Estuary is designated as a Site of Special Scientific Interest (SSSI) and as a Special Area of Conservation (SAC), whilst the whole of Cardigan Bay forms part of the Llŷn Peninsula and Sarnau SAC (see Figure 12.2). The dunes do not have formal nature conservation designation, but the dunes are priority Biodiversity Action Plan (BAP) features which are now relatively scarce in Wales and across Europe. These dunes consist of dynamic foredunes and embryo dunes.

12.9.30 The site comprises predominantly of intertidal habitats, hardstanding structures in contact with the sea (artificial seawall and groynes), and small patches of grassland and scrub. For a detailed description of the other surrounding habitats, ecological networks and biodiversity descriptions, refer to ES Volume 2, Chapter 6 Biodiversity and Protected Sites.

12.9.31 The influence and impacts of marine and coastal processes are assumed to be constrained to the intertidal and hardstanding habitats.

12.9.32 The intertidal habitats within the study area, are predominantly composed of fine sand, supporting low biodiversity and a limited presence of macroinfauna. A detailed understanding of the intertidal biotopes identified is provided in the ES Volume 2, Chapter 6 Biodiversity and Protected Sites.

12.9.33 Of notable importance in the intertidal area, honeycomb worm reefs comprising of *Sabellaria alveolata* were identified in the rocky intertidal area approximately 270m to the north/northwest of the site. This habitat is classified as a UK Biodiversity Action Plan (UKBAP) Priority Habitat and is described as a key feature as part of the Pen Llŷn a'r Sarnau SAC.

12.9.34 An invasive non-native barnacle species (*Austrominius modestus*) was recorded as widespread across the site, particularly on groynes, though it is considered to pose a low ecological risk.

12.9.35 The most biodiverse ecosystems were observed on the timber groynes, which are colonised by various algae, crustaceans, and molluscs. Blue mussels were found in high densities on approximately two-thirds of the timber groynes, serving as an important forage resource for local bird species such as oystercatchers. This habitat is classified as a Priority Habitat and is described as a key feature as part of the Pen Llŷn a'r Sarnau SAC.

12.9.36 The artificial seawall was not identified as a UKBAP Priority Habitat.

Future Baseline

12.9.37 The Welsh Government, (2022) Guidance "Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales" recommends that coastal risk management scheme appraisals follow sea level rise scenarios from UK Climate Prediction 2018 (UKCP18):

- A higher central allowance RCP8.5 70th %ile for the main assessment.
- An upper end allowance RCP8.5 95th %ile for sensitivity test.

This is where RCP8.5 is a high-emissions scenario used in climate modelling and research. The 70th%ile is used as a higher central estimate, while the 95th%ile is used as a sensitivity test which covers the upper extremes of climate change.

Metocean Conditions

12.9.38 The future water levels referenced in this section are extracted from Consideration of revised water levels estimates by ABPmer which can be found in Appendix 12.4.

Sea Level Rise

12.9.39 Table 12-10 presents the Sea Level Rise (SLR) allowance for 2025, 2075 and 2125 for both the 70th %ile and 95th%ile projections from a base year of 2017.

Table 12-10 SLR allowances using latest Welsh Government (2022) guidance

Scenario	2025	2075	2125
SLR increase from 2017 based on RP8.5, 70th %ile	0.040 m	0.436 m	1.014 m
SLR increase from 2017 based on RP8.5, 95th %ile	0.049 m	0.575 m	1.401 m

Extreme Water Levels and Surge

12.9.40 The extreme still water levels for future epochs were derived by applying the UKCP18 (RCP8.5 70th %ile) SLR scenario to CFBD (2018) dataset. The results can be seen in Table 12-11.

Table 12-11 Extreme Still Water Levels for 2025 and future epochs derived from CFBD (2018) and SLR UKCP18 RC8.5 70th%ile projections (extracted from Appendix 12.4)

Return Period	AEP (%)	Extreme Still Water Level (mODN)			
		Base date 2017	Epoch 2025	Epoch 2075	Epoch 2125
T1	63	3.46	3.50	3.90	4.47
T10	10	3.86	3.90	4.30	4.87
T50	2	4.13	4.17	4.57	5.14
T100	1	4.25	4.29	4.69	5.26
T200	0.5	4.37	4.41	4.81	5.38
T1000	0.1	4.66	4.70	5.10	5.67

Waves

12.9.41 Following the methodology described in paragraph 12.9.15, the extreme wave levels are derived from national precautionary sensitivity ranges for offshore wind speed and wave heights by the Welsh Government. The increased values for the different epochs can be found in Table 12-12. Refer to Appendix 12.4 for details on the assessment.

Table 12-12 Recommended national precautionary sensitivity ranges for offshore wind speed and wave height (extracted from Appendix 12.4)

Parameter	Sea Level Rise up to 2025 (mm/yr)	Sea Level Rise 2026 to 2055 (mm/yr)	Sea Level Rise 2056 to 2085 (mm/yr)	Sea Level Rise 2085 to 2120 (mm/yr)
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

12.9.42 To assess the sensitivity of the area to wind speed and wave height increases, the conditions at the model boundary were increased by 10% for the 2119 epoch, as suggested in Table 12-12. Model results indicated an average increase in wave height of 8% at the contour level of -7 mODN. It is however to be noted that these uplifts have significant uncertainty associated with them and hence they were only used as a sensitivity test at the initial modelling stage and not adopted in design.

12.9.43 Wave direction is largely unaffected by increases in water level, therefore the direction of waves in the future baseline can be assumed to be unchanged from present day.

Coastal Processes

Beach Evolution Trends

12.9.44 Assuming no active intervention on the existing baseline, erosion is predicted to continue along Barmouth North Beach. The rate of erosion is likely to increase with SLR as larger waves will reach the coastal defences which in turn will likely increase beach erosion.

12.9.45 The SMP2 suggests the rate of erosion could increase by a factor of 1.7 to 2.5 times the existing base rate over the next 100 years. For the area of interest, the predicted 100 year high level erosion range is of 30 to 120m. This corresponds to an estimated high level predicted beach lowering at the toe of the defence of 0.2m by 2069 and 0.7m by 2119 for Barmouth North Beach. More information on future erosion and beach lowering rates is provided in Section 6.3 of Appendix 12.2.

Sediment Transport

12.9.46 Predicting future sediment transport is inherently challenging due to the complex interplay of coastal processes and variability in future climate conditions. The coastal processes report by ABPmer (Appendix 12.2) concluded an overall limited southerly longshore drift direction in the nearshore with strong evidence that there is very limited transport of coarse sediment along the frontage.

12.9.47 Insights can also be drawn from a baseline sediment transport model, which was extended over a 38-year hindcast period (1979–2016) to assess the

sensitivity to long-term variability (refer to Section 3 in appendix 12.3). This report utilised a fixed shoreline orientation with no morphological updating and therefore differences in annual rates of transport between years are directly related to differences in wave conditions between the years. The study concludes that both net and gross predicted transport rates are very low, in relation to transport rates along open coasts with similar wave heights, although it highlights the remaining uncertainty associated with the lack of actual measurements of longshore transport rates of the upper/shingle cobble beach. Therefore, although an inherent risk remains that future changes in wave conditions could noticeably change longshore transport rates along the beach, this is not considered to be associated to the implementation of the scheme but rather offshore changes in bathymetry and more general wave directional trends.

12.9.48 The baseline model indicates that annual variations in sediment transport rates are closely linked to fluctuations in wave conditions. Given projections of increased water levels and wave heights, it is expected that a greater volume of upper beach material will therefore be mobilised, particularly during high water events. This will likely lead to higher sediment transport rates. While the baseline model provides a strong foundation for understanding future trends, it is important to acknowledge that future conditions may introduce additional variability not fully captured.

12.9.49 Overall foreshore bed levels along North Promenade are lowering and this lowering is expected to continue. The lack of credible groynes and coarser material in the upper foreshore along North Promenade is likely to have accelerated the rate at which the foreshore has lowered with additional wave energy being reflected off the sea wall.

Coastal Flooding

12.9.50 The future coastal flooding baseline is described in ES Volume 2, Chapter 10 Flooding and Water Quality.

Limitations and Assumptions

Limitations

12.9.51 ES Volume 3, appendix 12.1 (R3105) summarises the wave modelling, extremes analysis and overtopping assessments that were undertaken to support the OBC. No local bathymetric data or wave measurements were available to construct and validate the wave model, however, the resultant overtopping results were validated against anecdotal evidence from past events.

12.9.52 ES Volume 3, appendix 12.2 (R3096) reviews and summarises the coastal processes regime along the frontage, and the morphological changes that occurred up to the date of the study (2019). The morphological and sediment transport assessment was based on a conceptual understanding of coastal processes derived from the SMP2, wave model by ABPmer and detailed literature review including a composite Digital Surface Model (DSM) which incorporated key information from previous studies including an historical overview developed by Kenneth Pye Associates Ltd (2016).

12.9.53 ES Volume 3, appendix 12.3 describes results of initial shoreline evolution modelling to examine the likely alongshore stability of the shingle beach identified in the OBC preferred option. The modelling had been undertaken

using the Coastal Evolution module in the DHI Littoral Processes FM suite of models. The model provides a Shoreline evolution model baseline schematisation which has been used to assess the behaviour of the baseline. However, there remains some uncertainty as to the actual longshore transport rates of the upper shingle/cobble beach.

Assumptions

12.9.54 Previous studies included as appendices to this chapter have concluded that there is very limited variability in wave direction nearshore due to the narrow shore normal sector from which predominant incoming waves approach the coast and that longshore transport rates are expected to be very low. However, it has not been possible to quantify and verify this through numerical modelling as the shoreline baseline modelling, undertaken to assess the beach nourishment option, only considered the transport of the upper mobile shingle/cobble beach. The assessment of wave direction variability could be improved by obtaining local bathymetric data and wave measurements to calibrate and validate existing models, but this would have significant cost and time implications and was considered to provide limited added value to the project. Validation of longshore drift rates by undertaking additional field measurement was considered. However, the difficulties in obtaining reliable sediment transport rates and potential outcomes given the anticipated very low rate of longshore transport deemed this of limited value to the project. Therefore, the level of detail of existing models was deemed appropriate taking into account the information assessed in the desktop study, site characteristics and type of solution.

12.9.55 A set of assumptions is included in ES Volume 2, Chapter 4 EIA approach.

12.10 Embedded Environmental Design Measures

12.10.1 A range of measures have been embedded into the Proposed Development design to avoid or minimise environmental impacts.

12.10.2 The proposed rock revetment has been designed with a shallow slope of (H:V) 3:1 to minimise wave reflection and any potential scour effects. The proposed ramps are surrounded by rock armour and with a buried toe to minimise any potential scour effects.

12.10.3 The proposed revetment will terminate against the west face of the existing seawall. The extent where it protrudes beyond the seawall will be backfilled with shingle to mitigate the risk of becoming a sediment trap until the area is filled up. A range of measures relevant to marine and coastal physical processes are set within the Outline Construction Environmental Management Plan (CEMP), (document reference- EN.F.15).

12.10.4 The following measures with potential impact on coastal processes will be put in place during construction:

- For both rock armour delivery options (Option 1 by road and Option 2 by sea), temporary stockpiles located on the beach below MHWS will be used to store rocks for the rock revetment prior to placement. All sand/shingle excavated from the beach will be stored on the beach above MHWS to minimise losses before being used for reinstatement along the beach.
- Works will take place “in the dry”, during low tide windows.

- Stockpiled rock armour will be moved to its final location within a limited timeframe.

12.11 Assessment of Effects

12.11.1 This section presents the assessment of effects on marine and coastal physical processes resulting from the construction and operation and maintenance of the Proposed Development (refer to ES volume 2, Chapter 2 for Project Description).

Construction Effects

12.11.2 This section presents the assessment of potential effects on marine and coastal physical processes resulting from the construction of the proposed development. Construction is defined as all the works undertaken to build the Proposed Development. The potential effects are assessed based on design presented in ES volume 2, Chapter 2 Project Description.

Hydrodynamics and sediment transport processes

12.11.3 Stockpiling of rock armour in intertidal areas has the potential to impact hydrodynamics and sediment transport processes, causing localised areas of erosion and accretion in the areas around the stockpile. During construction, stockpiling of rock armour is expected to cause a temporary minor adverse impact or no impact.

Release of sediments

12.11.4 During construction, the excavation of sand and shingle required to construct the works on the beach, and the temporary storage of these materials on the beach could cause a potential release of sediment into the sea. This could cause turbidity in the water column and have implications on marine ecology and sensitive habitats. However, it is expected that this will result in a temporary minor adverse effect on sediment release during construction as the works will take place “in the dry”, and the material will be stockpiled above MHWS.

12.11.5 Removal of existing groynes would involve the removal of groyne piles using an excavator with a grab or chain attachment (or similar). It is expected that these works will take place at low tide “in the dry” so no impact on release of sediments and water turbidity is expected.

Operational and Maintenance Effects

12.11.6 Operation is defined as the post-construction phase of the Proposed Development, including maintenance activities, until there is further development or until the site ceases to operate as a standard of protection against coastal flooding. Refer to ES Volume 2, Chapter 2 Project Description, for the description and period of maintenance activities, and the design life of the proposed development. Some impacts on marine and coastal physical processes may occur during this phase, such as areas of higher variability of beach levels due to localised scour/accretion in front of the rock revetment.

Intertidal and Subtidal Areas

12.11.7 A permanent loss of recreational use of intertidal area will occur as a result of the construction of rock revetment. The loss of beach area for recreational use will be in part offset by the removal of sections of groynes which will improve the amenity value of the beach at lower levels. Permanent loss of recreational use in the footprint of the revetment has been assessed to be minor adverse. This is based on analysing the current situation of the beach which is compartmentalised by the groynes in a series of approximately 45x45m cells. It is considered that it is the seaward-most part of these cells that is predominantly used by beachgoers, with the exception of the access points from the promenade which are adjacent to the existing concrete structure. The width of the proposed revetment will be less than half the length of the groynes and therefore will not encroach into the seaward-most area of these cells. Furthermore, there will be a series of access points integrated into the revetment design to provide access to the beach from the promenade.

Wave - Structure Interaction

12.11.8 The risk of wave overtopping and flooding behind the breakwater is reduced from the baseline, which is considered to be a major beneficial impact.

12.11.9 The rock revetment will reduce wave reflections and increase wave energy absorption compared with the baseline scenario of a concrete seawall, reducing scouring of the toe of the wall, helping the lowering of the foreshore in front of the wall and mitigating against the risk of undermining in this area. These improvements in localised scour and erosion reduction are assessed to be of major beneficial impact.

12.11.10 The rock revetment will reduce the wave loads on the seawall in comparison with the baseline, which will reduce the risk of failure and improve the longevity of the structure. This is assessed as a major beneficial impact.

12.11.11 The rock revetment will induce wave breaking under specific tidal levels. This will modify the hydrodynamics in the areas close to the structure and can increase locally the sediments in suspension.

12.11.12 Negligible changes in currents are expected due to the alignment of the rock revetment, which is parallel to the shoreline.

12.11.13 Changes in wave environment are considered to have negligible impact on the *S.alveolata* reef to the north and dunes to the south since both are located more than 400m away from the proposed rock revetment.

Sediment transport and beach morphology

12.11.14 The rock revetment will contribute to ‘Hold the line’ and mitigate against erosion in front of the seawall, as the rock revetment will dissipate wave energy and reduce wave reflection off the existing wall. Therefore, erosion reduction, potential build-up of the beach in the scheme and future hold the line have been assessed as major beneficial when compared with the baseline which consists of an eroding coastline subject to wave reflections from the seawall.

12.11.15 It is anticipated that the revetment will have minimal effect on longshore sediment transport. Due to its geometry parallel to the shoreline, it does not retain longshore drift in the nearshore, which is assessed to be limited in the baseline. This impact is assessed as negligible.

12.11.16 Waves will diffract around the northern end of the rock revetment at high tide. This may contribute to a localised re-orientation of the beach towards a new equilibrium shape. This effect will overlap with the localised scour and local variability in beach levels. This impact is assessed as minor adverse given the limited extension of the rock revetment in comparison with the existing footprint of the promenade and since it should occur in a short period of time following construction and in a localised area.

12.11.17 The extension of the rock revetment north of the existing seawall will create a limited sheltered area behind. This area will be backfilled such that it does not become a sediment trap. This small area may be subject to wave overtopping. This impact is assessed as minor adverse.

12.11.18 The rock revetment will influence cross-shore transport. The design has taken this into consideration to minimise its impact (see 12.10). However, variability of beach levels (accretion and erosion) immediately in front of the revetment is expected as short-term effects from storm events. This impact is assessed as minor adverse. However, it is expected that this will not interfere with the transport of sediment alongshore or on/offshore at the bed. Given the limited volumes of scour expected over a high timeframe it is not expected that these can cause any turbidity effects when suspended in the water column, therefore, the effect of variability of beach levels in front of the rock revetment on turbidity is negligible. Moreover, the occurrence of this variability in levels over a long timeframe can be monitored and would allow for reactive and proactive beach management measures, as needed.

12.11.19 The proposed rock revetment is unlikely to have a negative impact on the dune system at the south. From the historical review of coastal processes presented in Appendix 12.2, it is understood that the main driver for the dune formation is wind driven (aeolian) sand transport with high rates of windblown sand transport during periods of strong winds from the northwest and west reported in Appendix 12.6. The River Mawddach brings sediment to the coast and deposition has been exacerbated by the construction of the causeway linking the Ynys y Brawd island to the mainland. The causeway effectively blocked off any flow from the estuary towards the north, having a profound effect over time on the coastal processes in the area and leading to accretion of material transported mainly by wind at the southern extents. It is noted that the sandy area to the south of the site (shallow area where sand is mostly above the high tide) is more mobile as it is subject to wind transport while the sandy area to the north is mostly within the tidal range and less prone to aeolian transport. The dunes and sandy beach south of the site are not affected by the proposed scheme so there will not be changes in aeolian transport. The potential loss of material from the upper intertidal beach as a direct result of the construction of the revetment is unlikely to cause any material reduction in the sand supply to the dunes given the reduced quantity and localised effect.

12.11.20 Overall, the groynes are in a very poor state and providing no significant role on helping to maintain beach levels. Therefore, their removal would generally have limited implications. Only a number of the groynes along the southern end of the frontage are in a slightly better state of repair, in particular, the refurbished groyne at northern end of the coarse sediment upper beach along the southern end of the frontage. Removal of these groynes would result in greater mobility of the upper sediment in the beach as a result of littoral transport and could lead to

increased wind driven sand supply which is being currently retained by these. However, the volume of sand currently trapped by the groynes is limited given the status and geometry of the existing groynes. Therefore, the effect of removal of existing groynes is considered negligible.

12.12 Zone of influence

12.12.1 Field blockage (defined as Blockage related changes: changes to wave, current/flow and sediment transport regimes caused by the presence of the project including changes to turbulence and scour development according to GN41) effects due to coastal processes involved at the end of the breakwater affecting adjoining areas include scour effects, and potential variability of beach levels in of the areas surrounding the rock revetment. Field blockage has been assessed as affecting an area up to 15m when taking into account the estimated scour depth against design wave conditions. cour depth has been calculated using an empirical equation for the depth of scour at the toe of a vertical seawall developed using an extensive database of published laboratory data (HR Wallingford 2006b, Sutherland et al. 2006b) including considerations to take into account beneficial effects of the sloping structure [5].

$$\frac{Stmax}{Hs} = 4.5e^{-8\pi\left(\frac{ht}{Lm}+0.01\right)}\left(1 - e^{-6\pi\left(\frac{ht}{Lm}+0.01\right)}\right.$$

Where:

Stmax= maximum toe scour depth (m)

ht = water depth above the beach level at the toe of the structure (m)= 4.3m

Lm= wavelength offshore (-7mODN extraction location).

$$Lm = \frac{gTm^2}{2\pi} = 225m$$

According to linear theory wavelength based on mean wave period Tm (s) and acceleration due to gravity g (assumed to be 9.81 m/s^2) where design wave conditions and water levels correspond to values used for design of the rock revetment associated to an extreme return period of 200 years for the epoch year 2075 as follows:

Hs= 4m

Tp= 12s

Water level=4.3m

Breaking wave=3.4m

The range of validity of Equation is given in the square brackets in terms of ht and Lm: [-0.013 ≤ ht / Lm ≤ 0.18]

A value of 3.2m is obtained as maximum toe scour depth (m).

Assuming that the scour hole in front of the revetment ties back to the natural seabed at an angle of 15º, a maximum horizontal distance of 12.1m is estimated an rounded conservatively toa 15m.

12.12.2 It is noted that this value is conservative as there is a significant reduction in scour depth for sloping or permeable seawall when compared to vertical walls as found by Powell and Lowe (1994) who showed a reduction in scour depth of almost 65 per cent in a shingle beach when a vertical wall was replaced by a

sloping wall of 1:1.25. The scour depth was reduced by about 80 per cent for a 1:2 slope and there was accretion at the structure toe for a 1:3 slope (which is also the slope of the proposed rock revetment). Powell also noted that rock armour revetments generally showed less susceptibility to local scour and may even show accretion.

12.12.3 Variability of beach levels due to wave overtopping on the shingle beach behind the rock revetment section which extends beyond the west face of the existing seawall is limite due to its confinement.

12.12.4 These zones and the combined maximum zone of influence is provided in ES Volume 4, Figure 12.1 The zone of influence and the adjoining protected areas are shown in ES Volume 4, Figure 12.2.

12.13 Mitigation

12.13.1 This section outlines the mitigation required where adverse effects have been identified.

Mitigation of Construction Effects

12.13.2 No construction effects are assessed to be significant adverse.

12.13.3 While stockpiling of rock armour may cause a temporary minor adverse impact on hydrodynamics and sediment transport, measures to manage placement of stockpiled material, together with limitations on duration of stockpiling, have the potential to reduce the impact to negligible.

Mitigation of Operational Effects

12.13.4 No construction effects are assessed to be significant adverse.

12.13.5 Proposed mitigation of operational effects is shown in Table 12-13.

12.14 Residual Effects

12.14.1 Cumulative and in-combination effects are addressed within ES Volume 2, Chapter 14 Cumulative Effects.

No significant effects from construction or operation have been identified and there are therefore no significant residual effects. A summary of effects identified in the main assessment are shown in Table 12-13.

Table 12-13 Summary of effects matrix

Receptor	Potential Impact	Significance of effect	Mitigation proposed	Residual effect
Hydrodynamics and sediment transport	Localised areas of erosion and accretion in the areas around the stockpile.	Minor adverse or no effect (temporary)	Stockpile management measures and limitation on durations	Negligible
Sediments release	The excavation of sand and shingle and the storage of these materials could cause a potential release sediment into the sea which could cause	Minor adverse (temporary)	Construction to be planned to maximise working windows during low tide periods to reduce turbidity during excavation. Stockpiling of sand and shingle to be	Minor adverse or no effect (temporary)

Receptor	Potential Impact	Significance of effect	Mitigation proposed	Residual effect
	turbidity in the water column and have implications on marine ecology and sensitive habitats on the reef.		done above MHWS to minimise loss of sediments into the sea.	
Sediment release	Removal of existing groynes and piling works for new timber posts done “in the dry” so no impact on release of sediments is expected.	Negligible (temporary)	Construction planned “in the dry” so no impact on release of sediments is expected.	No effect
Intertidal and Subtidal Areas	Permanent loss of recreational use in the footprint of the revetment	Minor adverse (permanent)	None	Minor adverse (permanent)
Hydrodynamics	Wave overtopping and flooding reduced from the baseline	Major beneficial (permanent)	None	Major beneficial (permanent)
Hydrodynamics	Waves: changes in waves and currents impact on the adjacent *S.alveolata* reef	Negligible	None	Negligible
Sediment transport and beach morphology	Variability of beach levels due to wave overtopping behind the north extent of the rock revetment.	Minor adverse (permanent)	Backfilling with shingle material behind proposed limited extension of revetment will further support a reduction in wave turbulence in the area, helping to reduce variability in beach levels.	Minor adverse (permanent)
Sediment transport and beach morphology – Cross-shore	Scour at the toe of the existing concrete structure and stability risks	Major beneficial (permanent)	The rock revetment will mitigate against risk of scour at the base of the existing concrete structure	Major beneficial (permanent)
Sediment transport and beach morphology – Localised scour	Variability of beach levels in front of the proposed toe of the rock revetment	Minor adverse (permanent)	None	Minor adverse (permanent)
Sediment transport and beach morphology – Long-shore Transport	Longshore transport along the beach	Negligible	None	Negligible
Dunes (aeolian transport)	Changes in the sand supply to the dunes due to slight loss of upper intertidal beach as a result from the revetment	None	None	None
Sediment transport and beach morphology	Beach changes due to field blockage of sediments	Minor adverse (permanent)	None	Minor adverse (permanent)

Receptor	Potential Impact	Significance of effect	Mitigation proposed	Residual effect
Sediment transport and beach morphology	Turbidity impact on the adjacent *S.alveolata* reef	Negligible	None	Negligible
Sediment transport and beach morphology including effects on aeolian transport – Removal of groynes	Greater mobility of the upper sediment in the beach	Negligible	None	Negligible

12.14.2

12.15 Alignment with SMP2

12.15.1 The majority of the Proposed Development is within Policy Unit 11.15 (Barmouth North). For this unit, the policy plan is Hold the Line (HTL) for epoch 1 (to 2025), followed by Managed Realignment (MR) in epochs 2 and 3 (2025-2055 and 2055-2105 respectively). Importantly, the SMP2 also notes that there is significant benefit in continuing to manage the frontage, and that

'in all probability works will be needed to the north Barmouth frontage towards the end of Epoch 1'. [7]

12.15.2 The Proposed Development deviates from the policy framework set out in SMP2 for epoch 2, in that it will essentially continue a HTL policy until 2075 by providing betterment of the existing defences. This was accepted by Welsh Government as part of the approved OBC in 2021.

12.15.3 It should also be noted that the adjacent Policy Units (Llanaber and Barmouth South) have a policy of HTL for all three epochs. Some of the Proposed Development will be carried out in the Llanaber unit.

Shapefile data from https://lle.gov.wales/

Graphic 12-5 SMP2 policy units of Barmouth. Llanaber (11.16), Barmouth North (11.15) and Barmouth South (11.14) (Appendix 12.2)

12.15.4 In September 2024 it was agreed with the West Wales Coastal Group to raise the scheme with the National Coastal Forum as a Major Change, bringing the policy for Epoch 2 to HTL. This process is ongoing, including consultation led by the West Wales Coastal Group.

12.16 Coastal Squeeze

12.16.1 The SMP2 Habitats Regulations Assessment (HRA) proposed MR in Epoch 2; as such, the SMP2 HRA did not require a coastal squeeze assessment for this location.

12.16.2 Therefore a HRA Coastal Squeeze Addendum (doc ref BMTH-ARP-EBD-OFFSH-TN-OE-000003) has been produced to provide a Coastal Squeeze Assessment, considering the proposed policy change. The purpose of this HRA Coastal Squeeze Addendum is to consider the potential for coastal squeeze impacts on the features of the Pen Llyn a'r Sarnau / Lleyn Peninsula and the Sarnau Special Area of Conservation (SAC). This HRA Coastal Squeeze Addendum has been prepared in accordance with Natural Resources Wales (NRW) Operational Guidance Note OGN62 (Assessment of Coastal Squeeze), following the appropriate screening steps to Stage 3: Appropriate Assessment.

12.16.3 Following an assessment of the potential likelihood and impacts of coastal squeeze associated with the Hold the Line scenario for Epoch 2, the HRA Coastal Squeeze Addendum concluded that there will be no adverse effect on the integrity of the Pen Llyn a'r Sarnau / Lleyn Peninsula and the Sarnau SAC site. Overall, the assessment confirms that the proposed Policy Change from

MR to HTL will not result in coastal squeeze impacts on the Annex I SAC features, nor any Section 7 Priority Habitats.

12.16.4 A separate HRA has been undertaken to support the Proposed Development that will deliver the defence requirements in lieu of an approved policy change - Barmouth North Promenade FAS HRA (Document Reference BMTH-ARP-EBD-ZZ-RP-OE-000003).

Abbreviations List

AGC	Alun Griffiths Contractors
D&B	Design and Build
ECI	Early Contractor Involvement
EIA	Environmental Impact Assessment
ES	Environmental Statement
FAS	Flood Alleviation Scheme
OBC	Outline Business Case
YGC	Ymgynghoriaeth Gwynedd Consultancy

[1] NRW, “Guidance Note 13: Scoping an Environmental Impact Assessment for Marine Developments,” 2017.

[2] NRW, “Guidance Note GN19: Completing a coastal or physical processes assessment for small-scale projects,” 2024.

[3] NRW, “Guidance Note GN41: Marine Physical Processes Guidance to inform Environmental Impact Assessment,” 2025.

[4] Met Office, “UKCP18 Marine Report,” 2018.

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