LLŶR FLOATING OFFSHORE WIND PROJECT

Llŷr 1 Floating Offshore Wind Farm

Environmental Statement

Volume 3: Chapter 17 – Physical Environment

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Acronyms and abbreviations

Acronym or Abbreviation	Definition	Acronym or Abbreviation	Definition
ABP R&C	ABP Research & Consultancy Ltd	MFE	Mass Flow Excavator
ABPmer	ABP Marine Environmental Research Ltd	MHWN	Mean High Water Neap
BERR	Department for Business Enterprise and Regulatory Reform	MHWS	Mean High Water Springs
BGS	British Geological Survey	MLWN	Mean Low Water Neap
BSI	British Standards Institution	MLWS	Mean Low Water Spring
CD	Chart Datum	MMO	Marine Management Organisation
CEA	Cumulative Effects Assessment	MNR	Mean Neap Range
Cefas	Centre for Environment, Fisheries and Aquaculture Science	MSL	Mean Sea Level
COWRIE	Collaborative Offshore Wind Research into the Environment	MSR	Mean Spring Range
CPA	Coast Protection Act	nm	Nautical Miles
Defra	Department for Environment, Food and Rural Affairs	NPS	National Policy Statement
DDV	Drop Down Video	O&M	Operations and maintenance
deg	Degree(s)	ODN	Ordnance Datum Newlyn
DTI	Department of Trade and Industry	OWF	Offshore Wind Farm
EIA	Environmental Impact Assessment	RWC	Realistic Worst Case
EMODnet	European Marine Observation and Data Network	SAC	Special Area of Conservation
ES	Environmental Statement	SEA	Strategic Environmental Assessment
ETG	Expert Topic Group	SMP	Shoreline Management Plan
FEPA	Food and Environment Protection Act	SMP2	Shoreline Management Plan 2
HAT	Highest Astronomical Tide MHWS	SPA	Special Protection Area
HDD	Horizontal Directional Drilling	SPM	Suspended Particulate Matter
HW	High Water	SSC	Suspended Sediment Concentration
IEMA	Institute of Environmental Management and Assessment	SSSI	Site of Special Scientific Interest
inc.	Including	TSS	Total Suspended Solids
JNCC	Joint Nature Conservation Committee	UK	United Kingdom
km	Kilometres	UKCP18	UK Climate Projections 2018
KP	Kilometre Point	WTG	Wind Turbine Generator
LAT	Lowest Astronomical Tide		
LiDAR	Light Detecting and Ranging		
m	Metres		
MCZ	Marine Conservation Zone		
META	Marine Energy Test Area		

Glossary of project terms

Term	Definition
The Applicant	The developer of the Project, Llŷr Floating Wind Limited.
Array	All wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure within the Array Area, as defined, when considered collectively, excluding the offshore export cable(s).
Array Area	The area within which the wind turbine generators, inter array cables, mooring lines, floating sub-structures and supporting subsea infrastructure will be located.
Astronomical tide	The tide levels and character which would result from the gravitational effects of the earth, sun and moon, without any atmospheric influences.
Beach	A deposit of non-cohesive material (e.g. sand, gravel) situated on the interface between dry land and the sea (or other large expanse of water) and actively "worked" by present-day hydrodynamic processes (i.e. waves, tides and currents) and sometimes by winds.
Bedforms	Features on the seabed (e.g. sandwaves, ripples) resulting from the movement of sediment over it.
Bedload	Sediment particles that travel near or on the bed.
Benthic	A description for animals, plants and habitats associated with the seabed. All plants and animals that live in, on, or near the seabed are benthos.
Breaking	Reduction in wave energy and height in the surf zone due to limited water depth.
Clay	A fine grained sediment with a typical grain size of less than 0.004 mm. Possesses electromagnetic properties which bind the grains together to give a bulk strength or cohesion.
Climate change	A long term trend in the variation of the climate resulting from changes in the global atmospheric, and ocean, temperatures, and affecting mean sea level, wave height, period and direction, wind speed and storm occurrence.
Coast	A strip of land of indefinite length and width that extends from the seashore inland to the first major change in terrain features.
Coastal processes	Collective term covering the action of natural forces on the coastline and adjoining seabed.
Cumulative effects	The combined effect of the proposed Project in combination with the effects from a number of different projects, on the same single receptor/resource.
Diurnal	Having a period of a tidal day i.e. 24.84 hours.
European Marine Observation and Data Network (EMODnet)	EMODnet is a Directorate-General for Maritime Affairs and Fisheries (DG MARE) funded network of organisations supported by the European Union's integrated maritime policy. These organisations work together to observe the sea, process the data according to international standards, and make that information freely available as interoperable data layers and data products.
Erosion	Movement of material by such agents as running water, waves, wind, moving ice and gravitational creep.

Term	Definition
Floventis Energy	A joint venture company between Cierco Ltd and SBM Offshore Ltd of which Llŷr Floating Wind Limited is a wholly owned subsidiary.
Geophysical survey	Activities to obtain data on the distribution and nature of geophysical properties of the seabed (e.g. bathymetry, surficial sediment type and bedforms, sub-surface geology). Geophysical survey outputs typically include multibeam bathymetry, side-scan sonar and sub-bottom profiler data.
Habitat	The place in which a plant or animal lives. It is defined for the marine environment according to geographical location, physiographic features and the physical and chemical environment (including salinity, wave exposure, strength of tidal streams, geology, biological zone, substratum, 'features' (e.g. crevices, overhangs, rockpools) and 'modifiers' (e.g. sand-scour, wave-surge, substratum mobility)).
Hindcast	The retrospective prediction of historical (wind and wave) conditions.
Horizontal directional drilling (HDD)	A trenchless method of cable installation where the duct (or ducts) is installed to allow the cable(s) to be installed at a later date.
Hydrodynamic	Of, or relating to, the motion of fluids and the forces acting on solid bodies immersed in fluids and in motion relative to them.
Intertidal zone	The zone between the highest and lowest tides. May also be referred to as the littoral zone.
Landfall	The location where the offshore export cable(s) from the Array Area, as defined, are brought onshore and connected to the onshore export cables (as defined) via the transition joint bays (TJB).
Light Detecting and Ranging (LiDAR)	A surveying method that measures distance to a target by illuminating that target with a laser light.
Littoral processes	The movement of beach material in the littoral zone by waves and currents. Includes movement parallel (longshore transport) and perpendicular (onshore- offshore transport) to the shore.
Llŷr 1	The proposed Project, for which the Applicant is applying for Section 36 and Marine Licence consents. Including all offshore and onshore infrastructure and activities, and all project phases.
Marine Licence	A licence required under the Marine and Coastal Access Act 2009 for marine works which is administered by Natural Resources Wales (NRW) Marine Licensing Team (MLT) on behalf of the Welsh Ministers.
Morphological	Of, or relating to, the form, shape and structure of landforms.
Neap tides	Tides with the smallest range between high and low water, occurring at the first and third quarters of the moon.
Offshore Development Area	The footprint of the offshore infrastructure and associated temporary works, comprised of the Array Area and the Offshore Export Cable Corridor, as defined, that forms the offshore boundary for the S36 Consent and Marine Licence application.
Offshore Export Cable	The cable(s) that transmit electricity produced by the WTGs to landfall.
Offshore Export Cable Corridor (OfECC)	The area within which the offshore export cable circuit(s) will be located, from the Array Area to the Landfall.
Onshore Development Area	The footprint of the onshore infrastructure and associated temporary works, comprised of the Onshore Export Cable Corridor and the Onshore Substation, as defined, and including new access routes and visibility splays, that forms the onshore boundary for the planning application.

Term	Definition
Onshore Export Cable(s)	The cable(s) that transmit electricity from the landfall to the onshore substation.
Onshore Export Cable Corridor (OnECC)	The area within which the onshore export cable circuit(s) will be located.
Onshore Substation	Located within the Onshore Development Area, converts high voltage generated electricity into low voltage electricity that can be used for the grid and domestic consumption.
proposed Project	All aspects of the Llŷr 1 development (i.e. the onshore and offshore components).
Regime	The behaviour, statistical properties and trends characterising the variability of hydrodynamic, meteorological, sedimentological and morphological parameters.
Section 36 consent	Consent to construct and operate an offshore generating station, under Section 36 (S.36) of the Electricity Act 1989. This includes deemed planning permission for onshore works.
Scour	Local erosion of sediments caused by local flow acceleration around an obstacle and associated turbulence enhancement.
Sediment	Particulate matter derived from rock, minerals or bioclastic debris.
Sediment transport	The movement of a mass of sedimentary material by the forces of currents and waves. The sediment in motion can comprise fine material (silts and clay), sands and gravels. Potential sediment transport is the full amount of sediment that could be expected to move under a given combination of waves and currents, i.e. not supply limited.
Sediment transport pathway	The routes along which net sediment movements occur.
Significant wave height	The average height of the highest of one third of the waves in a given sea state.
Spring tides	Tides with the greatest range which occur at or just after the new and full moon.
Seastate	The state of the sea as described using the Douglas sea scale, based on wave height and swell, ranging from 1 to 10, with accompanying descriptions.
Shoreline Management Plan (SMP)	A Shoreline Management Plan (SMP) is a large-scale assessment of the risks associated with coastal processes. It aims to lessen these risks to people and the developed, historic and natural environments.
Suspended Particulate Matter (SPM)	Close to the bed, suspended matter typically consists of re-suspended mineral matter, but higher up in the water column SPM is typically in the form of flocs – loosely bound aggregates composed of mineral matter (e.g. clay minerals) as well as organic matter.
Surficial sediments	Sediments located at the seabed surface (not necessarily of the same character as underlying sediments).
Surge	In water level as a result of meteorological forcing (wind, high or low barometric pressure) causing a difference between the recorded water level and that predicted using harmonic analysis, may be positive or negative.
Suspended load	The material moving in suspension in a fluid, kept up by the upward components of the turbulent currents or by the colloidal suspension.
Suspended sediment concentration	Mass of sediment in suspension per unit volume of water.

Term	Definition
Swell (waves)	Wind-generated waves that have travelled out of their generating area. Swell characteristically exhibits a more regular and longer period and has flatter crests than waves within their fetch.
Tidal excursion	The Lagrangian movement (the physics of fluid motion as an individual fluid parcel moves through space and time) of a water particle during a tidal cycle.
Tidal excursion ellipse	The path followed by a water particle in one complete tidal cycle.
Tide	The periodic rise and fall in the level of the water in oceans and seas; the result of gravitational attraction of the sun and moon.
Topography	The form of the features of the actual surface of the earth in a particular region considered collectively.
Turbidity	Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particles. Suspended sediment concentration (SSC) refers to the mineral fraction of the suspended solids load whilst SPM includes both the inorganic and organic component.
United Kingdom Climate Projections (UKCP)	UKCP09 is the name given to the latest UK Climate Projections. UKCP09 provides information on plausible changes in 21st century climate for land and marine regions in the United Kingdom.
Wave refraction	When waves approach the shoreline obliquely, the wave crests tend to conform to the bottom (bed) contours; due to the inshore portion of the wave travelling at a lower velocity than the portion in deeper water. The extent of wave refraction depends on the relative magnitudes of water depth to wavelength.

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17. CHAPTER 17 – PHYSICAL ENVIRONMENT

17.1 Introduction

1. Llŷr Floating Wind Limited (hereafter the Applicant) is proposing to develop the Llŷr 1 Floating Offshore Wind Farm (hereafter referred to as the proposed Project), located approximately 35 km off the coast of Pembrokeshire in the Celtic Sea.

2. The proposed Project is a test and demonstration wind farm development, comprising up to 10 wind turbine generators (WTGs). The proposed Project will make landfall at Freshwater West before connecting into Pembroke Dock power station and the national grid network.

3. The Applicant is seeking a Section 36 consent and Marine License for the proposed Project, and this chapter forms part of the Environmental Statement (ES) which is submitted in support of the consent applications. This chapter describes the potential impacts and effects of the proposed Project on the marine physical environment during the construction, operation and maintenance and decommissioning phases, and includes mitigation and good practice measures to reduce the impacts of the proposed Project on the physical environment.

4. **Section 17.10** of this ES chapter provides a summary of the impact assessment undertaken and any residual significant effects on the marine physical environment following consideration of any mitigation measures.

5. The assessment presented in this chapter should be read in conjunction with the following linked and supporting chapters:

   - **Chapter 04: Description of the Proposed Project** provides further details of the design parameters; and
   - **Chapter 05: EIA Approach and Methodology** provides further details of the general framework.

6. The topic chapters relevant to the Physical Environment and which draw upon the assessments presented in this chapter are:

   - **Chapter 18: Marine Water Quality;**
   - **Chapter 19: Benthic Ecology;**
   - **Chapter 20: Fish and Shellfish Ecology;**
   - **Chapter 24: Marine Archaeology;**
   - **Chapter 26: Commercial Fisheries; and**
   - **Chapter 28: Other Sea Users**.

7. The assessment has been undertaken by ABPmer. Further details of the proposed Project Team's competency are provided in **Volume 6 (Appendix 1A: Statement of Competence)**.

8. The physical environment and associated marine physical processes are defined as encompassing the following elements:

   - Meteorological and oceanographic conditions (wind, waves and tides);
   - Coastal geomorphology;
   - Seabed geomorphology; and

- Marine and coastal sediments and geology (including seabed sediment distribution, sediment transport and water column turbidity).

9. The offshore element of the proposed Project refers to infrastructure installed in the marine environment up to Mean High Water Springs (MHWS). This includes floating Wind Turbine Generator (WTG) foundations, and their moorings, cables and associated protection measures and the subsea converter.

17.2 Legislation, Policy and Guidance

10. The following sections identify specific legislation, policy and guidance that is applicable to the assessment of the Physical Environment. Further detail on the wider legislation, policy and guidance relevant to this ES is provided in **Chapter 02: Regulatory and Planning Policy Context**.

17.2.1. Legislation

11. The physical environment and physical processes are not subject to specific topic legislation but are relevant to legislative requirements of other aspects, including the Birds Directive (Directive 2009/147/EC), Habitats Directives (Directive 92/43/EEC) and the Water Framework Directive (Directive 2000/60/EC), due to the potential for pathways of physical environment effects to impact other aspects. Relevant topics or chapters include:

- **Chapter 18: Marine Water Quality;**
- **Chapter 19: Benthic Ecology;**
- **Chapter 20: Fish & Shellfish Ecology;**
- **Chapter 21: Marine Mammals; and**
- **Chapter 22: Ornithology.**

17.2.2. National Planning Policy

12. National planning policies taken into consideration within the Physical Environment assessment are set out in **Table 17-1**. Included here are National Policy Statements which are a key part of the system for managing Nationally Significant Infrastructure Projects (NSIPs). Although the proposed Project is not a NSIP, the principles set out in the National Policy Statements remain relevant to the delivery of a robust EIA.

Table 17-1. A summary of national planning policy relevant to the Physical Environment

Summary of policy	How and where it is considered in the chapter
Paragraph 2.25.1 of the National Policy Statement for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023a) states: *"The construction, operation and decommissioning of offshore energy infrastructure can affect the following elements of the physical offshore environment, which can have knock on impacts on other biodiversity receptors:* • *Water quality* • *Waves and tides* • *Scour effect*	Predictions of change to physical processes (including all of those listed in Paragraph 2.25.1 of Draft NPS EN-3) which could arise from construction, O&M and decommissioning of the proposed Project are presented in **Paragraph 89 *et seq***. (for the construction phase), **Paragraph 148 *et seq***. (for the O&M phase) and **Paragraph 191 *et seq***. (for the decommissioning phase).

Summary of policy	How and where it is considered in the chapter
• *Sediment transport* • *Suspended solids"*	
Paragraph 2.25.3 of the National Policy Statement for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023a) states: *"Geotechnical investigations should form part of the assessment as this will enable design of appropriate construction techniques to minimise any adverse effects."*	Project specific geophysical survey data has been collected for the full Array Area and parts of the Offshore Export Cable Corridor (OfECC) and ground truthed using existing geotechnical (borehole) data from the region.
Paragraph 2.25.5 of the National Policy Statement for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023a) states: *"The SoS should expect applicants to have considered the best ecological outcomes in terms of potential mitigation. These might include the burying of cables to a necessary depth, using scour protection techniques around offshore structures to prevent scour effects or designing turbines to withstand scour, so scour protection is not required or is minimised."*	The embedded mitigation measures relating to cable burial and scour are set out in **Table 17-15**.
Paragraph 2.6.1 of the National Policy Statement for Electricity Networks Infrastructure (EN-3) (DESNZ, 2023b) states: *"Applicants should in particular set out to what extent the proposed development is expected to be vulnerable, and, as appropriate, how it has been designed to be resilient to… coastal erosion – for the landfall of offshore transmission cables and their associated substations in the inshore and coastal locations respectively."*	The vulnerability of the proposed Project to coastal change is considered in the context of the proposed Project design, in **Chapter 04: Description of the Proposed Project**. A cable landfall assessment is presented in **Paragraph 127 et seq**. and **Paragraph 177 et seq**. This assessment considers the nature of ongoing and potential future shoreline change at the landfall.
Paragraph 2.6.8.5 of the Marine Policy Statement (2011) states that: *"Marine plan authorities should consider existing terrestrial planning and management policies for coastal development under which inappropriate development should be avoided in areas of highest vulnerability to coastal change and flooding. Development will need to be safe over its planned lifetime and not cause or exacerbate flood and coastal erosion risk elsewhere."*	The vulnerability of the proposed Project to coastal change is considered in the context of the proposed Project design, in **Chapter 04: Description of the Proposed Project** A cable landfall assessment is presented in **Paragraph 127 et seq**. and **Paragraph 177 et seq**. This assessment considers the nature of ongoing and potential future shoreline change at the landfall.

17.2.3. Regional Planning Policy

13. The Welsh Government published its first marine plan for Welsh inshore and offshore waters, the Welsh National Marine Plan (WNMP), in November 2019. The WNMP was developed in

accordance with the Marine and Coastal Access Act (2009) and the UK Marine Policy Statement. The WNMP covers a 20-year period from its adoption in 2019. The following key objectives of the WNMP are of direct relevance to the physical environment:

- Objective 4: "Provide space to support existing and future economic activity through managing multiple uses, encouraging the coexistence of compatible activities, the mitigation of conflicts between users and, where possible, by reducing the displacement of existing activities";
- Objective 11: "Maintain and enhance the resilience of marine ecosystems and the benefits they provide in order to meet the needs of present and future generations"; and
- Objective 13: "Develop a shared, accessible marine evidence base to support use of sound evidence and provide a mechanism for the unique characteristics and opportunities of the Welsh Marine Area to be better understood".

14. Also of relevance to this Chapter are the key policies set out in Planning Policy Wales (Edition 12), 2024 (**Table 17-2**).

Table 17-2. A summary of regional planning policy relevant to the Physical Environment

Summary of policy	How and where it is considered in the chapter
Policy SOC 08 (Resilience to coastal change and flooding) in the Welsh National Marine Plan (2019) states that: *"Proposals should demonstrate how they are resilient to coastal change and flooding over their lifetime."*	Natural variability and potential changes in climate are described in the baseline **Section 17.5** and are considered alongside predicted changes described in the assessment **Section 17.8.**
Policy SOC 09 (Effects on coastal change and flooding) in the Welsh National Marine Plan (2019) states that: "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."	Predictions of change to the physical environment that could arise from the construction, O&M and decommissioning of the proposed Project are presented in **Paragraph 89 et seq**. (for the construction phase), **Paragraph 148 et seq**. (for the O&M phase) and **Paragraph 191 et seq**. (for the decommissioning phase). Full consideration of Shoreline Management Plans at the coast is provided in the landfall assessment presented in **Paragraph 127 et seq**. and **Paragraph 177 et seq**. An assessment of flood risk is set out within **Chapter 10 Water Environment**.
Policy GOV 01 (Cumulative effects) in the Welsh National Marine Plan (2019) states that: *"Proposals should demonstrate that they have assessed potential cumulative effects and, in order of preference: a) avoid adverse effects; and/or b) minimise effects where they cannot be*	Cumulative impacts are assessed in Section 17.11.

Summary of policy	How and where it is considered in the chapter
avoided; and/or c) mitigate effects where they cannot be minimised. If significant adverse effects cannot be adequately addressed, proposals should present a clear and convincing justification for proceeding. Proposals that contribute to positive cumulative effects are encouraged."	
Planning Policy Wales (2024) Edition 12 (Welsh Government, Cardiff) shttps://www.gov.wales/planning-policy-wales Paragraph 6.5.10 of Section 6.5 Coastal Areas of Planning Policy Wales (Welsh Government) states that where [coastal] 'development is considered to be justified it should be designed so as to be resilient to the effects of climate changeover its lifetime and not result in unacceptable incremental increases in risk'.	The impacts of the cable landfall on nearshore and shoreline morphology is assessed in **Paragraph 127 et seq**. and **Paragraph 177 et seq**. The effects of climate change at the landfall is considered in **Paragraph 73 et seq.**
Paragraph 6.5.16 of Section 6.5 Coastal Areas of Planning Policy Wales (Welsh Government) states that for 'Shoreline Management Plans are developed by local authorities in partnership with a range of stakeholders and establish long-term local policy frameworks for the management of coastal risk. The priorities contained within them should influence and inform the preparation of development plans'.	The SMP policy is discussed in Section **Paragraph 73 et seq.**
Paragraph 6.5.19 of Section 6.5 Coastal Areas of Planning Policy Wales (Welsh Government) states that 'development should not generally be proposed or permitted in areas which would need expensive engineering works, either to protect developments on land subject to erosion by the sea or to defend land which might be inundated by the sea. Where active interventions are needed in areas which already contain development, a full understanding of the implications will need to be drawn up by the local authority in conjunction with all relevant stakeholders and roles and responsibilities in the process clearly identified'.	The potential impacts of the landfall on the shoreline morphology is assessed using baseline information and expert geomorphological analysis in **Paragraph 127 et seq.** and **Paragraph 177 et seq.**

17.2.4. Local Planning Policy

15. Local planning policies taken into consideration within the Physical Environment assessment are set out in **Table 17-3**.

Table 17-3. A summary of local planning policy relevant to the Physical Environment

Summary of Guidance	How and where it is considered in the chapter
Pembrokeshire Coast National Park (2020) Local Development Plan 2 (end date 2031). Adopted Local Development Plan (Pembrokeshire Coast National Park Authority) https://www.pembrokeshirecoast.wales/wp-content/uploads/2020/09/LDP-Text-for-Adoption.pdf Policy 17 Shore Based Facilities states 'development of shore based facilities including those linked to proposals below mean low water, will be permitted within the developed areas of the coast where compatible with adjacent uses. The potential effects of development on Natura 2000 sites will be considered in accordance with Policy 10'.	The impacts of the landfall on seabed areas within designated site is assessed using expert geomorphological analysis in **Paragraph 89 et seq.** (for the construction phase), **Paragraph 148 et seq**. (for the O&M phase) and **Paragraph 191 et seq.** (for the decommissioning phase) in accordance with Policy 10: assessment of the ecological effects on the designated site

17.2.5. Guidance

16. The assessments in this Chapter are consistent with the following best practice guidelines / guidance, set out in **Table 17-4**. The following studies have also been considered:

- MMO (2014). Review of post-consent offshore wind farm monitoring data associated with licence conditions. A report produced for the Marine Management Organisation, MMO Project No: 1031. MMO, Newcastle;
- Fugro Emu (2014). Review of environmental data associated with post-consent monitoring of licence conditions of offshore wind farms. MMO Project No: 1031;
- ABPmer, et. al. (2010). Further review of sediment monitoring data: ScourSed-09. COWRIE;
- BERR (2008). Review of Cabling Techniques and Environmental Effects applicable to the Offshore Wind farm Industry Technical Report. Department for Business Enterprise and Regulatory Reform in association with Defra;
- ABPmer, et. al. (2007). Review of Round 1 Sediment process monitoring data - lessons learnt: Sed01. ABPmer, Southampton;
- HR Wallingford, et. al. (2007). Dynamics of scour pits and scour protection - Synthesis report and recommendations: Sed02. HR Wallingford, Wallingford; and
- Cooper B and Beiboer F (2002) Potential effects of offshore wind developments on coastal processes. Department of Trade and Industry, London.

Table 17-4. A summary of guidance relevant to the Physical Environment

Summary of Guidance	How and where it is considered in the chapter
Marine Physical Processes Guidance to inform Environmental Impact Assessment (EIA). Natural Resources Wales (NRW), Cardiff (NRW, 2020).	This guidance aims to help inform the design of survey and monitoring strategies, and the application of numerical modelling, for major

Summary of Guidance	How and where it is considered in the chapter
	marine development projects including offshore wind farms. This guidance has been used to help assess the adequacy of baseline data which underpins the impact assessment (see Section 17.8).
Evidence Report No: 243 Guidance on Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to inform EIA of Major Development Projects. Natural Resources Wales, Cardiff (Brooks et. al. 2018).	This Evidence Report provides the technical detail underpinning the NRW (2020) physical processes guidance, outlined above.
Environmental Impact Assessment for Offshore Renewable Energy Projects (BSI, 2015)	This provides a summary of marine physical process impact pathways, potential assessment methods and tools. Also provides guidance on the development of impact assessment matrices. The potential impact assessment pathways identified in this guidance are all considered later in this document, within the likely significant effects section (see **Paragraph 89 et seq**. (for the construction phase), **Paragraph 148 et seq**. (for the O&M phase) and **Paragraph 191 et seq**. (for the decommissioning phase).
Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects (Cefas, 2012).	These guidelines assist in the design, review and implementation of environmental data collection and analytical activities associated with all stages of offshore renewable energy developments. There is a specific section covering ‘physical and sedimentary process studies’, setting out guidance on data acquisition and adequacy, survey design and impact assessment techniques (including modelling). The scope of the Project specific geophysical surveys are consistent with this guidance. When combined with existing high resolution bathymetry data from the region, they allow for robust analysis of sediment transport processes and morphological understanding within the Study Area. Survey results are presented in the baseline section (Section 17.5).
Guidelines in the use of Metocean Data Through the Lifecycle of a Marine Renewables Development (CIRIA, 2008).	This guide has been developed to identify and recommend on the uses of metocean data through the life cycle of a marine renewable energy development. It includes a review of metocean data types, data sources and

Summary of Guidance	How and where it is considered in the chapter
	identifies the importance of good data management. This guidance has been used to help assess the adequacy of metocean data used to inform the impact assessment (see Section 17.8).
Offshore Windfarms: Guidance note for Environmental Impact Assessment in Respect of FEPA and CPA Requirements (Cefas, 2004).	This guidance provides scientific guidance to those involved with the gathering, interpretation and presentation of data within an EIA. The marine physical process parameters which require assessment are set out and divided into direct and indirect impacts, with guidance also given regarding the key parameters which need documenting in the marine processes baseline. Recommendations for mitigation and monitoring are also set out. The baseline description which will be produced as part of the EIA complies with the above guidance, whilst the assessment also takes into consideration the full range of marine physical processes parameters set out in Cefas (2004).

17.3 Stakeholder Engagement and Consultation

17. Consultation with statutory and non-statutory organisations is a key element of the EIA process. Consultation with regards to the physical environment has been undertaken to inform the approach to, and scope of, the assessment.

18. Stakeholders for the proposed Project include statutory consultees, landowners, local communities and other sea users. In addition to the statutory consultation process, there has been ongoing engagement with statutory and non-statutory consultees to steer the development of the proposed Project and this is detailed in **Table 17-5.**

17.3.1. Summary of Stakeholder Consultations

19. Table 17-5 provides a summary of the key issues raised by consultees and how each issue has been addressed in the Physical Environment assessment.

Table 17-5. Summary of the key issues raised by consultees and how each issue was addressed

Consultee	Main matter raised	How the issue has been addressed	Location of response in chapter
NRW (Expert Topic	Export cable corridor rerouted south and east of Turbot Bank, to the same landfall at Freshwater	Survey data (drop down imagery) has been collected that confirm sediment cover and channels are present in	**Section 17.8** **Figure 17-1**

Consultee	Main matter raised	How the issue has been addressed	Location of response in chapter
Group (ETG) Meeting 20/5/24)	West. Features of the new route were discussed. NRW advised that the realistic worst case design scenario should be assessed.	which the cable might be buried and not intersect directly with the Turbot bank designated area. Cable installation experts have been consulted on the worst case scenario for a realistic assumption of burial alongside Turbot Bank. The final cable route, burial depths and design would need to be developed and confirmed post consent, through a Cable Burial Risk Assessment (CBRA) informed by additional data collection (geophysical and geotechnical surveys). New multibeam data has been collected (July 2024) from the eastern edge of Turbot Bank, furthering understanding of processes in this area by addressing an existing data gap.	
NRW (ETG Meeting 30/3/23)	Extent of the Study Area to be (also) informed by the spatially varying tidal excursion distance and direction	The selected Study Area is (also) informed by the spatially varying tidal excursion distance and direction.	**Section 17.4** **Figure 17-1**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.19**)	Request that the 'maximum spring tidal excursion' distance should be used to define the proposed Project ZoI (study area extent), referencing NRW guidance note OGN 041.	The selected Study Area is (also) informed by the spatially varying mean spring tidal excursion distance and direction. This measure is commonly used for OWF EIA and is representative of larger tidal excursion distances, and is close to the maximum spring (largest astronomical) tidal excursion distance, with no difference in direction.	**Section 17.4** **Figure 17-1**

Consultee	Main matter raised	How the issue has been addressed	Location of response in chapter
		Guidance note OGN 041 directs the use of 'Spring tidal excursion ellipses' but does not define a maximum or mean value.	
NRW (ETG Meeting 30/3/23)	Potential impacts on Turbot Bank as a result of cable protection installation nearby in the OfECC are a concern, following similar discussions for Erebus.	Since this consultation, the route of the OfECC has been revised. The updated OfECC does not overlap with the Article 17 boundary of Turbot Bank but instead passes circa 600 m to the east of it (**Figure 17-1**). Notwithstanding this, an assessment of potential impacts to Turbot Bank has been undertaken. This draws upon detailed sediment transport modelling, describing baseline sediment transport pathways.	**Section 17.8**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 1.9**)	Advised the modification/removal of sandwaves would result in temporary disturbance of the seabed and changes to patterns of sediment transport resulting in morphological change. Recommended that disturbed sediment from these activities (and cable installation) is retained within the same sediment system, for example depositing the disturbed sediment upstream of the trenches to encourage natural backfill.	Localised sandwave levelling may be required to ensure sufficiently deep burial of cables under the present-day position of larger bedforms, to reduce the risk of future cable exposure and so the potential requirement for cable protection to be installed. The potential impact of sandwave levelling on the local sediment transport environment, including the estimated timescale for sandwave recovery, is assessed.	**Section 17.8**
NRW (**ES Volume 6 Appendix 5B Scoping**	Requested a better understanding of how the baseline is expected to evolve over the course of the proposed Project and	The present-day baseline understanding presented in the ES Chapter for this topic is based on the patterns and statistics of relevant	**Section 17.5**

Consultee	Main matter raised	How the issue has been addressed	Location of response in chapter
Opinion, Paragraph 3.21)	details of the proposed surveys. Further information on details of survey activity proposed re Section 19.7.3.	conditions over the recent past (last 30-40 years), reflecting the range of natural variability on a range of timescales. The same baseline variability is expected to also reflect future baseline conditions throughout the lifetime of the proposed Project. The future influence of climate change trends is also quantified and included in relevant assessments. New bathymetric, sediment and benthic surveys have been carried out (described in the ES) and are used to inform both the baseline understanding and assessments.	
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 0.8**)	NRW should be engaged early on potential cable routing changes.	NRW has been engaged and updated about all planned offshore cable routing changes.	**Section 17.3**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 1.14**)	All decommissioning options for all infrastructure should be considered in the ES. Scour and cable protection impact mitigation beyond the lifespan of the proposed Project as suggested by Natural England.	All decommissioning options will be considered in the ES chapter. The worst-case scenario is to be total removal of infrastructure including the buried cables and cable protection.	**Section 17.8**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion,**	Advised that marine water quality should be a chapter separate to physical processes.	A separate chapter has now been created for marine water and sediment quality.	**ES Volume 3, Chapter 18: Marine Water and Sediment Quality.**

Consultee	Main matter raised	How the issue has been addressed	Location of response in chapter
Paragraph 1.21)			
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.6**)	Clarification that other than morphological features changes in hydrodynamics and sediment transport are not receptor themselves and are in the context of indirect impacts on other scoped in receptors e.g. Benthic ecology and water quality.	Receptors and pathways have been clarified in all technical chapters within the ES.	All technical chapters within the ES Volumes 2 and 3 (**Chapters 7 to 28**).
NRW (**ES Volume 6 Appendix 5B Scoping Opinion**)	Regulatory and Planning Policy. Further research and guidance recommended detailed in the NRW scoping response letter to inform the baseline and impact assessment.	These references are considered in the ES where appropriate.	**Section 17.2**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.12**)	Study area seabed geomorphology details is insufficient. Data gap analysis should be undertaken to assess the requirement of further bathymetric survey data.	The Project specific geophysical survey for the array area and export cable corridor has been combined with various other regional scale surveys and bathymetry data (with variable but reasonable resolution) to provide a combined data set for the whole ZOI (and beyond). The available bathymetry supports a sufficiently detailed understanding of baseline seabed bedform dimensions and distribution for the purpose of the assessments undertaken in the ES.	**Section 17.5**
NRW (**ES Volume 6 Appendix**	Landfall baseline environment should include detailed information on coastal	The baseline environmental description of the landfall includes more detailed information on coastal	**Section 17.5**

Consultee	Main matter raised	How the issue has been addressed	Location of response in chapter
5B Scoping Opinion, Paragraph 3.13)	sediment transport and beach morphodynamics.	sediment transport and beach morphodynamics.	
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.13**)	Study area and geomorphological features overlay map recommended.	Geomorphological features are mapped within the study area in a Figure of the ES.	**Figure 17-1**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.15**)	Water quality, physical process and benthic significant likely effects sections should be separated.	Separate chapters have now been created for marine water and sediment quality, and for benthic ecology.	**ES Volume 3, Chapter 17: Physical Processes, Chapter 18: Marine Water and Sediment Quality, Chapter 19: Benthic Ecology**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.12**)	Recognise that marine physical processes are pathways and the indirect sediment transport and hydrodynamics impacts on receptors (e.g. SSC plumes). Receptors include designated coast, offshore sandbanks (Turbot Bank) and seabed areas.	The physical process Chapter quantifies and describes changes to physical processes from the baseline condition due to construction, operation and decommissioning of the wind farm. Only some changes have a sensitive physical receptor identified and an assessment of significance is provided for these. Other changes are pathways of effect that are subsequently used by other chapters to inform assessment of impacts on other sensitive receptor groups.	**Section 17.8**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion,**	The impact of advection and redeposition of the SSC plume should be considered.	The assessment of changes to suspended sediment concentration (i.e. sediment plumes) includes the likely advection of the sediment	**Section 17.8**

Consultee	Main matter raised	How the issue has been addressed	Location of response in chapter
Paragraph 3.18)		plume and redeposition of the material in the plume.	
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 1.21, 3.8 and 1.13**)	Water Quality should be a separate section. Scope in: Cable laying impacts on the seabed, changes to the tidal regime, abrasion impacts of mooring chains, Increased turbulence on sediment transport, requirement for cable protection in the nearshore zone. HDD is the preferred landfall installation method.	A separate chapter has now been created for marine water and sediment quality.	**ES Volume 3, Chapter 18: Marine Water and Sediment Quality.**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.20**)	Disagree that numerical modelling is not required. A review of evidence to determine whether numerical modelling is required.	The Physical Processes assessment is now supported by a range of numerical modelling, including a more detailed and quantitative baseline understanding of wave, tidal and sediment transport regimes. Assessments of changes to suspended sediments are based on spreadsheet numerical modelling. New numerical modelling was not considered necessary for the assessment of impacts on waves and currents by the relatively small blockage presented by the proposed worst-case array design.	**Section 17.4**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.19**)	Data sources should be current and have appropriate tempo- spatial coverage purpose in line with NRW GN041 and Brooks *et al.,* 2018. Review of further surveys advised.	The collection of data sources used to inform the assessments is sufficient, in line with the guidance outlined in these documents.	**Section 17.4**

Consultee	Main matter raised	How the issue has been addressed	Location of response in chapter
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.12**)	A review of data gaps and quality should be undertaken. Multibeam bathymetry survey data advised.	Multibeam bathymetry data has been collected by the Project specific geophysical survey. No additional actions.	**Section 17.4**
NRW (**ES Volume 6 Appendix 5B Scoping Opinion, Paragraph 3.16**)	Scope in the impact of HDD drilling fluids and potential of suspension of Bentonite increasing SSC in Table 19.2.	The impact of HDD drilling fluids and potential of suspension of Bentonite increasing SSC at the landfall has been assessed.	**Section 17.8**

17.4 Approach to Assessment

20. This section describes the approach that has been applied to assess the potential effects on the physical environment associated with the proposed Project. The assessment has been based on a Project Design Envelope (PDE), as set out in **Chapter 04: Description of the Proposed Project**. The worst-case scenarios have been identified for the construction, operation, and decommissioning phases of the proposed Project. The environmental impact assessment has identified any potentially significant adverse environmental effects and, proposes Project-specific mitigation measures which aim to avoid, reduce or offset negative effects or maximise environmental benefits.

21. The EIA has been carried out using a range of evaluation techniques including desk-based studies, supported by numerical modelling in some cases, and with reference to standards, guidelines and best practice established from assessment work for similar projects in the marine and coastal environment. The assessment draws upon information set out in the Erebus ES (Blue Gem Wind Ltd, 2021a) and follow up discussions with Natural Resources Wales (Blue Gem Wind Ltd, 2022) – including sediment dispersion modelling, as previously discussed with stakeholders (**Table 17-5**).

17.4.1. Assessment Methodology

22. **Chapter 05: EIA Approach and Methodology** provides a summary of the general impact assessment methodology applied in this ES. The following sections provide further detail on the specific methodology used to assess the potential impacts on the Physical Environment.

23. The approach to the assessment of cumulative impacts, transboundary impacts and interrelated effects is provided in **Sections 17.11, 17.12, and 17.13.**

24. The significance of potential effects has been evaluated using a systematic approach together with the expert judgement of ABPmer. The systematic approach is based upon the identification of the importance / value of receptors and their sensitivity to the proposed Project together with the predicted magnitude of the potential impact.

25. The terms used to define receptor sensitivity and magnitude of impact are largely based on standard EIA definitions set out in IEMA (2004), as described in **Chapter 05: EIA Approach and Methodology**. However, the terms have been tailored to ensure applicability to the physical environment topic.

17.4.2. Significance Criteria

Magnitude of Impact

26. The scale or magnitude of potential impacts (both beneficial and adverse) is determined by a combination of three criteria: scale of change, spatial extent of change and duration of change, as outlined in **Chapter 05: EIA Approach and Methodology**, **Section 5.4.9.**

27. The criteria for defining magnitude of impact for the purpose of the assessment on the physical environment are provided in **Table 17-6.**

Table 17-6. A summary of the magnitude criteria that are associated to specific impacts

Magnitude Criteria	Definition
Large	Permanent changes across the near- and large parts of the far-field, to key characteristics or features of the environmental aspect’s character or distinctiveness. **Adverse:** Severe damage to key characteristics, features or elements **Beneficial:** Extensive restoration; major improvement of attribute quality
Medium	Permanent changes, over the near- and parts of the far-field, to key characteristics or features of the environmental aspect’s character or distinctiveness. **Adverse:** Partial loss of / damage to key characteristics, features or elements **Beneficial:** Improvement of attribute quality
Small	Noticeable, temporary change (for part of the proposed Project duration), or barely discernible change for any length of time, restricted to the near-field and immediately adjacent far-field areas, to key characteristics or features of the environmental aspect’s character or distinctiveness. **Adverse:** Some measurable change in attributes, quality, minor loss of, or alteration to, one or more key characteristics, features or elements. **Beneficial:** Minor benefit to, or in addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk or negative impact occurring
Negligible	Changes which are not discernible from background conditions and/or which impact an extremely small proportion of the total footprint of the feature **Adverse:** Very minor loss of detrimental alteration to one or more characteristics, features or elements. **Beneficial:** Very minor benefit to or positive addition of one or more characteristics, features or elements

Sensitivity of Receptor

28. Receptor sensitivity is defined as the degree to which a receptor would be affected by an impact. The sensitivity of the receptor is characterised by three factors: vulnerability, recoverability and importance, as outlined in **Chapter 05: EIA Approach and Methodology, Section 5.4.10**.

29. The criteria for defining receptor sensitivity for the purpose of the assessment on the physical environment are provided in **Table 17-7.**

Table 17-7. Receptor sensitivity criteria

Receptor Sensitivity Criteria	Definitions
Very High	Very low or no capacity to accommodate the proposed form of change; and/or receptor designated and/or of international level importance. Likely to be rare with minimal potential for substitution. May also be of very high socio-economic importance.
High	Moderate to low capacity to accommodate the proposed form of change; and/or receptor designated and/or of regional/national level importance. Likely to be relatively rare. May also be of moderate socio-economic importance.
Medium	Moderate to high capacity to accommodate the proposed form of change; and/or receptor designated and/or of regional level importance. Likely to be relatively rare. May also be of moderate socio-economic importance.
Low	Moderate to high capacity to accommodate the proposed form of change; and/or receptor not designated but of district level importance.
Negligible	High capacity to accommodate the proposed form of change; and/or receptor not designated and only of local level importance.

Significance of Effect

30. As set out in **Chapter 05: EIA Approach and Methodology**, an Impact Assessment Matrix (IAM) is used to determine the significance of effect which is a function of the sensitivity of the receptor and the magnitude of the impact, as shown in **Table 17-8.**

31. The matrix provides a framework for the consistent and transparent assessment of predicted effects across all receptor topics; however, it is important to note that the IAM acts as a guide and that assessments also allow for the application of expert judgement.

Table 17-8. Significance Matrix

		Value / Sensitivity				
		Very High	**High**	**Medium**	**Low**	**Negligible**
Magnitude	**Large**	Major	Major / Moderate	Major / Moderate / Minor	Moderate/ Minor	Minor/ Negligible
	Medium	Major Moderate	Major / Moderate	Moderate / Minor	Minor / Negligible	Negligible
	Small	Major / Moderate / Minor	Moderate / Minor	Moderate / Minor	Minor / Negligible	Negligible
	Negligible	Minor / Negligible	Minor / Negligible	Minor / Negligible	Negligible	Negligible

32. The IAM provides levels of effect significance ranging from major to negligible. Assignment of significance is carried out with consideration of embedded mitigation measures relevant to the physical environment topic. Embedded mitigation measures (including project design measures and best practice) are presented within **Section 2.7**. Details on additional mitigation measures and associated definitions can be found in **Section 2.9**. For the purposes of this assessment, Moderate and Major levels of significance are defined as significant, and where relevant additional mitigation measures may be required, whilst Negligible or Minor impacts are defined as not significant and additional mitigation measures are not required (**Table 17-9).**

Table 17-9. Description of significant categories

Significance Category	Definitions	Significant / Not Significant Effect
Major	A large and detrimental change to a valuable / sensitive receptor; likely or apparent exceeding of accepted (often legal) threshold; or A large and beneficial change, resulting in improvements to the baseline result in previously poor conditions being replaced by new legal compliance or a major contribution being made to national targets. These effects may represent key factors in the decision-making process. Potentially associated with sites and features of national importance or likely to be important considerations at a regional or district scale. Major effects may relate to resources or features which are unique and which, if lost, cannot be replaced or relocated.	Significant
Moderate	A medium scale change which, although not beyond an acceptable threshold, is still considered to be generally unacceptable, unless balanced out by other significant positive benefits of a project. Likely to be in breach of planning policy rather than a legal statute; or A positive moderate effect is a medium scale change that is significant in that the baseline conditions are improved to the extent that guideline targets (e.g. UK BAP targets) are contributed to. These effects, if adverse, are likely to be important at a local scale and on their own could have a material influence on decision making.	Significant (unless otherwise specified)
Minor	A small change that, whilst adverse, does not exceed legal or guideline standards. Unlikely to breach planning policy; or A small positive change, but not one that is likely to be a key factor in the overall balance of issues. These effects may be raised as local issues and may be of relevance in the detailed design of a project but are unlikely to be critical in the decision-making process.	Not Significant
Negligible	A very small change that is so small and unimportant that it is considered acceptable to disregard. Effects which are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error. These effects are unlikely to influence decision making irrespective of other effects.	Not Significant

Receptors and Pathways

17.4.3. In most cases, marine physical processes are not in themselves receptors but are, instead, 'pathways' which have the potential to indirectly impact other environmental receptors, i.e. benthic ecology, fish ecology etc. Accordingly, whilst potential changes assessed in this chapter may not themselves be significant, it may be the case that they have potential to cause significant impacts to other EIA topic receptors. For example, the creation of sediment plumes (which is considered in the physical environment assessment) may lead to settling of material on to benthic habitats. The topic chapters relevant to the marine physical environment are:

- **Chapter 18: Marine Water Quality;**
- **Chapter 19: Benthic Ecology;**
- **Chapter 20: Fish and Shellfish Ecology;**
- **Chapter 24: Marine Archaeology;**
- **Chapter 26: Commercial Fisheries; and**
- **Chapter 28: Other Sea Users.**

17.4.4. It is important to note that where the impact is a marine physical process pathway (such as hydrodynamics, waves and sediment transport processes) without any associated receptors, this chapter of the EIA does not consider the resulting significance of effects. This is assessed in the respective chapters where the receptors are identified. Only receptors linked to marine physical processes are fully assessed in this chapter.

17.4.5. The main marine physical processes receptor which requires assessment is the coast itself. This could, potentially, be directly impacted during the construction phase, because of cable installation at the landfall, and in the operational phase if any proposed cable protection (in the form of rock berms) causes disruption to sediment transport.

17.4.6. The Study Area also overlaps with several nationally and internationally designated nature conservation sites, which contain key morphological features. Of particular note are Turbot Bank and St Gowan Shoals, which are both Annex I sandbank features.

17.4.7. *Study Area*

33. The Array Area is situated in the northeast Celtic Sea. The OfECC extends from the Array Area to the southwest coast of Pembrokeshire and into the Milford Haven Waterway. The OfECC makes landfall at Freshwater West (**Figure 17-1**).

34. The Study Area for the assessment of the physical environment is shown in **Figure 17-1**, along with the location of designated nature conservation sites. The Study Area has been defined based on the following and sets out the theoretical maximum extent that impacts may normally be experienced:

- The distance away from the proposed Project which suspended sediment plumes may be advected (and meaningfully interact with potentially sensitive receptors). This has been defined by a mean spring tidal excursion ellipse buffer around the Array Area and the OfECC which is consistent with the guidance set out in Brooks et al. (2018) and in NRW Guidance GN041 (NRW, 2020);
- The distance up/down drift from the landfall, that littoral processes could theoretically be impacted by proposed Project infrastructure, has been defined through consideration of coastal sub-cell information set out in the Lavernock Point to St Ann's Head Shoreline Management Plan (Pye & Blott, 2009); and

- The distance from the Array Area that wave blockage impacts could theoretically be detected has been informed by expert judgment, drawing upon (amongst other things), the evidence base from analogous projects and consideration of the prevailing wave directions.

35. Within the assessment, the following terms have been used to refer to different locations within the Study Area:

- Array Area and OfECC: the area within which the WTGs, inter array cables, mooring lines, floating sub-structures, Offshore Export Cable and supporting subsea infrastructure will be located;
- Wider Study Area: locations outside of the Array Area and OfECC;
- Offshore Area: areas seawards from the 20 m LAT contour; and
- Nearshore Area: areas landwards from the 20 m LAT contour.

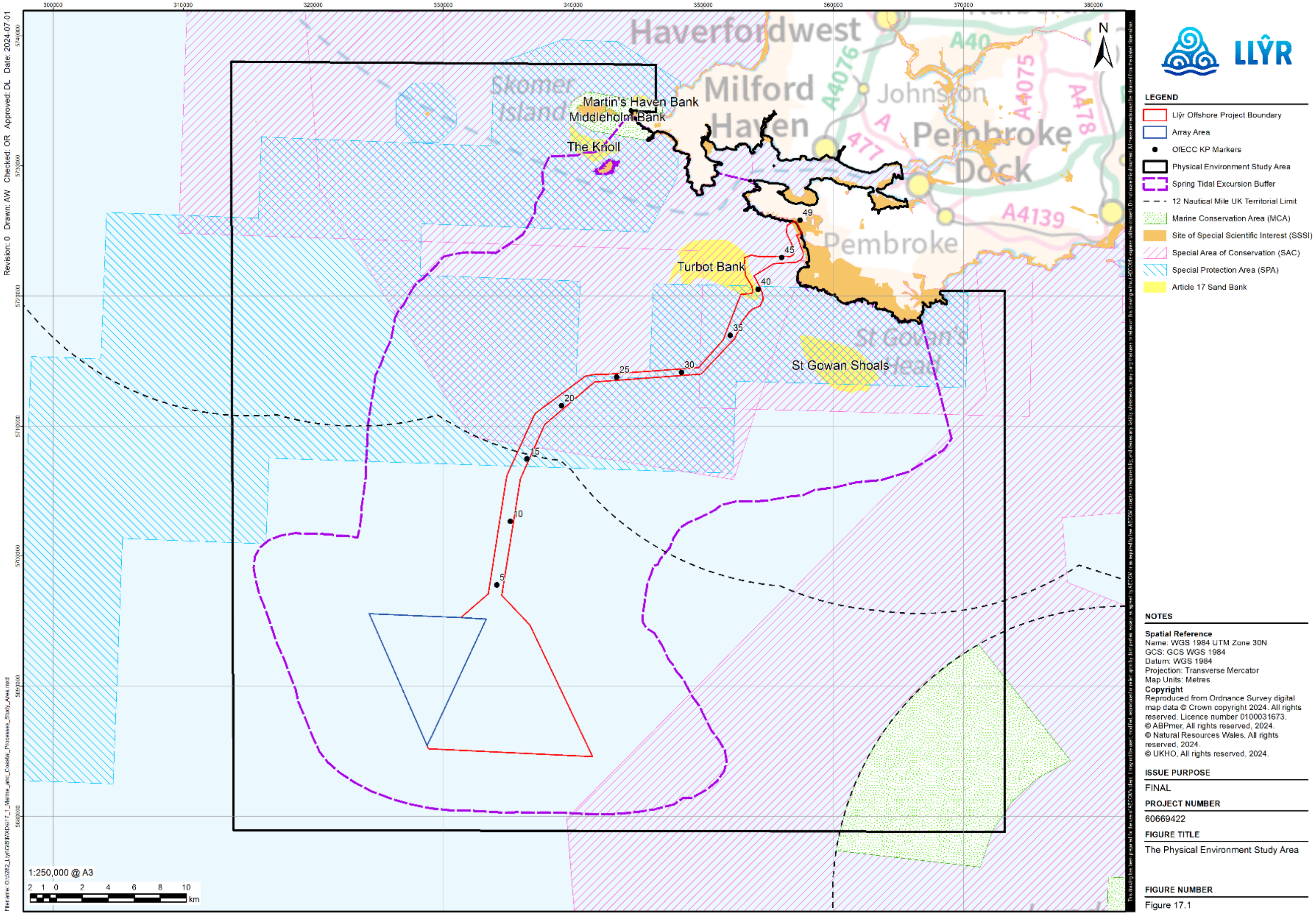


Figure 17-1. The physical environment Study Area

17.4.8. *Data Sources*

36. The baseline understanding of the physical environment within the Study Area has been developed through consideration of a range of Project specific surveys, desktop reports and metocean data sets. The baseline understanding is consistent with the data collected and baseline understanding for other nearby projects, presented in the Erebus Environmental Statement (Blue Gem Wind Ltd, 2021a) and Valorous EIA Scoping (Blue Gem Wind Ltd, 2021b). Key reports and data sources have been identified in the section below, with supporting reports referenced as appropriate throughout the baseline and assessment. The locations of key datasets described in this section are shown in **Figure 17-2**. Also included on this figure are the consenting boundaries for Erebus and the Greenlink interconnector since physical environment information collected for these projects has been used to help inform baseline understanding for the proposed Project.

Site Specific Surveys

37. To provide site specific information on which to base the impact assessment for the physical environment, site specific surveys were conducted:

- Geophysical survey of the Array Area (100% coverage) and OfECC (partial coverage) (N-Sea, 2023), consisting of:
  - Bathymetric survey;
  - Side scan survey with magnetometer; and
- Sub bottom profiling.
- Multibeam Echo Sounder (MBES) survey (**Volume 6, Appendix 17B**).
- Benthic characterisation survey of the Array Area (100% coverage) and OfECC (partial coverage) (Ocean Ecology, 2023), consisting of:
  - A total of 16 stations within the Offshore Project Boundary; and
  - All 16 grab stations successfully sampled for Total Organic Carbon (TOC), Particle Size Distribution (PSD) and macrobenthic analyses.
- Drop Down Video (DDV) collected in an area to the east of Turbot Bank between (approximately) KP 41 and KP 46 (**Figure 17-2)** (Ocean Ecology, 2024).

38. As shown in **Figure 17-2**, the section of the OfECC between approximately KP 24 and KP 48 is partially covered by the Project specific geophysical survey campaign. However, all areas are covered by high resolution multibeam survey data – with data either collected by the Project or available from existing sources (UKHO and SEACAMS). This includes the area of seabed where the export cable corridor passes to the east of Turbot Bank (**Figure 17-3**). These additional datasets are described further in **Table 17-10**.

39. In addition to the collection of Project specific survey data outlined above, Project specific metocean criteria analysis was undertaken by Aktis Hydraulics (Aktis Hydraulics, 2022). This modelling analysis drew upon existing observational metocean records from the region to calculate a series of extreme values for winds, waves, water levels and currents.

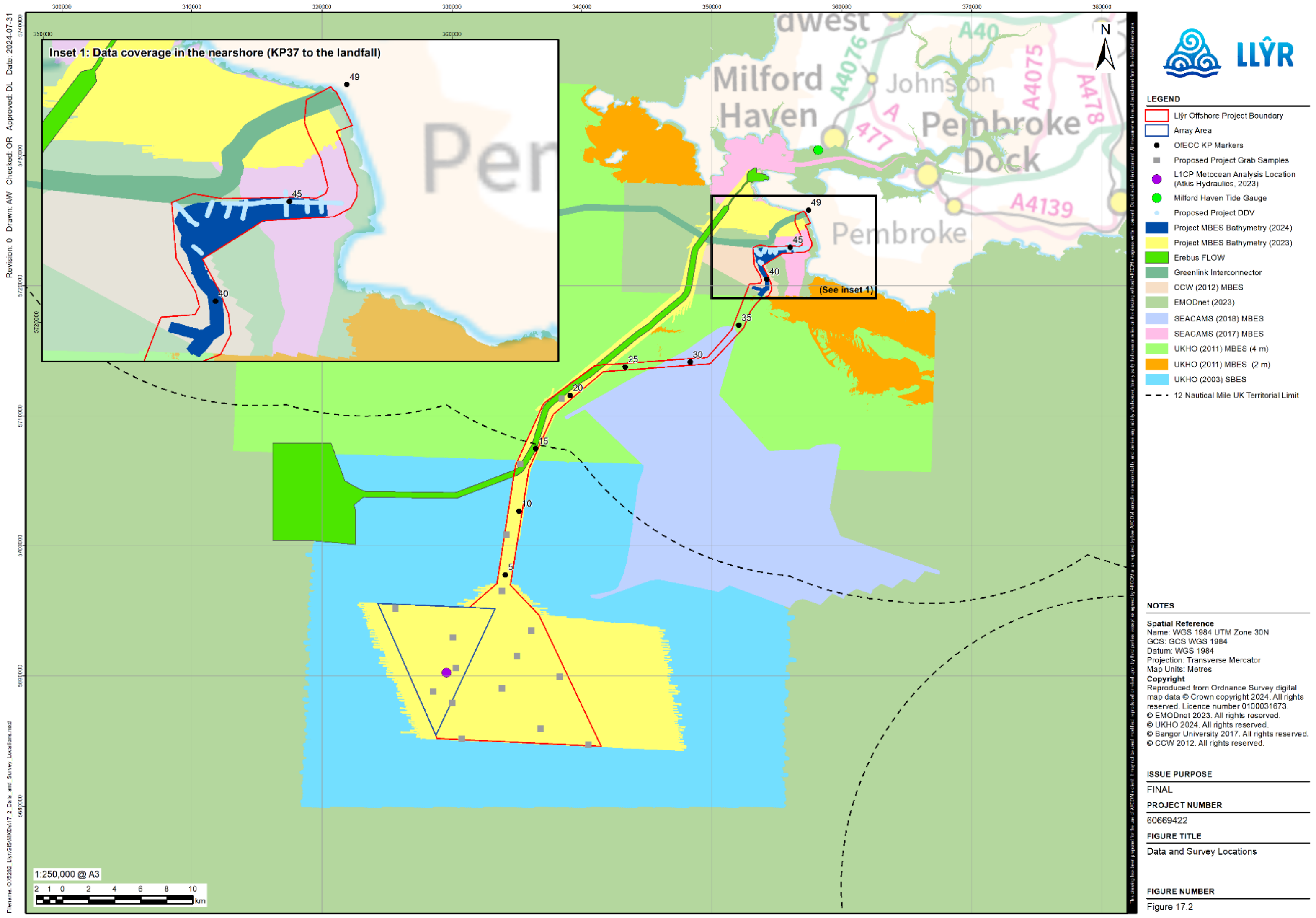


Figure 17-2. Data and survey locations

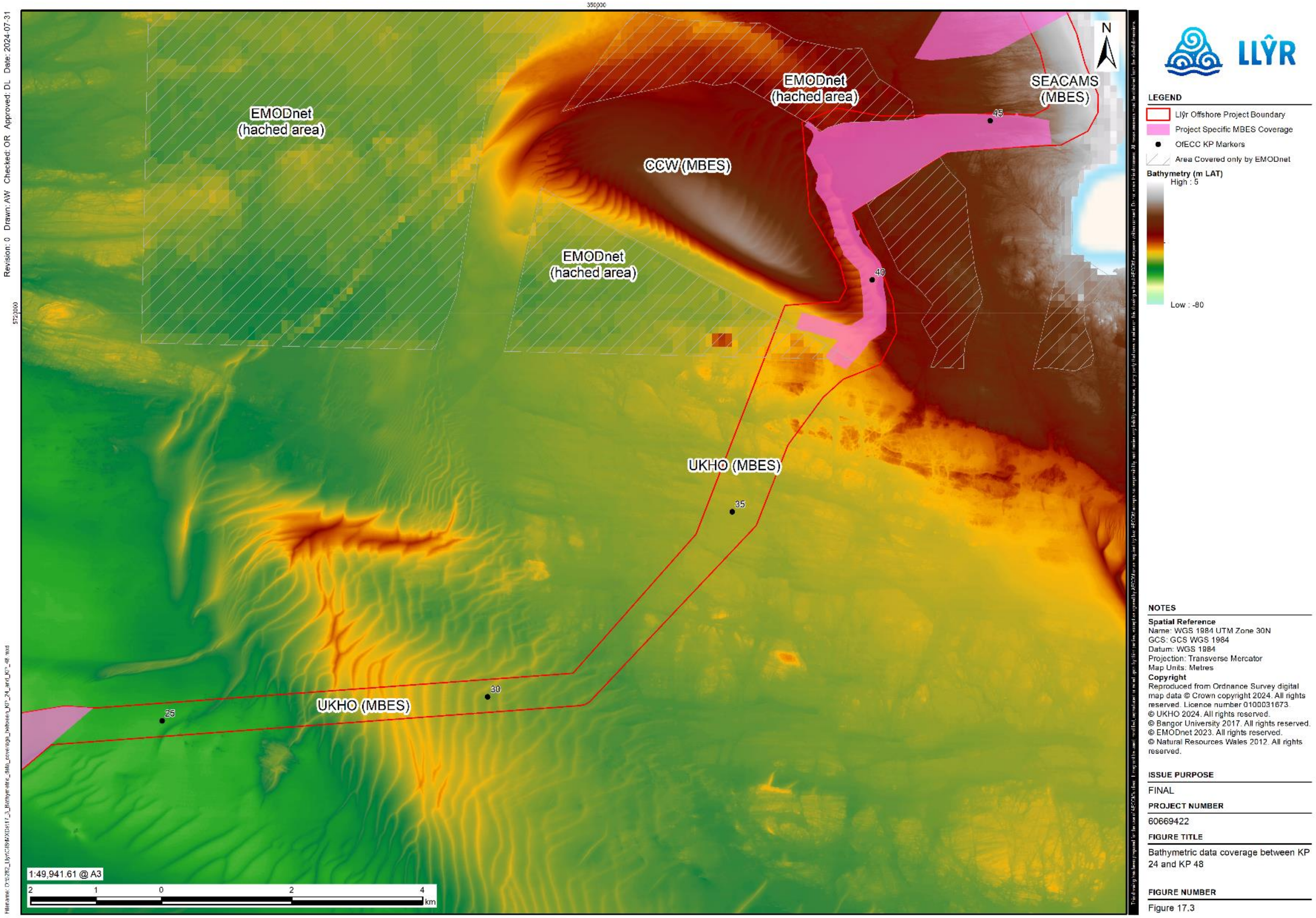


Figure 17-3. Bathymetric data coverage between KP 24 and KP 48

Desk Study

40. A comprehensive desk-based review was undertaken to inform the baseline for the physical environment topic. Key data sources used to inform the assessment are set out in **Table 17-10**.

Table 17-10. Summary of key desktop sources

Title	Source	Year	Brief description	Author
Atlas of UK Marine Renewable Energy Resources	www.renewables-atlas.info/user-guide	2008	Information on winds, waves and tides	ABPmer
BGS Offshore Geoindex	www.bgs.ac.uk/map-viewers/geoindex-offshore/	(various)	Information on seabed sediments, bedforms and shallow geology	British Geological Survey
European Atlas of the Seas	https://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/	2024	Information on seabed sediments, geology and coastal characteristics	EMODnet
Greenlink Interconnector ES	https://www.greenlink.ie/	2019	Description of physical processes at the Landfall (Freshwater West)	Greenlink (2019)
Lavernock Point to St. Ann's Head, Shoreline Management Plan SMP2	https://naturalresources.wales/flooding/managing-flood-risk/shoreline-management-plans/?lang=en	2012	Description of physical processes around the coastlines within the Study Area	SCBEG (2012)
Marine Energy Test Area (META) EIA Scoping Report	https://www.meta.wales/	2018	High level overview of physical process understanding within parts of the Study Area	RPS Energy (2018)
National Tide and Sea Level Facility (NTSLF)	https://www.ntslf.org/	(various)	Milford Haven tide gauge data	NTSLF
Erebus ES (including follow-up analysis to support discussions with NRW)	https://publicregister.naturalresources.wales/	2021,2022	ES for Erebus OWF, containing outputs from the Project specific surveys and analysis of	Blue Gem Wind Ltd (2021a, 2022)

Title	Source	Year	Brief description	Author
			physical processes	
Valorous Environmental Impact Assessment Scoping Report	https://www.bluegemwind.comilford	2020	High level overview of physical process understanding within parts of the Study Area	Blue Gem Wind Ltd (2021b)
SEASTATES	https://www.seastates.net/	2024	Hindcast data on winds and waves	ABPmer
SEACAMS	http://www.seacams.ac.uk/	(various)	High resolution bathymetry data from the Study Area	SEACAMS
The Outer Bristol Channel Marine Habitat Study	British Geological Survey (and others)	2006	Geophysical and benthic survey of the Outer Bristol Channel	Mackie et al. (2006)
United Kingdom Climate Projections (UKCP) 18	https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index	2018	Future climate change projections, including for sea level rise and changes in wave conditions.	Palmer et al. (2018)
United Kingdom Hydrographic Office (UKHO) Seabed Mapping Service	https://seabed.admiralty.co.uk/?x=51900.14&y=6971216.87&z=10.03	(various)	Bathymteric data for the Study Area	UKHO
Welsh Coastal Monitoring Centre geoportal	https://www.wcmc.wales/	(various)	Welsh coastal survey data including LiDAR and beach topographic survey data.	Welsh Coastal Monitoring Centre

17.5 Baseline

41. The following sections describe the baseline environmental conditions relating to the physical environment.

17.5.1. Existing Baseline

Water Levels

42. The tidal range within the Study Area are semi-diurnal and large (macro-tidal, >4 m tidal range), this is in keeping with its proximity to the Bristol Channel and Severn Estuary, known for having the second largest tidal range in the world.

43. The nearest location of tidal data from the UK National Tide Gauge Network is located at Milford Haven (**Figure 17-2**). Standard tidal levels from the UK Hydrographic Office Admiralty Tide Tables (UKHO, 2023) are provided in **Table 17-11** below. At Milford Haven, there is an implied mean spring tide range (MSR) of 6.3 m and a mean neap range (MNR) of 2.7 m.

Table 17-11: Tidal Water Levels at Milford Haven (UKHO, 2023)

	Level	
Tide	**Metres above Chart Datum (m CD)**	**Metres above Ordnance Datum (m OD)**
Highest Astronomical Tide (HAT)	7.8	4.09
Mean High Water Spring (MHWS)	7.0	3.29
Mean High Water Neap (MHWN)	5.2	1.49
Mean Sea Level (MSL)	3.85	0.14
Mean Low Water Neap (MLWN)	2.5	-1.21
Mean Low Water Spring (MLWS)	0.7	-3.01
Lowest Astronomical Tide (LAT)	0	-3.31

44. Mapped tidal water level range statistics are provided by the Atlas of UK Renewable Energy Resources (**Figure 17-4**) (ABPmer et al., 2008). At the landfall (Freshwater West), MSR and MNR is approximately 6.1 m and 3.0 m, respectively. Tidal range generally decreases with distance offshore along the OfECC, with MSR and MNR of approximately 5.4 m to 5.6 m and 2.6 m to 2.8 m, respectively, around the Array Area. These values and pattern of variance are consistent with the Project specific metocean assessment (Atkis Hydraulics, 2023) as well as results from a Project specific hydrodynamic model, validated using measured data, for Erebus (Blue Gem Wind Ltd, 2021a).

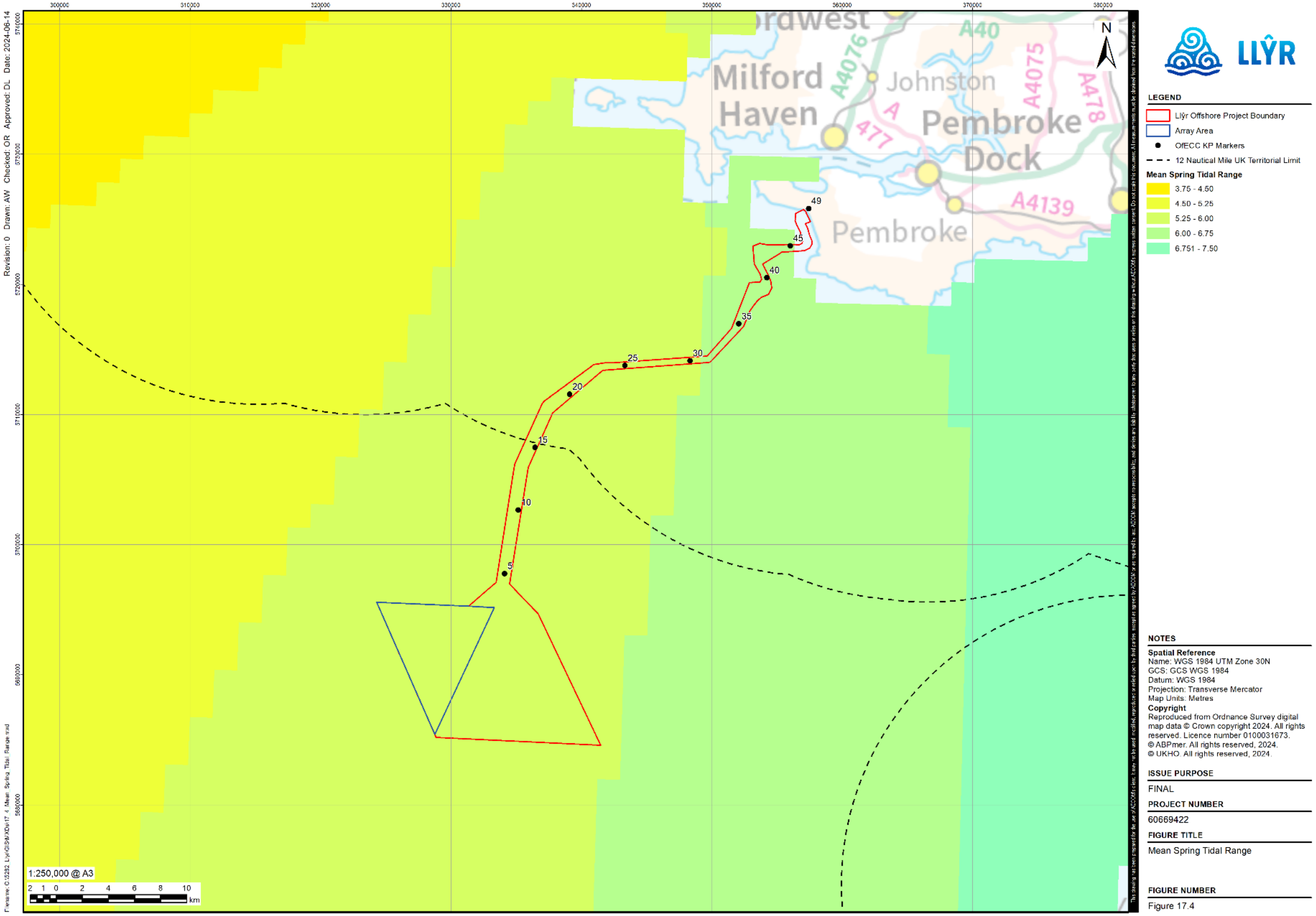


Figure 17-4. Mean spring tidal range (ABPmer et al., 2008)

45. Meteorological surges, resulting from the passage of low-pressure systems over the northwest European shelf seas, can elevate the water surface above the predicted astronomical tide level. The Bristol Channel, in particular, is affected by passage of Atlantic depressions especially those which take a more southerly track across Ireland (SCBEG, 2012). Uncles and Stephens (2007) suggest that storm surges in the area, for a 1 in 50-year return period, may temporarily increase water levels by over 1.0 m. See **Section 17.5.2 f**or further analysis of extreme water levels associated with future baseline conditions.

Tidal Currents

46. Mapped peak tidal current speed statistics, and ellipses showing the magnitude, axis orientation and degree of rotation of tidal currents, are provided by the Atlas of UK Renewable Energy Resources (**Figure 17-5**) (ABPmer, 2008). This information is consistent with the Project specific metocean assessment (Atkis Hydraulics, 2023) as well as the site specific metocean survey in the nearby Erebus array area and other hindcast data.

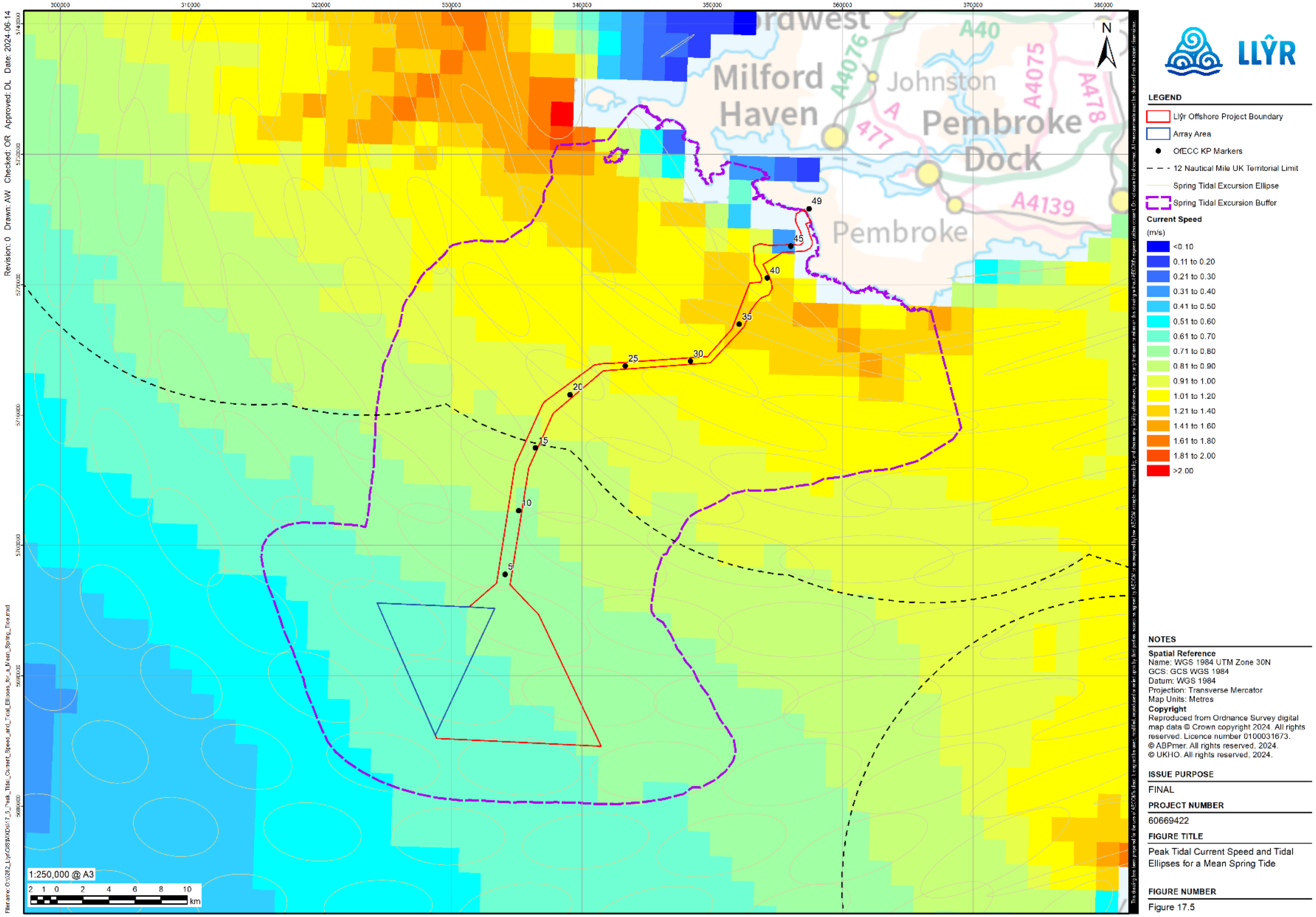


Figure 17-5. Peak tidal current speed and tidal excursion ellipses on a mean spring tide (ABPmer et al., 2008)

47. Based on the mapped statistics, in and around the Array Area, peak current speed on a mean spring tide is approximately 0.6 m/s to 0.8 m/s. Peak current speeds gradually increase along the OfECC to approximately 1.0 m/s to 1.4 m/s in the vicinity of Turbot Bank. In the more locally sheltered landfall location at Freshwater West - where water depths are less than circa 10 m LAT, the peak current speed can be significantly lower, in the order of 0.1 m/s to 0.2 m/s.

48. In the Array Area, tidal currents are directed towards the east or east-southeast at the peak of the flood tide and reverse at the peak of the ebb; at times of less than peak current speed, the direction of currents rotates gradually and continuously throughout the tidal cycle, resulting in limited to no completely slack water condition. Elsewhere along the OfECC, the axis of peak tidal currents is closer to southeast / northwest offshore, becoming progressively more aligned to the local coastline and becoming more rectilinear (less rotational) in nearshore areas.

49. Tidal excursion ellipses describe the distance or footprint over which water is normally transported by regular tidal currents. The dimensions of the ellipses are proportional to the magnitude of the peak speed, and the shape is dependent on the degree of relative tidal current rectilinearity (or rotation). Based on the data presented in ABPmer et al. (2008) and as illustrated in **Figure 17-5**, approximate mean spring tidal excursion distances are as follows:

- Array Area: approximately 10 km;
- Distance of around 20 km offshore (representing the middle of the OfECC): approximately 14 km; and
- Distance of around 5 km offshore: approximately 19 km.

Wind

50. The wind rose in **Figure 17-6** illustrates that winds in the offshore region are: mainly from the southwest and west; from directions between south clockwise through to west, approximately 50% of the time; from (the predominant) southwesterly direction for approximately 20% of the time; and from the east for about 8% of the time.

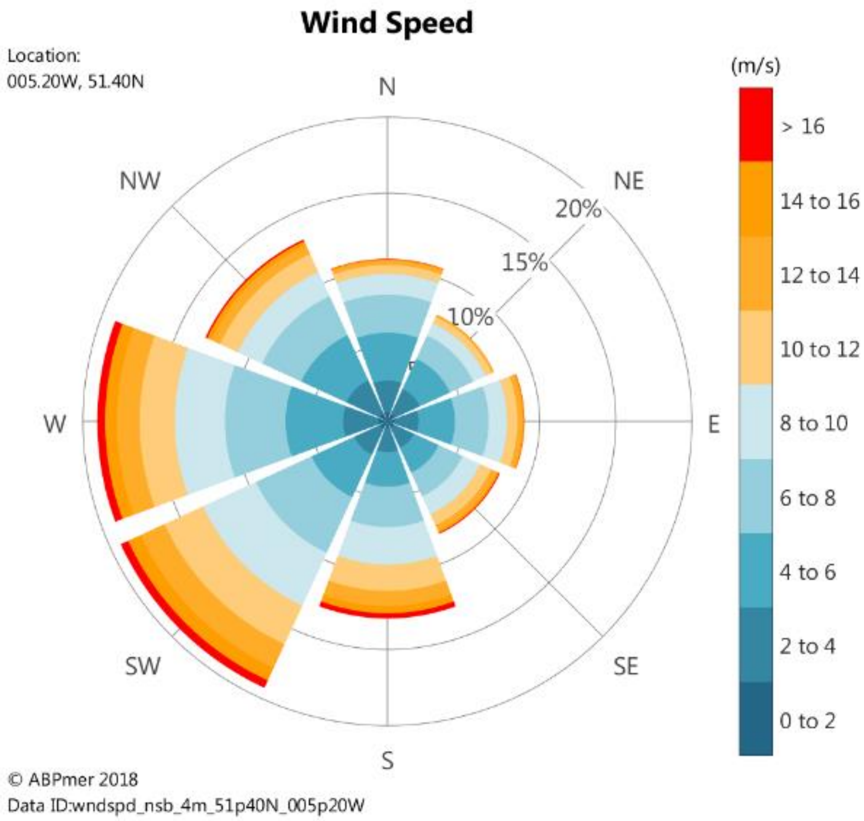


Figure 17-6. Annual wind speed at the Llŷr OWF Array Area (ABPmer, 2018a)

Waves

51. The wave climate of the Celtic Sea is influenced by both swell waves from distant sources in the Atlantic Ocean, and by locally generated wind-waves. At most locations along the coast of South Wales there is a strong dominance of waves approaching from a southwesterly and westerly direction (SCBEG, 2012).

52. Mapped annual mean significant wave height statistics are provided by the Atlas of UK Renewable Energy Resources (**Figure 17-7**) (ABPmer, 2008) and are found to be broadly consistent with the Project specific metocean assessment (Atkis Hydraulics, 2023), site specific metocean survey in the nearby Erebus array area and other hindcast data. Annual mean significant wave height in the vicinity of the Array Area is found to be approximately 2 m, reducing to circa 1.5 m in the approaches to Milford Haven and at Freshwater West (ABPmer, 2008, 2018a).

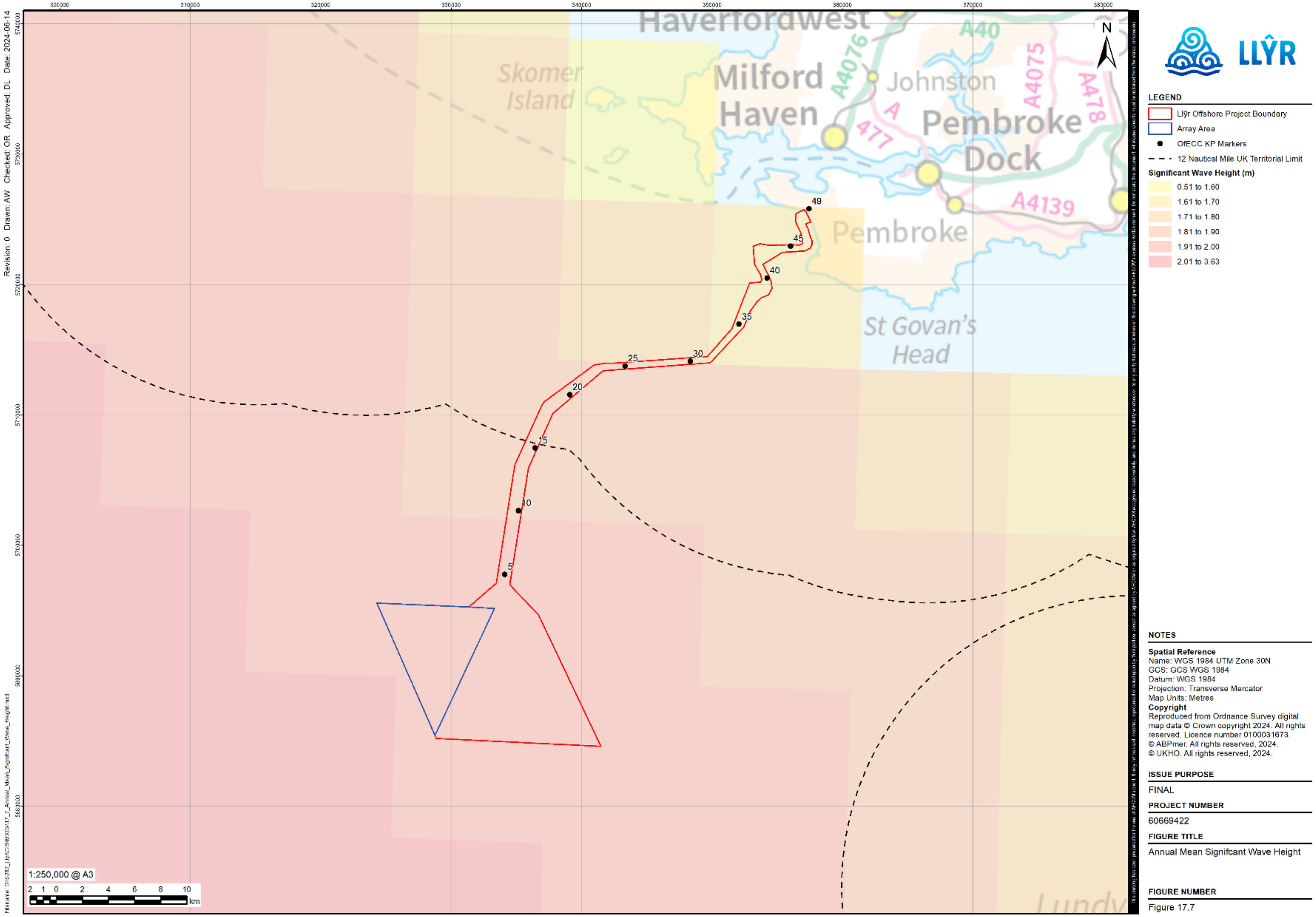


Figure 17-7. Annual mean significant wave height (ABPmer et al., 2008)

53. The most frequent significant wave height in the Array Area is between 1.0 m to 2.0 m, with the dominant wave direction from the west (**Figure 17-8)**. This correlates with the main wind direction (**Figure 17-6**) and is also consistent with data from the Project specific metocean assessment (Atkis Hydraulics, 2023).

54. The 1 in 1-year return period significant wave height within the Array Area is calculated to be approximately 7.8 m whilst the 1 in 50-year significant wave height is found to be 11.2 m (Atkis Hydraulics, 2023).

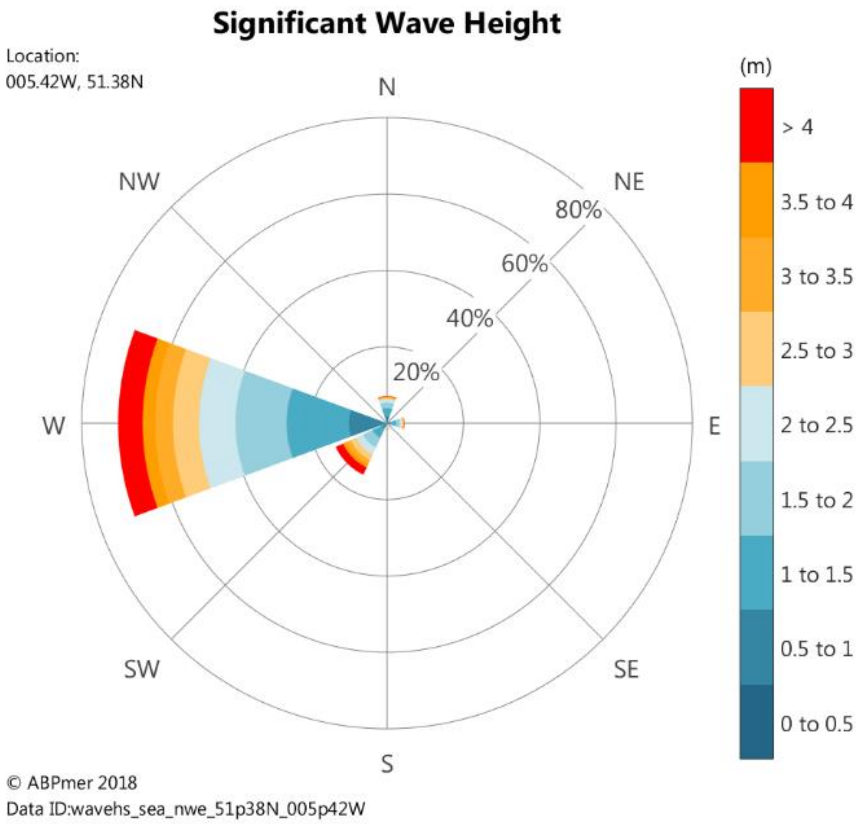


Figure 17-8 Annual significant wave height at the Llŷr OWF Array Area (ABPmer, 2018a)

55. The Shoreline Management Plan (SMP) for Lavernock Point to St Ann's Head (SCBEG, 2012) notes that steeper wind waves naturally cause beach draw-down (eroding sediment from the upper beach to form nearshore bars) during larger storm events. These are more likely to occur during the winter months. This process is then naturally reversed by prolonged periods of less steep and less energetic wave conditions, which are more likely during summer months.

Bathymetry

56. The dominant bathymetric feature of the Study Area is the wide trough along the length of the St George's Channel (northwest of the proposed Project, between the western-most point of Wales and Wexford in Ireland), where maximum depths are in excess of 100 m below LAT (**Figure 17-9**). To the south of the Study Area, within the approaches to the Bristol Channel, main channel depths reach up to 70 m to 80 m below LAT. In general, bathymetries shoal to the east, into the Bristol Channel, and water depths reduce further into the Severn estuary.

57. Within the Array Area, water depths are between circa 68 m and 72 m below LAT, and from around 72 m to 0 m below LAT along the OfECC. Bed slope gradients are generally shallow (average values are typically 1° or less across the wider area) but increase up to 6° along the OfECC, primarily associated with large sedimentary bedforms (sandwaves). Water depths along the OfECC are deepest where it joins the Array Area (KP 0), at around 70 m below LAT. For most of the OfECC, water depths are between approximately 70 m and 30 m below LAT.

Geology

58. **Figure 17-10** summarises the seabed geology across the Study Area. The bedrock geology in the vicinity of the Array Area is understood to mostly comprise chalk although mudstones and sandstones are expected to be present in the southern half of the Array Area. The cable approach to shore passes over chalk, interbedded mudstone and limestone near the Array Area, with mudstone and sandstone largely dominant closer inshore.

Seabed Sediments

59. Based on BGS seabed mapping, seabed sediments within the Study Area are predominantly sands and gravels. Nearshore (i.e. water depths <20 m below LAT) areas of seabed around the Pembrokeshire coast are characterised by rocky reefs, shoals and sandbanks, defined as ‘hard substrate’ by the BGS (**Figure 17-10**).

60. Seabed sediments within the Array Area and along the OfECC have been characterised through interpretation of the Project specific geophysical survey data (N-Sea, 2023) as well as analysis of grab samples (Ocean Ecology, 2023). Backscatter data from the Array Area suggests that muddy sand and sandy mud sediments are dominant although Particle Size Analysis (PSA) from the grab samples suggests sands and gravels are dominant, with less fine grained (muddy) material than inferred from the backscatter day.

61. The grab samples collected from the OfECC also suggest a slightly lower mud content than that inferred from the backscatter data, although the PSA does confirm that fine grained material is present in places, including in the approaches to the landfall at Freshwater West (**Figure 17-11**). However, the available data suggests that surficial sediment cover at the landfall is very limited (<1 m or so), with rock close or exposed at the seabed. Further detail regarding the characteristics of the benthic environment is provided in **Chapter 19: Benthic Ecology.**

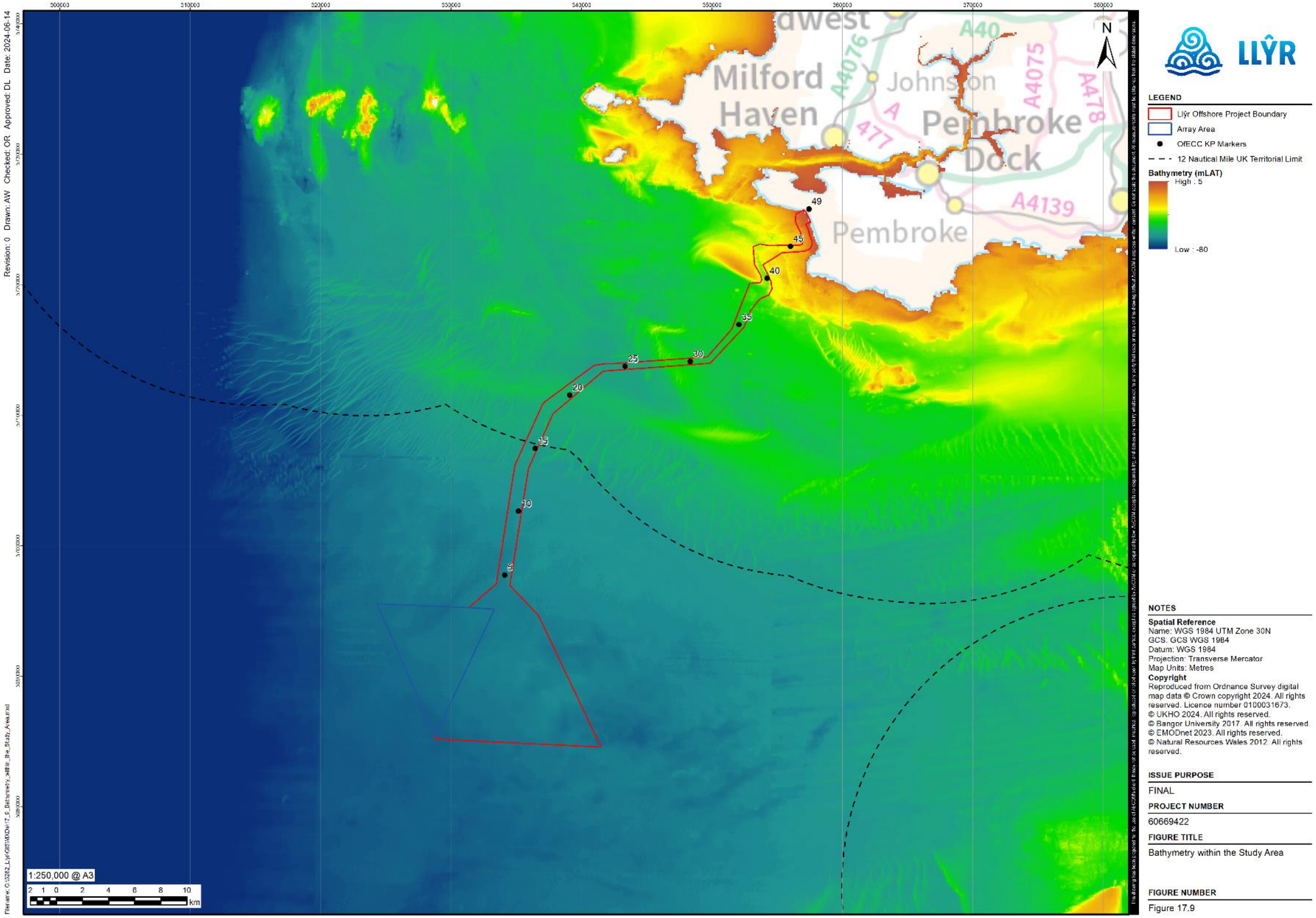


Figure 17-9 Bathymetry within the Study Area

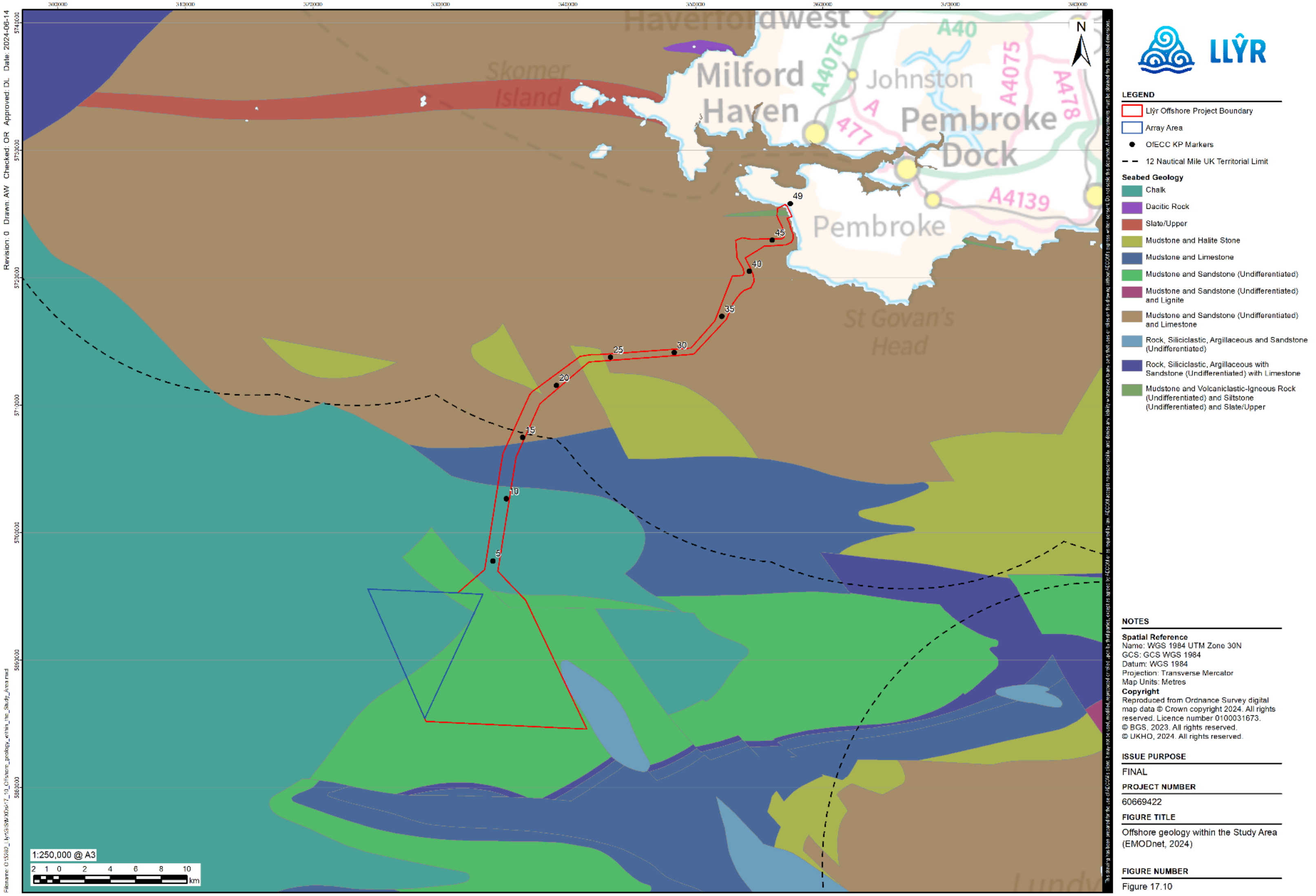


Figure 17-10. Offshore geology within the Study Area (EMODnet, 2024)

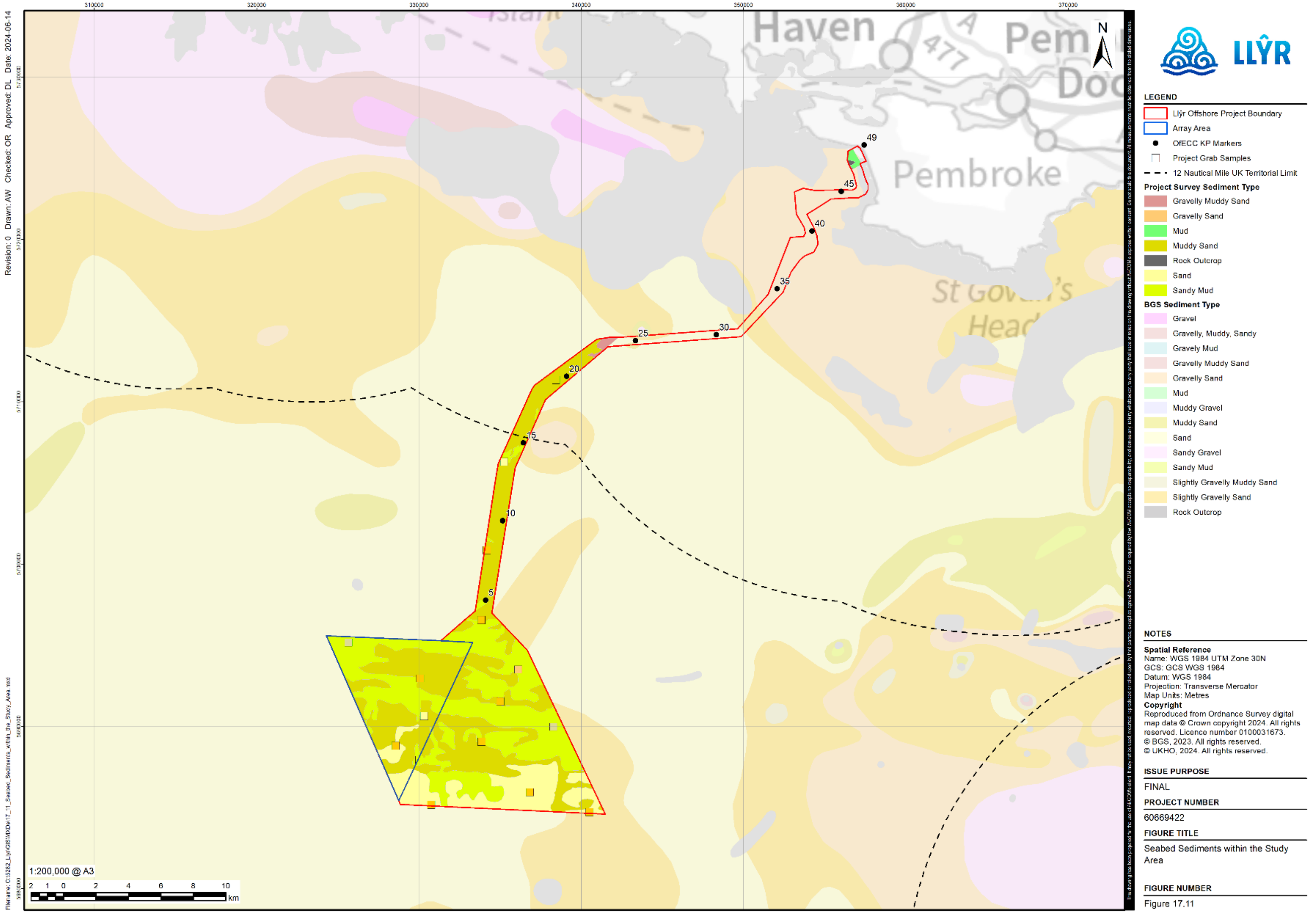


Figure 17-11. Seabed Sediments within the Study Area

Geomorphology

Offshore geomorphology

62. The Project specific geophysical survey shows that megaripples dominate throughout the Array Area and along much of the OfECC (**Figure 17-12**). These features are typically less than 1 m in height with wavelengths of around 10 m and, given the strength of the prevailing currents (**Paragraph 46**), are expected to be mobile. This is supported by comparison of present day (2023) and older bathymetric survey data which shows bed level change within the Array Area and along the OfECC of a magnitude consistent with the migration of these features (**Figure 17-13** and **Figure 17-14**).

63. Between approximately KP 14 and KP 17 of the OfECC, larger sandwaves are encountered within / nearby to the OfECC. These features are part of a much bigger field of very large sandwaves located to the south of Carmarthen Bay, with heights in excess of 10 m and wavelengths of several hundred metres (**Figure 17-9**) (Mackie et al., 2006). Where this sandwave field intersects the OfECC, the largest sandwave is around 5 m high, although migration rates are negligible (**Figure 17-14**). Around 10 km further to the northeast along the OfECC (between circa KP 25 and 31), a further series of sandwaves are mapped. These are up to approximately 4 m high in places (**Figure 17-14**).

64. Around 6 km from the Landfall (at approximately KP 40), the OfECC passes between Turbot Bank and St Gowan Shoal (**Figure 17-12**). The western edge of the OfECC and the proposed indicative cable route within the OfECC are circa 0.25 and 0.8 km, respectively, to the east of the main crest of Turbot Bank. Turbot bank is a large subtidal sandbank with numerous sandwaves and megaripples on its flanks that are actively migrating in a clockwise direction around the main body of the bank (Blue Gem Wind Ltd, 2021a). This is illustrated through a comparison between the existing CCW 2012 MBES survey of Turbot Bank and the newly acquired (2024) Project-specific MBES which shows that sandwaves of up to 6 m height are migrating in a general southerly direction at a rate of (up to) approximately 12 m per year (**Figure 17-15** and **Figure 17-16**).

65. At its closest point, St Gowan Shoal is located approximately 4 km to the southeast of the OfECC. MBES data collected by UKHO in 2011 shows the presence of extensive sandwaves on St Gowan Shoal and given the prevailing hydrodynamic conditions, these bedform features are expected to be mobile. Sediment transport pathways on and around both banks are discussed further in **Paragraph 71 et seq.**

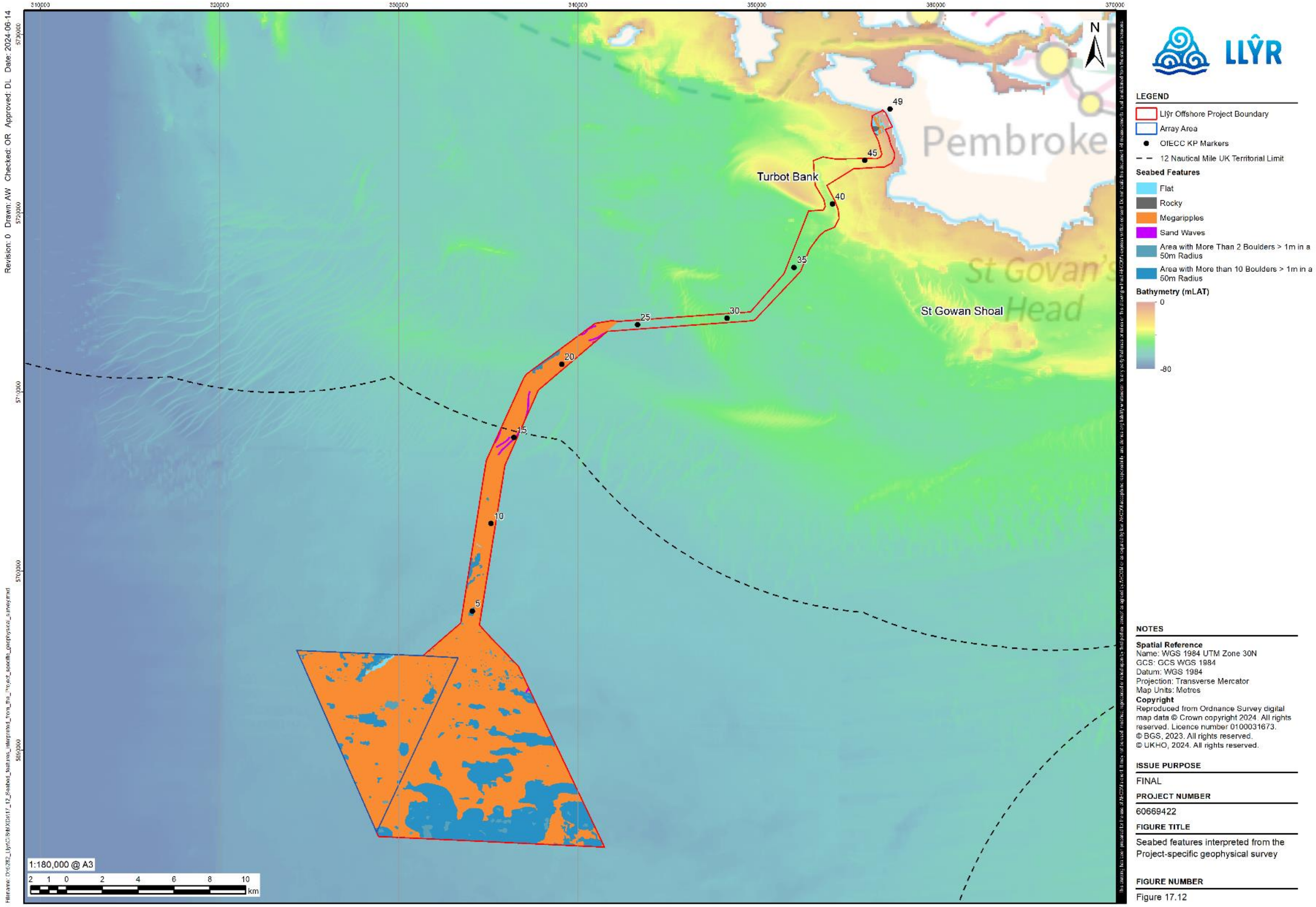


Figure 17-12. Seabed features interpreted from the Project specific geophysical survey

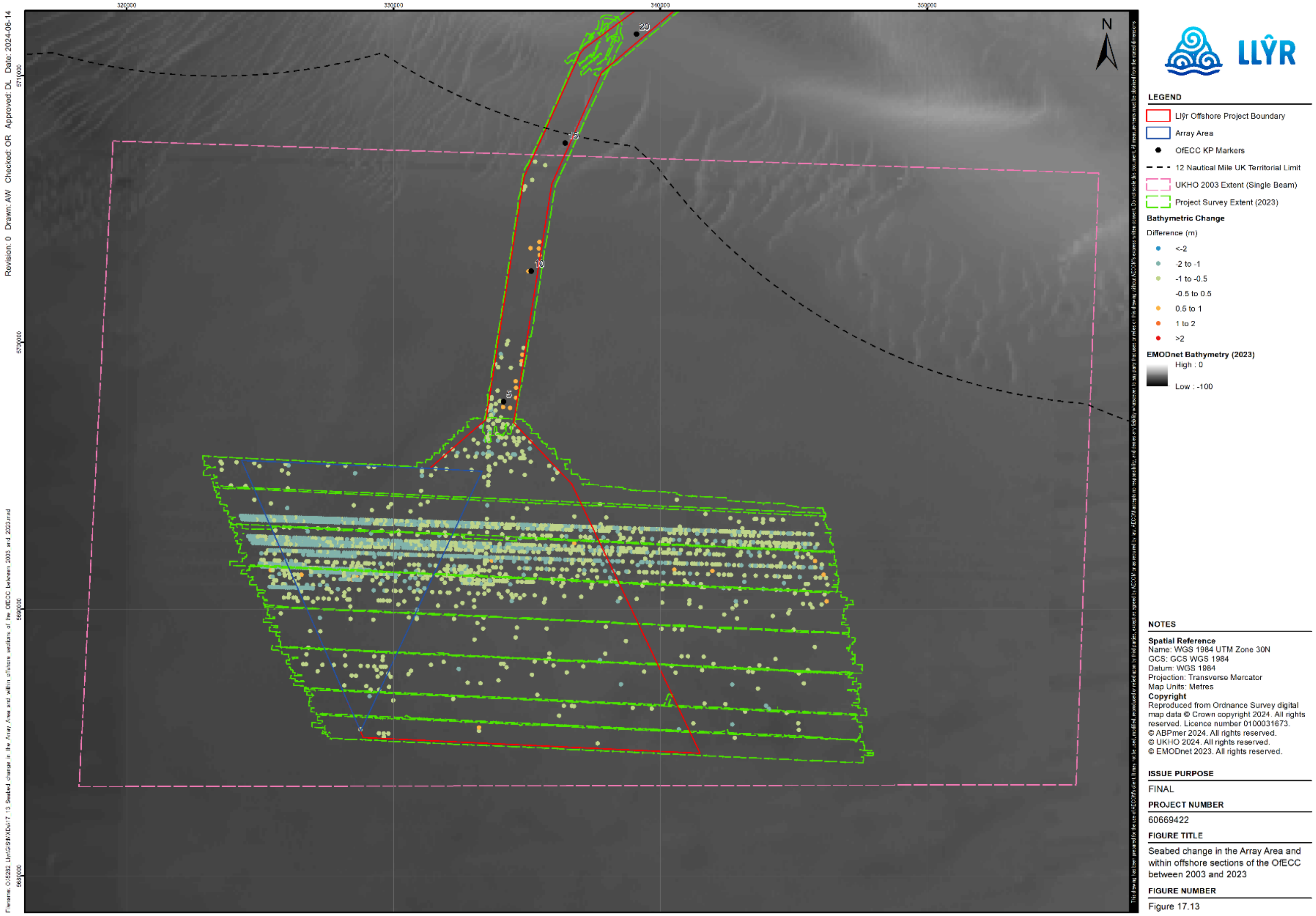


Figure 17-13. Seabed change in the Array Area and within offshore sections of the OfECC between 2003 and 2023

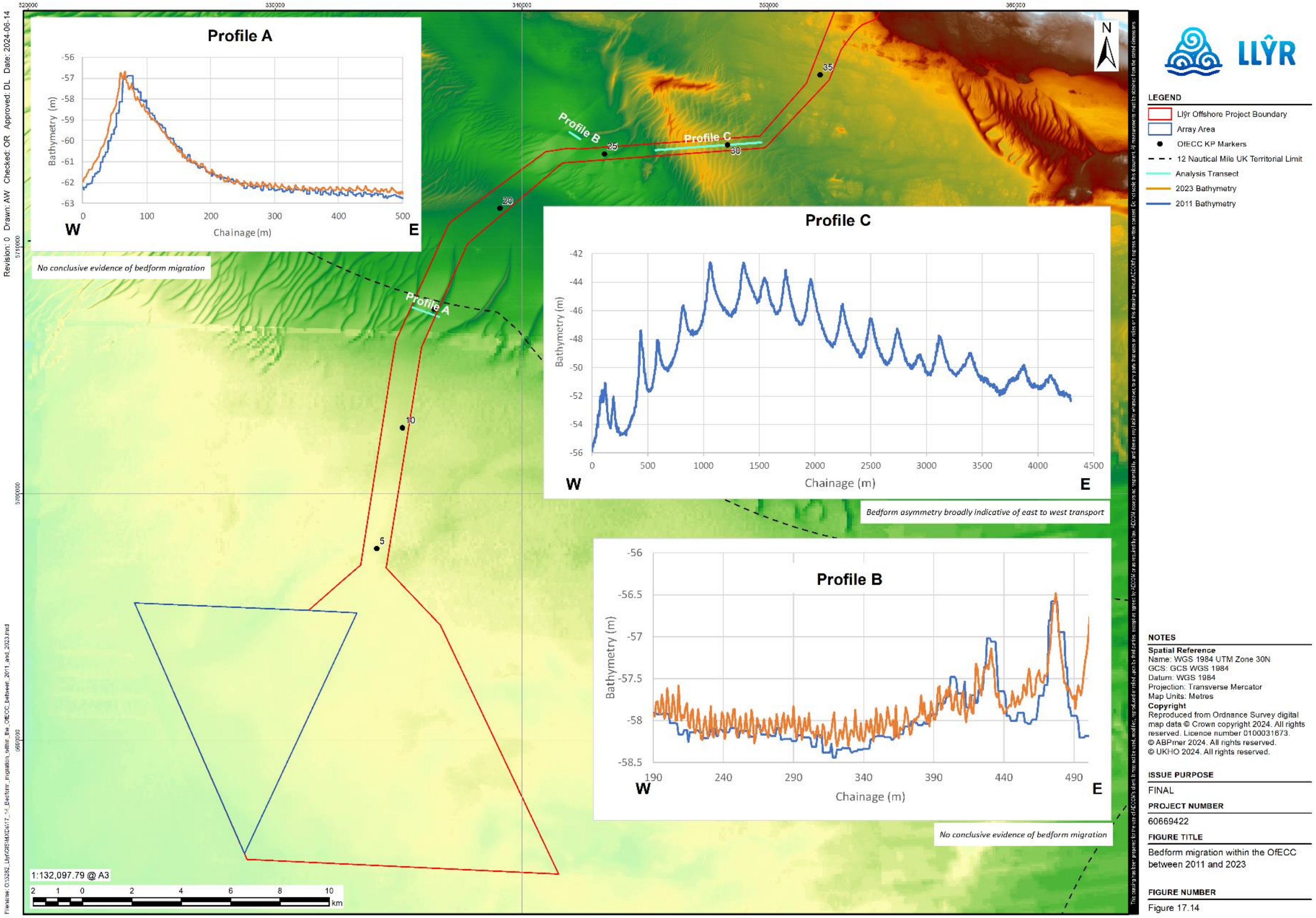


Figure 17-14. Bedform migration within the OfECC between 2011 and 2023

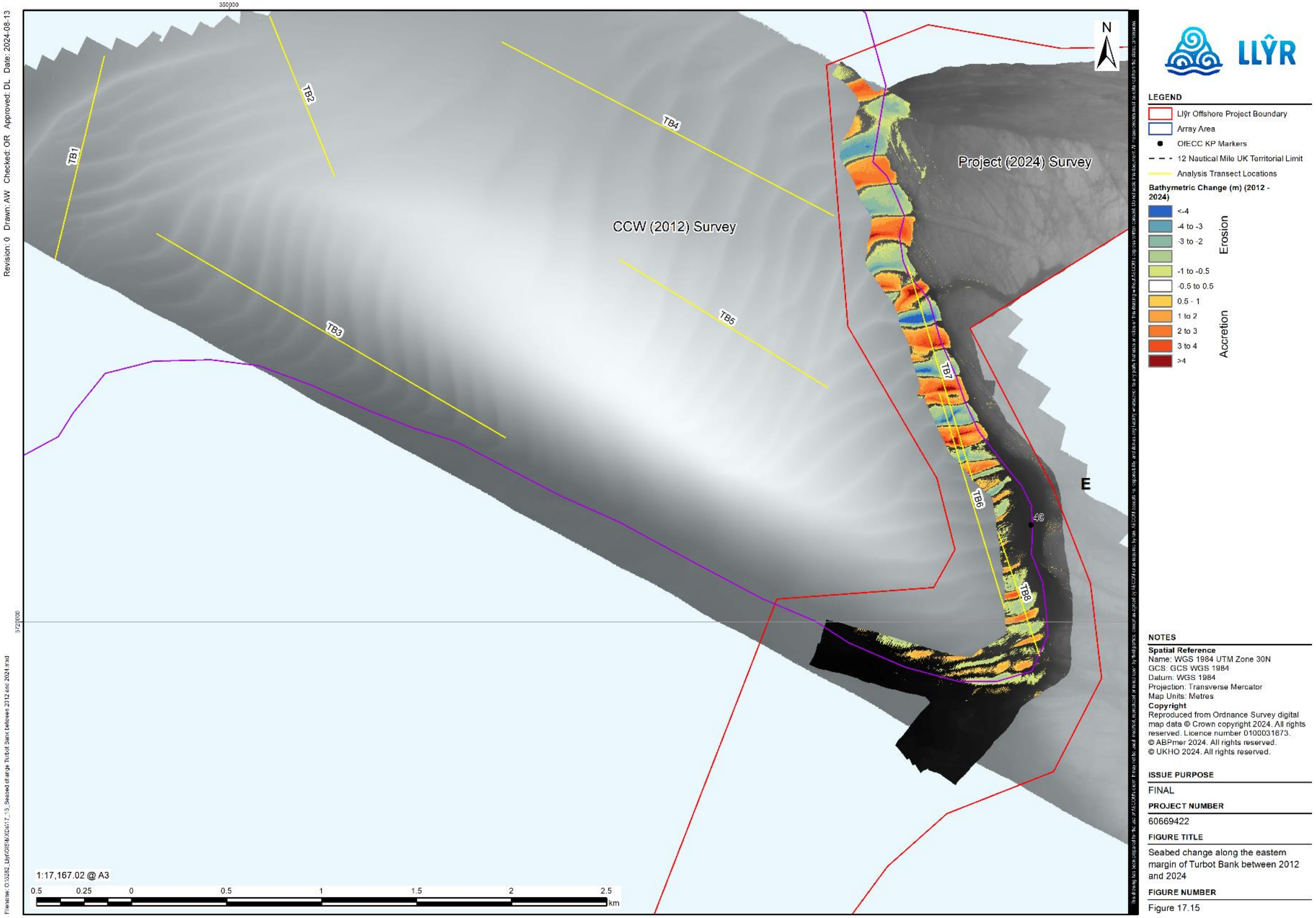


Figure 17-15. Seabed change along the eastern margin of Turbot Bank between 2012 and 2024

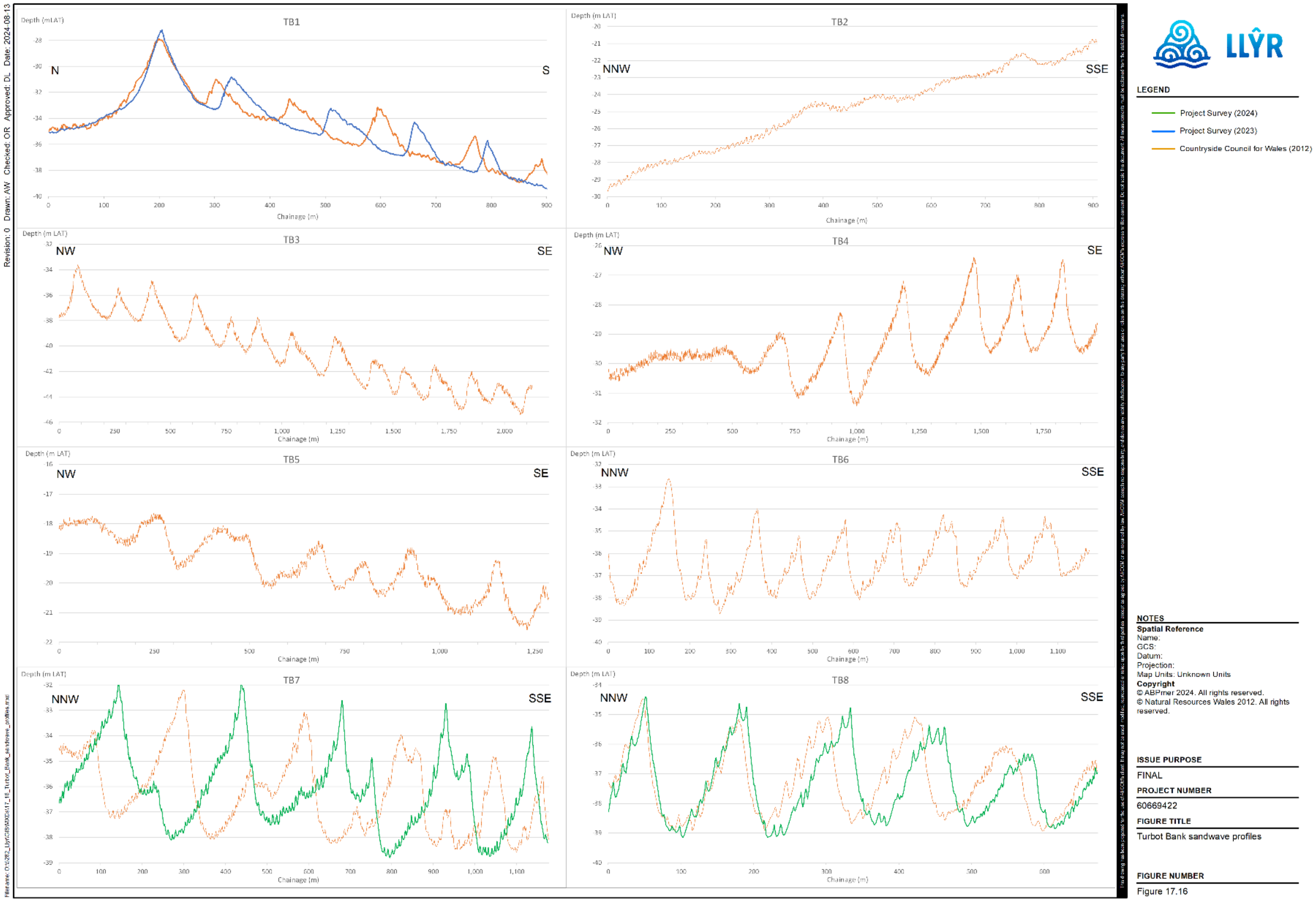


Figure 17-16. Turbot Bank sandwave profiles

Coastal geomorphology

66. The coastal characteristics of the Landfall at Freshwater West have previously been described in the Greenlink Interconnector ES (Greenlink, 2019), which comes ashore at the northern end of Freshwater West beach. Key points from this study are summarised below and shown in **Figure 17-17**:

- Freshwater West is a southwest facing sandy beach backed by extensive dunes (Broomhill Burrows, Gupton Burrows) and is exposed to high wave energy during the winter months. Both Freshwater West (and Frainslake Sands to the south) are enclosed by the limestone cliffs at Linney Head to the south, with low jagged sandstone cliffs backed by semi-natural vegetation on the south coast of the Angle Peninsula, to the north;
- The beach exhibits relatively large intra-annual fluctuations in elevation in response to seasonal changes in wave energy, with material generally moved offshore in winter and onshore in summer (**Figure 17-18**). However, the sediment at Freshwater West is relatively fixed by the rock reef structures in the nearshore and it is thought unlikely to escape the system by travelling alongshore or offshore;
- The upper beach is relatively steep, with a circa 5 m fall in elevation from the sand dunes flanking the beach, through a thin strip of shingle (cobbles) at the back of the beach moving to coarse to medium sand in the first 50 m of the profile. The mid-beach is a gentler gradient (circa 1:50) comprising medium sand. The lower beach comprises of medium to fine sand with a shallower gradient (1:200);
- The dune system is shifting and changing over time naturally, with periodic ‘blowouts’ (sandy depressions caused by the removal of sediment by wind). Broomhill Burrows is in a constant flux as sediment supply fluctuates seasonally with wave climate, beach steepness and the wet-drying cycle of the intertidal zone; and
- Within the dune systems at Freshwater West (and Frainslake Sands immediately to the south) a shoreline management policy of managed realignment is in place which is intended to enable the dunes to function naturally, whilst allowing dune management to be undertaken as required (SCBEG, 2012).

67. A comparison of the 2023 Project specific bathymetric survey with that previously collected by SEACAMS (in 2017) is shown in **Figure 17-18**. This figure shows that in most inshore areas adjacent to the Landfall, there is negligible change in seabed elevation as a consequence of the absence of surficial sediment and exposure of rock in many places. However, in the very shallow (circa 0 to -2 m LAT) inshore areas change of circa 2 m (or more) is observed between the two datasets. This is associated with inter and intra annual changes in beach profile in response to varying wave conditions.

68. The coastline at Freshwater West is within SMP 20 (Lavernock Point to St Anne’s Head); Policy Unit 18.2 (Frainslake Sands and Freshwater West). A policy of managed realignment is in place for the short-term (2005-2025), medium-term (2025-2055) and long-term (2055-2105). The intent is to enable the dune system to function naturally with minimal interference, whilst allowing localised dune management as required.

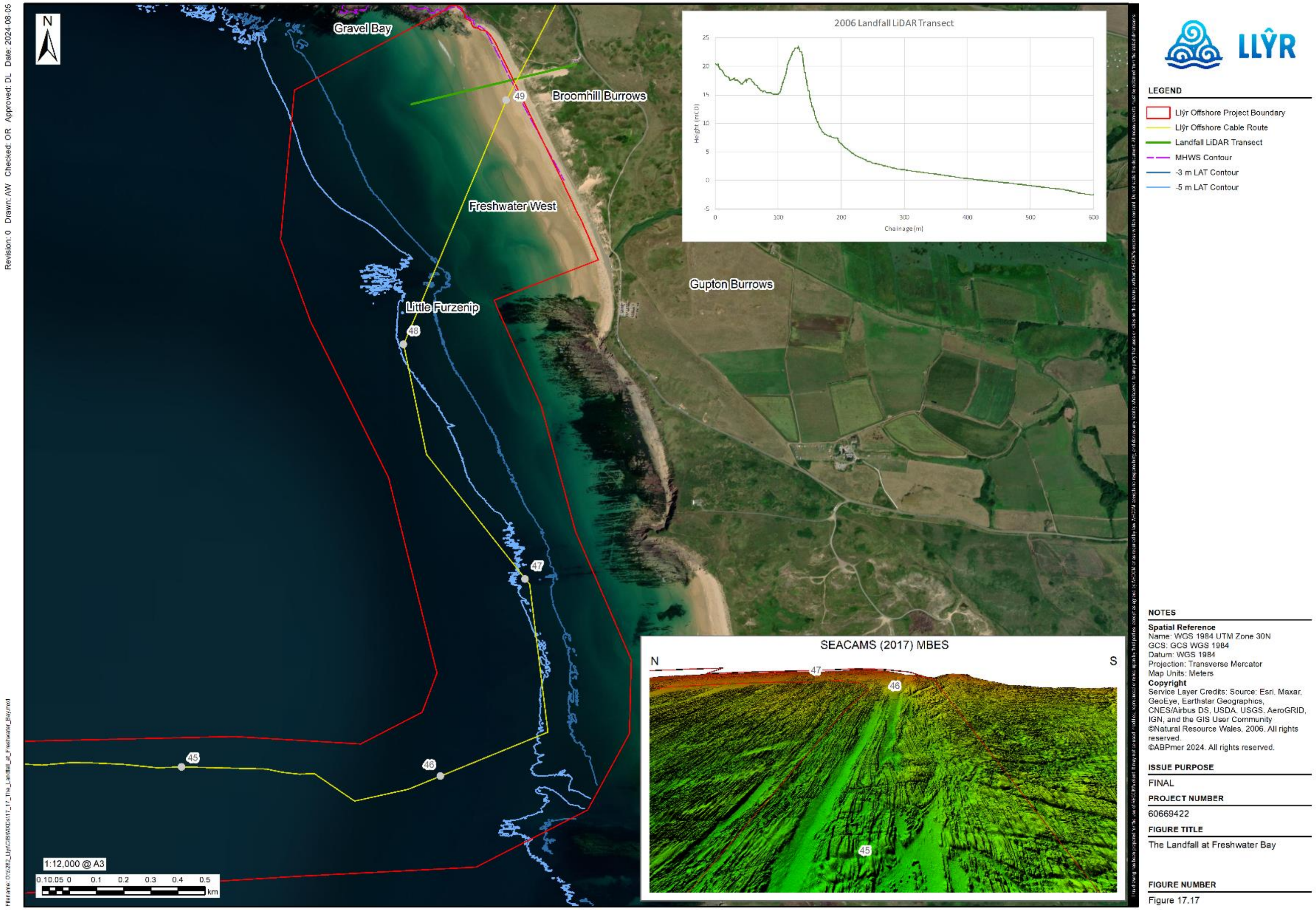


Figure 17-17. The Landfall at Freshwater West

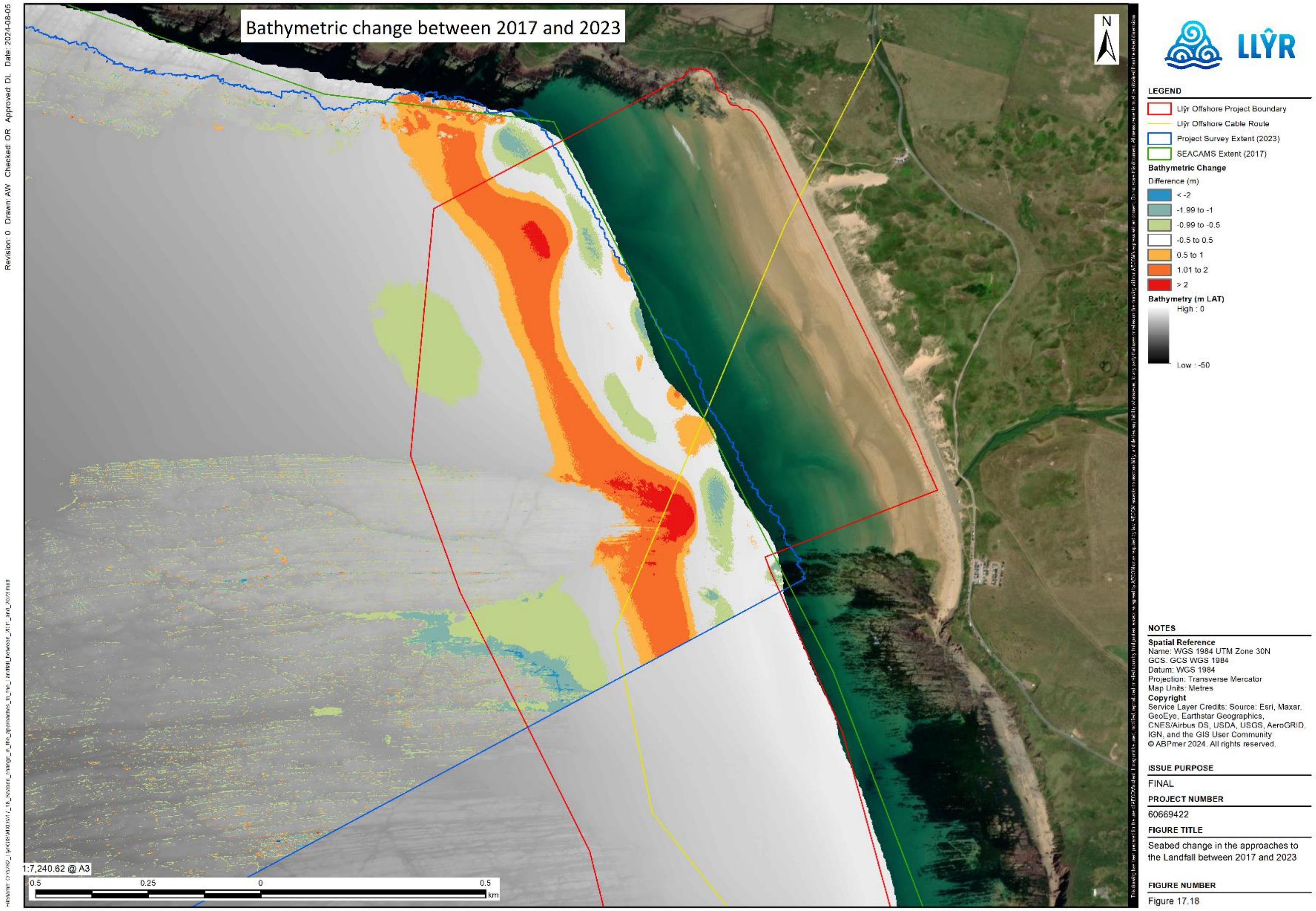


Figure 17-18. Seabed change in the approaches to the Landfall between 2017 and 2023

Suspended sediments

69. Mean surface concentrations of Suspended Particulate Material (SPM, mainly comprising sediment in suspension, but also other organic matter) have been assessed by Cefas (2016) using satellite data, calibrated against measurements from smart-buoys. SPM values are typically low across the Study Area but generally increase from offshore towards the coast, due to progressively shallower water depths, higher current speeds, and proximity to terrestrial sources of fine suspended material (rivers, estuaries, land run-off).

70. During summer months SPM concentrations increase from <1 mg/l across the Array Area, to around 3 mg/l at the landward end of the OfECC. Overall, SPM levels increase slightly during winter, but absolute concentrations are still relatively low, increasing from around 3 mg/l at the Array Area to approximately 8 mg/l in the approaches to the Landfall (at Freshwater West). It is noted, however, that locally stronger tidal currents around the Pembrokeshire coast can cause relatively high sediment resuspension and thus, higher SSC in these areas (DTI, 2007).

Sediment Transport and Wider Conceptual Understanding

71. Within the Celtic Sea and St George's Channel, tidal currents, rather than waves, are the main mechanism for sediment transport (DTI, 2007 and Kenyon & Cooper, 2005). However, more recent numerical modelling of sediment transport in the Celtic Sea by King et al. (2019) suggests that wave-tide interactions do significantly enhance sediment transport within the macrotidal environment, with waves having a greater influence than had previously been suggested. King et al. (2019) explain that median sized waves can increase sediment transport in the tidal direction, while extreme waves (1% exceedance) can temporarily change the dominant sediment transport pathway and initiate sediment transport in water depths greater than 120 m, where outside extreme conditions sediment transport in these deeper waters is usually negligible.

72. A numerical sediment transport model has been developed to quantify the potential rate of sediment transport for medium quartz sand (250 µm diameter grain size) under tidal current forcing. Maps of the daily average net sediment transport rate and direction over a representative mean spring-neap cycle are shown in **Figure 17-19** and **Figure 17-20**. Key findings are summarised below and in **Figure 17-21**, also drawing upon the morphological evidence:

Array Area

- Net sediment transport in the northern section of the Array Area is to the west. Across the northern section of the Array Area there is a gradient of net transport magnitude, higher to the east, and lower to the west.
- The modelling results are entirely consistent with the morphological evidence from the Array Area collected by the Project specific geophysical survey (N-Sea, 2023), with bedform (megaripple) asymmetry inferring a westerly direction of transport.

OfECC (including Turbot Bank)

- At the southern end of the OfECC, sediment transport is in a westerly direction but switches to a southeasterly direction around midway between the Array Area and the Landfall. Where the OfECC passes to the east of Turbot Bank, net transport is broadly in a southerly direction, with much higher potential rates of transport compared with locations further offshore (including the Array Area).

- The net sediment transport vectors indicate a clockwise pattern of sediment recirculation around Turbot Bank that is broadly in agreement with the observed pattern of sandwave asymmetry on the flanks of the bank (**Figure 17-15, Figure 17-16** and **Figure 17-22**);
- The net sediment transport vectors (**Figure 17-20** and **Figure 17-22**) indicate a complex convergence of potential transport pathways towards St Gowan Shoal from different directions. It is noted that potential transport pathways from the northwest (i.e. along the coastline, coming from the location of the cable route) towards St Gowan Shoal includes areas where the seabed is presently exposed rock with little or no sediment present to transport to downdrift locations.

Approaches to the Freshwater West (the Landfall)

- Within nearshore (< circa 20 m LAT), net sediment transport is in an easterly direction, towards the coast, with rates reducing closer inshore.
- Although potential rates of sediment transport are relatively high in places, much of this nearshore area is characterised by exposed bedrock at the seabed, with little surficial sediment (N-Sea, 2023). Accordingly, actual rates of sediment transport are expected to be relatively low.

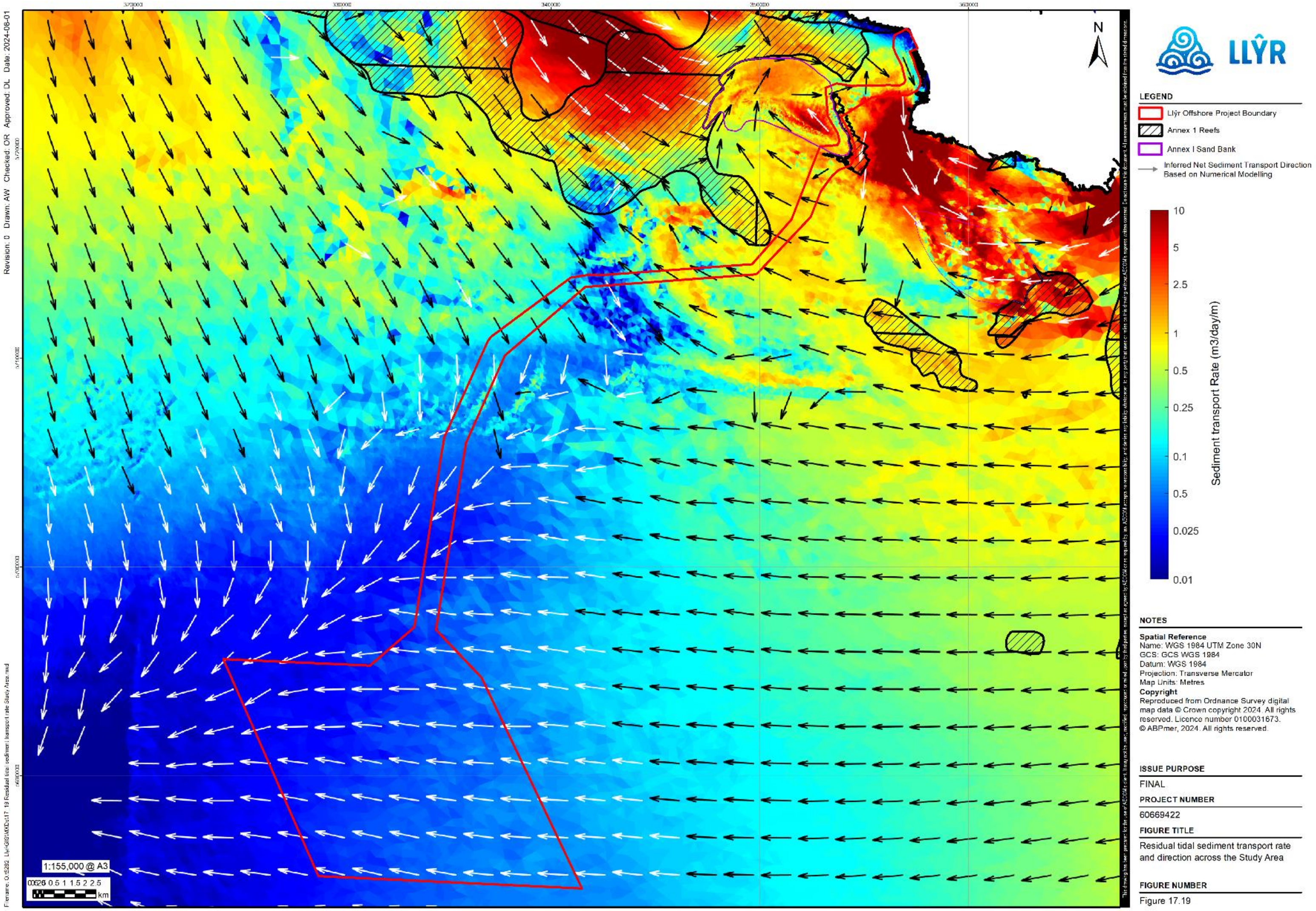


Figure 17-19. Residual tidal sediment transport rate and direction across the Study Area (m³ / day / m of 250µm quartz sand by tidal currents only)

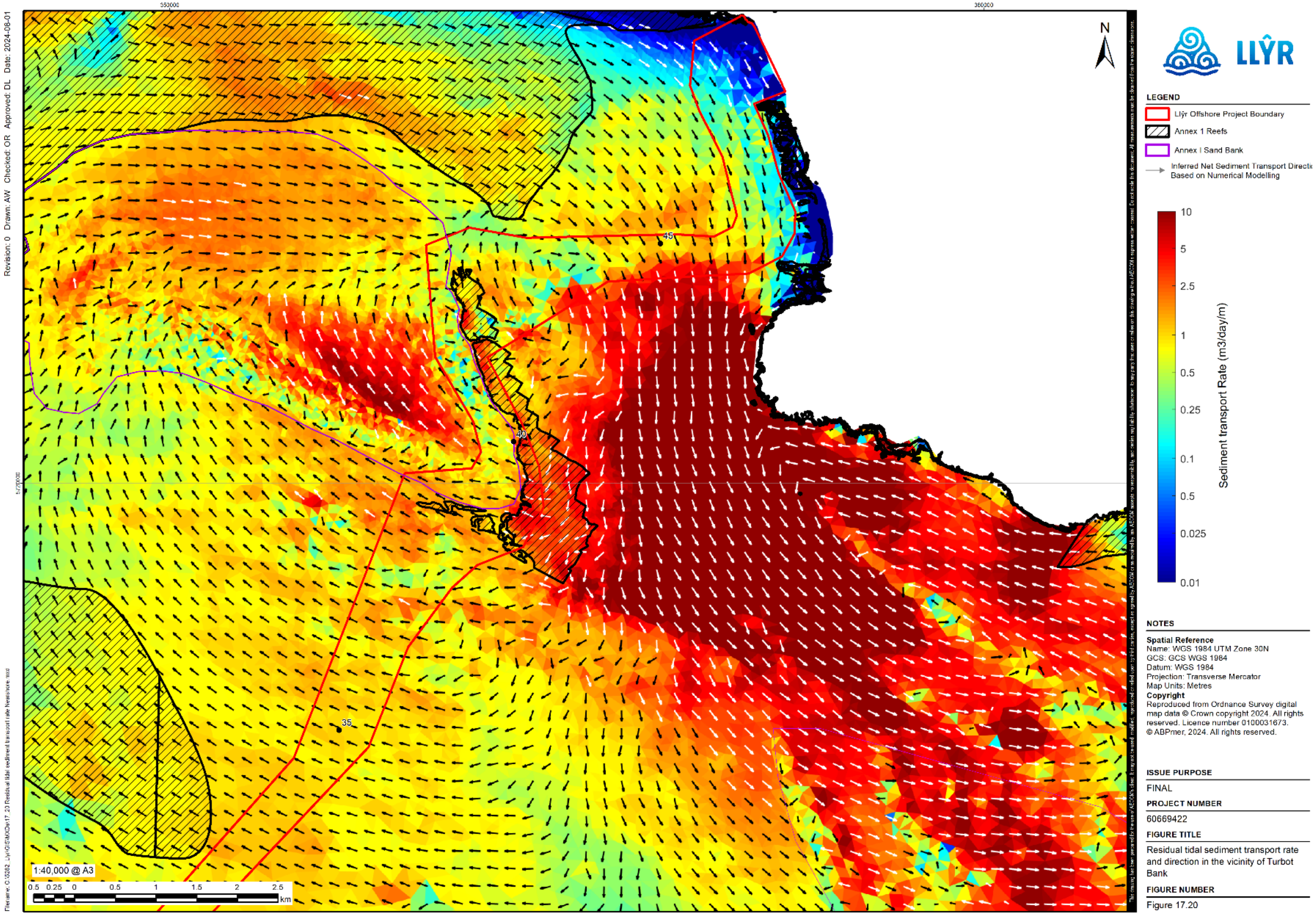


Figure 17-20. Residual tidal sediment transport rate and direction in the vicinity of Turbot Bank and St Gowan Shoals (m³ / day / m of 250μm quartz sand by tidal currents only)

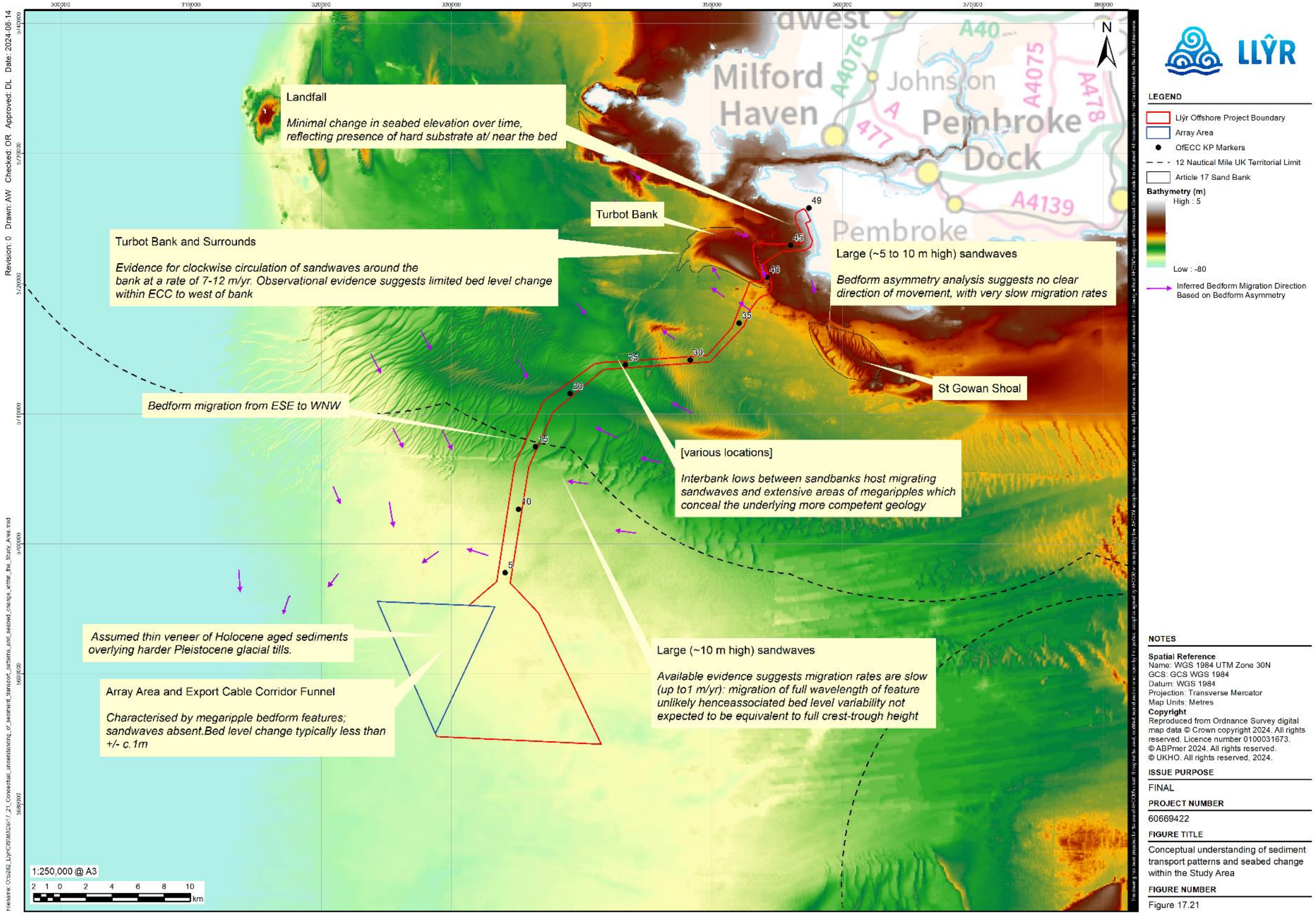


Figure 17-21. Conceptual understanding of sediment transport patterns and seabed change within the Study Area

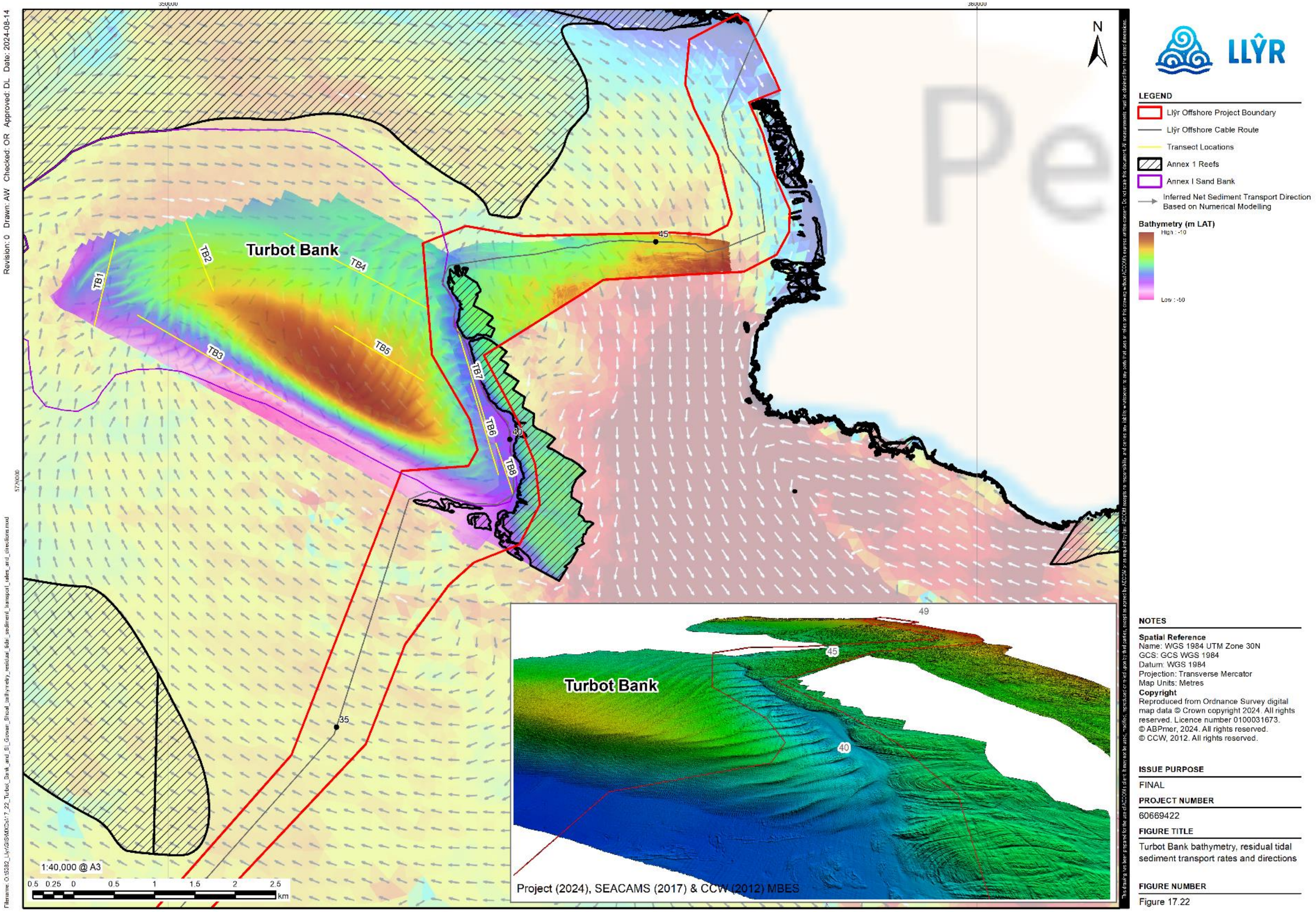


Figure 17-22. Turbot Bank bathymetry, residual tidal sediment transport rates and directions

17.5.2. *Future Baseline*

73. This section considers the changes to the baseline conditions described above that might occur during the period over which the proposed Project will be operational. It considers changes that might occur in the absence of the proposed Project being constructed.

74. Due to natural cycles and climate change effects, the baseline environment is expected to exhibit some degree of change over time, with or without the proposed Project in place.

Extreme sea levels

75. Extreme sea levels include contributions from tides, storm surge and sea level rise. Storm surges combined with strong winds and storm waves may have significant implications for coastal erosion and the stability of beaches and dunes. The extreme values at the landfall are available from the Environment Agency's Coastal Flooding Boundary (CFB) dataset (Environment Agency, 2018). Extreme sea levels for 1 in 1, 1 in 20 and 1 in 50-year return periods are summarised in **Table 17-12**. Sea level rise from the baseline year 2008 has been included in the extreme sea levels provided for 2027 and 2057, allowing for the 30-year design-life of the proposed Project.

Table 17-12. Extreme sea levels (m ODN) at the Landfall location

Return Period (yr)	Landfall	
	2027*	2057**
1	4.24	4.53
20	4.61	4.90
50	4.72	5.01

*Based on EA (2018), corrected to 2027 (from the baseline year of 2008)

**Based on EA (2018), corrected to 2027 and with the addition of sea level rise (RCP 8.5; 95 %ile

76. The astronomical tidal range about the new mean level and tidal currents are unlikely to be measurably affected by the relatively small increases in water level predicted over the proposed Project operational life (30 years).

77. The UK Climate Change Projections 2018 (UKCP18) provides the most up-to-date assessment of how the climate may change up to 2100 and post-2100 – see Palmer et al. (2018). The RCP8.5 scenario is a future scenario where greenhouse gas emissions continue to grow unmitigated. These best estimates suggest a global average temperature rise of 4.3°C by 2100 compared to the pre-industrial period. For the RCP8.5 scenario 95th percentile case, sea level rise from 2027 – 2057 at the landfalls is 0.29 m, allowing for the 30-year operational life of the proposed Project.

Wind and waves

78. UKCP18 provides projections of changes in wave climate over the 21st Century. The findings indicate that within the Study Area, mean significant wave heights may decrease but by less than 0.2 m by 2100 (Palmer et al., 2018). However, natural variability is noted to be high in this area and future projections are very sensitive to climate models devised for the North Atlantic storm track, which remains an area of considerable uncertainty (e.g., Bricheno et al. 2023).

Morphological characteristics

79. It Is likely that a rise in sea level and increased storminess will lead to the generation of larger waves. Therefore, greater wave energy can more frequently reach the coast which may result in an increase in local erosion rates, and may alter sediment transport around the coastline, affecting the equilibrium of coastal features. This could potentially result in erosion of the dune systems at the Landfall and beach roll back although there is considerable uncertainty associated with projections of how coastal morphology may be affected by climate change.

17.5.3. Designated Sites

80. The Study Area overlaps with several nationally and internationally designated nature conservation sites, which contain qualifying geological and geomorphological features. The locations of these sites are also included in **Figure 17-1**, with key details in **Table 17-13**. The sites are primarily designated for the habitats they contain rather than for the presence of geological and geomorphological features. However, changes to the physical characteristics of these sites have the potential to impact the habitats they support and, therefore, consideration is given to them in the physical processes assessment.

Table 17-13. Designated nature conservation sites considered within the Physical Environment Assessment

Site	Qualifying morphological features/ key physical characteristics	Where assessed in ES
Special Areas of Conservation (SACs)		
Bristol Channel Approaches	N/A (Harbour porpoise)	**Chapter 21 Marine Mammals**
West Wales Marine	N/A (Harbour porpoise)	**Chapter 21 Marine Mammals**
Limestone Coast of South West Wales	Vegetated sea cliffs of the Atlantic and Baltic Coasts, Fixed coastal dunes, and submerged/partially submerged sea caves	**Chapter 08 Ecology and Biodiversity**
Pembrokeshire Marine	Estuaries, Large shallow inlets and bays, reefs, sandbanks, mudflats, sandflats, coastal lagoons and submerged/partially submerged sea caves	**Chapter 19 Benthic Ecology**
Lundy	Reefs, sandbanks, and submerged/partially submerged sea caves	**Chapter 19 Benthic Ecology**
Special Areas of Protection (SPAs)		
Castlemartin Coast	Vegetated sea cliffs of the Atlantic and Baltic Coasts, Fixed coastal dunes, and submerged/partially submerged sea caves	**Chapter 22 Ornithology**
Skomer, Skokholm and the Sea of Pembrokeshire	Rocky coast/ shore, fringed by bays, promontories, cliffs	**Chapter 22 Ornithology**
Grassholm	Rocky coast/ shore	**Chapter 22 Ornithology**
Marine Conservation Zones (MCZs)		

Site	Qualifying morphological features/ key physical characteristics	Where assessed in ES
Lundy	Reefs, sandbanks, and submerged/partially submerged sea caves	**Chapter 19 Benthic Ecology**
Northwest of Lundy	Subtidal coarse sediment	**Chapter 19 Benthic Ecology**
Skomer	Rocky coast/ shore, fringed by bays, promontories, cliffs	**Chapter 19 Benthic Ecology**
Site of Special Scientific Interest (SSSI)		
Broomhill Burrows	Sand dunes, shingle ridge and rocky outcrops. (Cliff and foreshore rock outcrops of geological importance)	**Chapter 08 Ecology and Biodiversity**
Castlemartin Range	Limestone cliffs, dunes	**Chapter 08 Ecology and Biodiversity**
Stackpole	Limestone cliffs, dunes	**Chapter 08 Ecology and Biodiversity**
Angle Peninsula Coast	intertidal rock, sand, and gravel habitats and communities, particularly rockpools, caves, tide-swept and under-boulder communities	**Chapter 08 Ecology and Biodiversity; Chapter 19 Benthic Ecology**

17.6 Scope of the Assessment

81. An EIA Scoping Report for the proposed Project was submitted to NRW Marine Licensing Team (MLT) in April 2022. The Scoping Report was also shared with relevant consultees, inviting comment on the proposed approach adopted by the Applicant. A Scoping Opinion was provided to the Applicant by NRW MLT in July 2022. Based on the Scoping Opinion received and further consultation undertaken, potential impacts on the Physical Environment scoped into the assessment are listed below in **Table 17-14**.

82. As set out in **Section 17.4.117.4,** this assessment considers the design parameters of the proposed Project which are predicted to result in the greatest environmental impact, known as the 'realistic worst case scenario'. The realistic worst case scenario represents, for any given receptor and potential impact on that receptor, various options in the Design Envelope that would result in the greatest potential for change to the receptor in question. Given that the realistic worst case scenario is based on the design option (or combination of options) that represents the greatest potential for change, confidence can be held that the development of any alternative options within the design parameters will give rise to effects no greater or worse than those included in this impact assessment.

83. Accordingly, the design scenarios identified in **Table 17-14** have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group within the Study Area. These scenarios have been selected from the details provided in **Chapter 04: Description of the Proposed Project**.

Table 17-14. Design Envelope Parameters Relevant to the Physical Environment Assessments

Potential impact	Design scenario	Justification
Construction		
Potential Increases in SSC and Associated Changes to Seabed Substrate (Pathway)	Drilling for anchor installation - Maximum number of drilled pile anchors: 80 (max foundations = 10; max anchors per foundation = 8) - Maximum dimensions of drilled pile section: 3.5 m diameter, 55 m max penetration depth. - Maximum volume of drill arisings per pile: 529 m^3 - Maximum volume of drill arisings all piles: 42,300 m^3 Inter-array cable installation - Maximum number of IACs: 11 - Maximum total length of IAC in contact with seabed: 17.1 km (11 IACs, each with an average length of 1.6 km) - Trench dimensions: up to 25 m wide (at seabed); up to 1.5 m deep (average); 'V' shape profile - Excavation method: Jetting, Mass Flow Excavation (MFE), Ploughing / Pre-Ploughing, Trenching / Pre-Trenching (incl. dredging, cutting) Offshore export cable installation - Maximum number of export cables: 2 - Maximum total length of each export cable: 49 km - Trench dimensions: up to 25 m wide (at seabed); 0.8 to 3 m deep (average); 'V' shape profile, target depth of burial 1.2m and minimum burial depth of 0.8m (but spatially variable along OfECC) - Excavation method: [as above for inter-array]	Corresponds to (a combination of) the greatest amount of material disturbed, the largest dimensions and number of pile anchors, the largest dimensions of trenching, the greatest depth of seabed lowering/levelling and the greatest geographical extent of the impact. Boulder clearance is not considered here as the activity does not represent a Realistic Worst Case (RWC) in terms of potential increases in SSC and associated changes to seabed substrate.

Potential impact	Design scenario	Justification
	<u>Sandwave levelling (within OfECC)</u> - Length total (per cable): 10,351 m - Total area of sandwave levelling per cable (inc. 20% contingency): 310,524 m^2 - Volume displaced (for both cables): 900,520 m^3 (assumed average width of disturbance of 25 m and average sandwave crest depth of 2.9 m.) - Levelling method: Dredging vessel with disposal within OfECC <u>HDD exit pit excavation</u> - Number of exit pits: 2 - Exit pit dimensions: ≤10 m long by 5 m wide by 3 m deep (100 m^2 footprint for both pits combined) - 150 m^3 of excavated material for each pit (300 m^3 for both pits combined) <u>HDD drilling fluid release (at landfall)</u> - Number of exit/release events: up to 2 - Up to 1,700 m^3 drilling mud generated - Wet punch-out (i.e. exit depth of HDD point offshore 3-8 m LAT)	
Potential Changes to Sediment Transport Systems by Changes in Wave and Current Climate (Pathway)	N/A	The RWC for blockage associated with partially installed cable protection, floating turbines and / or the presence of anchoring structures cannot readily be defined. However, it will be no greater than that set out for the fully built/ operational proposed Project. Refer to the operation section of this table (below).

Potential impact	Design scenario	Justification
Potential Changes to the Morphology of the Seabed Including from Scour (Receptor)	Sandwave levelling (within OfECC) - Length total 10,351 m x width of 25 m (volume total for both cables is 900,520 m^3) - Total area of sandwave levelling disturbance is 310,524 m^2 - Levelling method: Dredging vessel	Corresponds to (a combination of) the greatest amount of material disturbed, the greatest depth of seabed lowering and the geographical extent of the impact
Potential Changes in Morphology of the Coast (receptor)	HDD installation techniques - Number of routes: 2 (subtidal punch-out with exit depth of HDD point offshore 3 m to 8 m below LAT) - Installation duration: 24 to 64 weeks (for 2 HDD cable installations) - Number of nearshore exit pits: 2 - Exit pit dimensions: ≤10 m long by 5 m wide by 3 m deep - 150 m^3 of excavated material for each pit (300 m^3 for both pits combined) - Max duration of works: up to 64 weeks (approx. 15 months) Cable protection - 5 m width of berm and 1.5 m height. - Rock protection at HDD exit point = 250 m^2. (based on x 2 cables, each 25 m and 5 m wide).	Sets out construction activities that give rise to the greatest (direct) disturbance to the beach and provide the greatest potential to interact with coastal processes responsible for maintaining the baseline form and function of the beach.
Operation and maintenance		
Potential Changes to the Sediment Transport System by Changes in Wave and Current Climate (Pathway)	***Wave blockage*** Floating substructures - Concrete barge (rectangular shape) - Maximum number of units: 10 - Maximum length of sides: 60 m width x 120 m length	The worst case for wave blockage is represented by the floating foundation substructure presenting the greatest blockage in the upper water column (i.e. at/ close to the sea surface) The worst case for hydrodynamic blockage is represented by the combination of foundation type, mooring

Potential impact	Design scenario	Justification
	- Minimum separation between WTG (tower centre to tower centre): 1000 m ***Hydrodynamic blockage*** Floating substructures - Concrete Semi-Submersible (Triangle) - Maximum number of units: 10 - Maximum width per element: 14 m (4 elements in total) - Maximum draught (during operation): 20 m - Minimum separation between WTG (tower centre to tower centre): 1000 m Mooring system and Electrical cables - Maximum number of mooring lines present in the water column: 80 mooring lines (10 units x 8 lines per foundation); - Up to 11 inter array electrical cables - Mooring line (wire / rope / cable): Diameter ≤320 mm - Diameter of electrical cable: 200 mm Anchors - Drilled anchors (8 per foundation; up to 80 in total) - Maximum diameter: 3.5 m - Maximum height above seabed: 4 m	configuration, anchor system and electrical cabling which is associated with the largest combined overall blockage within the water column. A short length of the ground chain, including clump weights, will be suspended above the seabed at the end of each mooring line. This near-bed section of each mooring will have only limited interaction with waves or currents.
Potential Changes to the Morphology of the Seabed Including from Scour (Receptor)	Mooring system and electrical cables - Maximum number of mooring lines present in the water column: 80 mooring lines (10 units x 8 lines per foundation);	See above for justification of number of moorings and electrical cables.

Potential impact	Design scenario	Justification
	- Mooring line (wire/ rope/ cable): Diameter ≤320 mm - Swept area per inter-array cable: 80,000 m^2 in total (10 foundations with 2 cables per foundation. Max 4,000 m^2 swept area per cable) - Anchor chain disturbance footprint: up to 34,880 m^2 (100 m chain on seabed = 436 m^2 per mooring line, x 8 max no. of mooring lines per turbine x max 10 turbines) - Dimensions of individual clump weights: 2 m long x 2 m wide x 1 m high. (Up to 25 mooring clumps per line, max. 8 mooring lines per floating substructure therefore 2000 mooring clumps in total) - Total Seabed Footprint of Mooring Clumps: 8000 m^2 (2 m x 2 m x 2000 clump weights) - Diameter of electrical cable: up to 200 mm <u>Anchors</u> - Drilled anchors (8 per foundation; up to 80 in total) - Maximum diameter: 3.5 m - Maximum height above seabed: 4 m <u>Cable protection</u> - 5m width of berm and 1.5 m height. - Total length of Array Area cable protection: 3,132 m. - Total length of OfECC cable protection (including cable crossings): 2,400 m of cable protection per cable (4.9% of total length); up to 11,000 m of iron articulated pipe protection per cable (22.4% of total (49 km) length, diameter 500 mm) between KP38 and KP48.	

Potential impact	Design scenario	Justification
	- 5 cable crossings, 4 of which requiring cable protection 1 (Greenlink) crossed via HDD - Length of protection/ mattressing at each crossing point: 200 m (100 m either side of cable) for protection proposed for each crossing (total of 800m) - Target separation distance between cables: 50 m	
Potential Changes in Morphology of the Coast (Receptor)	<u>Cable protection (nearshore areas)</u> - Subtidal areas: ≤1.5 m height - Duration: 30 years (proposed Project lifespan) <u>HDD installation techniques</u> - Rock protection at HDD exit point = 250 m^2 (based on x 2 cables, each 25 m and 5 m wide. (Berm height 1.5 m)	Maximum permanent change of coastal morphology resulting from blockage of waves
Potential Increases in SSC (Pathway) Via Cable Repairs/Remediation	Up to 5 cable repairs assumed in the lifetime of the proposed Project	The RWC for sediment disturbance will be no greater than that set out for the construction phase of the proposed Project. Refer to the construction section of this table (above).
Decommissioning		
Potential Increases in SSC (Pathway). Potential Changes to Sediment Transport System by Changes in Wave and Current (Pathway) Potential Changes to the Morphology of the Seabed Including From Scour (Receptor)	- Total removal of infrastructure including buried cables and cable protection - Decommissioning Plan will be prepared during the operational phase and will be consulted on (for both offshore and onshore infrastructure) before being submitted for approval to NRW MLT. - Decommissioning activities lasting up to 2 years	Maximum disturbance of seabed sediments and morphology

Potential impact	Design scenario	Justification
Potential Changes in Morphology and Sediment Transport at the Coast (Receptor)		

17.6.4. *Impacts Scoped Out of Assessment*

84. Based on the baseline environment information currently available and the proposed Project description (outlined in **Chapter 04: Description of the Proposed Project**), no impacts have been scoped out at this stage, principally due to the potential for indirect impacts on other topic receptors.

17.6.5. *Assessment Assumptions and Limitations*

85. The assessments have included the development and use sediment transport models. These models are robust tools but are subject to a number of assumptions. These include the input parameters (using a representative sediment grain size for sediment transport for example) as well as uncertainty in the underpinning datasets (e.g., hydrodynamic and bathymetry data). Such uncertainty is managed in the design of the modelling study and the interpretation of the model results in the context of the baseline and using expert judgement.

86. Other assessment assumptions include:

- Third party and publicly available information is assumed correct at the time of publication;
- Baseline conditions are accurate at the time of physical surveys but due to the dynamic nature of the environment, conditions may change before or during the installation and operation phases of the proposed Project (although the effects of the natural variation are included in the appraisal); and
- The proposed Project will not be subject to force majeure events resulting in a significant shift from the existing baseline.

17.7 Embedded Mitigation, Management Plans and Best Practice

87. As part of the project design process, a number of designed-in measures have been proposed to reduce the potential for impacts on the physical environment (see **Table 17-15**). The design of the proposed Project therefore includes embedded mitigation measures and reference to various management plans that will be produced as conditions of consent and which will further mitigate potential impacts. This approach has been employed in order to demonstrate commitment to mitigation measures by including them in the design of the proposed Project and as such these measures have been considered within the assessment presented in **Section 17.8** below. Assessment of sensitivity, magnitude and therefore significance includes the implementation of these measures.

Table 17-15. Mitigation measures, management plans and best practice adopted as part of the proposed Project

Embedded Mitigation Measures, Management Plans and Best Practice	Justification
Design Embedded Measures	
Careful routing of the OfECC within the cable corridor	Avoidance of sensitive features including Turbot Bank and St Gowan Shoal
Use of HDD at the Landfall	Minimise disturbance at the nearshore and beach
Cable burial as the preferred means of cable protection (where practicable)	Minimise the requirement for surface laid protection
All material that is dredged from the seabed will be disposed of close to the dredge location	Ensure material is retained within the local sediment transport system
Management Plans	

Embedded Mitigation Measures, Management Plans and Best Practice	Justification
Development of, and adherence to, a Cable Specification and Installation Plan (CSIP) post consent (if granted)	Sets out measures to minimise adverse effects to potentially sensitive receptors

17.8 Assessment of Environmental Effects

88. The impacts and effects (both beneficial and adverse) associated with the construction, operation and maintenance and decommissioning of the proposed Project is outlined in the sections below. The assessments consider the embedded mitigation measures described in **Section 17.7**.

17.8.1. Construction Effects

Potential Increases in SSC and Associated Changes to Seabed Substrate (Pathway)

89. During construction of the proposed Project, sediment will be disturbed and released into the water column. This will give rise to suspended sediment plumes and localised changes in bed levels as material settles out of suspension. The main activities resulting in disturbance of seabed sediments are:

- Drill arisings released at the water surface during drilling for pile anchors;
- Dredging including overspill and local dredge spoil disposal for localised sandwave levelling;
- Pre-lay cable trenching or cable installation using a plough, jetting or MFE tool(s) at the seabed;
- Drilling fluid release associated with HDD at the landfall; and
- Excavation of HDD exits pits near landfall.

90. Details of the RWC scenario for sediment disturbance events are set out in **Table 17-14**. The potential changes to SSC and associated sediment deposition caused by these activities have been assessed using numerical spreadsheet models, as described for Erebus (Blue Gem Wind Ltd, 2021a). The outputs from this model are consistent with the results of observational (monitoring) evidence, other spreadsheet modelling and particle tracking based numerical modelling of analogous activities (e.g., BERR, 2008; TEDA, 2012; Navitus Bay Development Ltd, 2014; Awel y Môr Offshore Wind Farm Ltd, 2022; Erebus Floating Offshore Wind Farm, 2022).

Magnitude of impact

91. Physical environment receptors are entirely insensitive to elevated levels of SSC and as such, it is not appropriate to carry out an assessment of significance which considers the magnitude of impact to a receptor and the sensitivity of that receptor. Instead, this section focuses on describing the spatial and temporal characteristics of potential sediment plumes, which are a 'pathway' connecting an impact source (i.e. construction activities) with potential receptors (such as designated benthic habitats).

92. Sediment disturbed and released into the water column during the construction, operational (cable repair/remediation events) and decommissioning phases will settle downwards at a rate depending upon its grain size. During settling, the sediment plume will be advected away from the point of release by any currents that are present and will be dispersed laterally by turbulence within the water column. The horizontal advection distance will be related to the flow speed and the physical properties of the sediment. The maximum near-bed level of SSC

is expected to be found where the main body of the settling plume of sediment reaches the seabed.

93. Coarse grained sediments (i.e., sand/ gravel) will behave differently to fine grained sediments (i.e., silt/ clay) when released into the water column. The disturbance of coarse grained or consolidated material is likely to give rise to high SSCs in the vicinity of the release location but is also likely to settle out of suspension quickly (e.g., in the order of seconds to minutes) so any sediment plumes are likely to be localised to both the time and location of the release. In contrast, fine grained material will tend to remain in suspension for a longer period of time (in the order of hours to days), potentially resulting in an increase in SSC over a larger area, at a progressively reduced concentration, due to advection and dispersion from the original release location.

94. Similar differences are expected when considering any resulting changes in bed level due to resettlement of the material in suspension. Coarser material will tend to give rise to thicker but more localised changes in bed levels whereas fine grained material may give rise to smaller changes in bed levels over a wider area. The exact pattern of re-deposition of sediment to the seabed will depend on the actual combination of construction methods which are used and environmental conditions at the time of the event which will be variable. The total volume of sediment which is disturbed is, however, known with greater certainty and a range of potential combinations of deposit shape, thickness and area (corresponding to the same total volume) can be more reliably provided, as a subset of all possible combinations. The actual magnitude and spatial extent of impacts will depend in practice on a range of factors, such as:

- The actual total volumes and rates of sediment disturbance;
- The local water depth and current speed at the time of the activity;
- The local sediment type and grain size distribution;
- The local seabed topography and slopes, etc.

95. There will be a wide range of possible combinations of these factors and so it is not possible to predict specific dimensions with complete certainty. However, although there is an element of uncertainty a realistic worst case scenario has been considered and therefore no effects will be greater than described and assessed here: the approach takes into consideration a range of realistic combinations, based on conservatively representative location (environmental) and proposed Project (MDS) specific information, including a range of water depths, heights of sediment ejection/initial resuspension, and sediment types.

96. This wide range of results can be summarised broadly in terms of four main zones of effect, based on the distance from the activity causing sediment disturbance, as illustrated in **Figure 17-23**. The zones of effect and typical SSC patterns over distance and time are summarised as follows:

- 0 m to 50 m – zone of highest SSC increase and greatest likely thickness of deposition. All gravel sized sediment is likely deposited in this zone, along with a large proportion of sands that are not resuspended high into the water column, and most or all dredge spoil in the active phase. Plume dimensions and SSC, and deposit extent and thickness, are primarily controlled by the volume of sediment released and the manner in which the deposit settles;
  - o At the time of active disturbance - very high SSC increase (tens to hundreds of thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following end of disturbance; sands and gravels may deposit in local

thicknesses of tens of centimetres to several metres; fine sediment is unlikely to deposit in measurable thickness;

 - Thirty minutes to one hour after the end of active disturbance - intermediate conditions, with progressively lower SSC than during active disturbance due to resettlement, advection and dispersion; and
 - More than one hour after the end of active disturbance – no change to SSC; no measurable ongoing deposition.

- 50 m to 500 m – zone of measurable SSC increase and measurable but lesser thickness of deposition. Mainly sands that are released or resuspended higher in the water column and resettling to the seabed whilst being advected by ambient tidal currents. Plume dimensions and SSC, and deposit extent and thickness, are primarily controlled by the volume of sediment released, the height of resuspension or release above the seabed, and the ambient current speed and direction at the time;
    - At the time of active disturbance - high SSC increase (hundreds to low thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following end of disturbance; sands and gravels may deposit in local thicknesses of up to tens of centimetres; fine sediment is unlikely to deposit in measurable thickness;
    - Thirty minutes to one hour after the end of active disturbance - intermediate conditions, with progressively lower SSC than during active disturbance due to resettlement, advection and dispersion; and
    - more than one hour after end of active disturbance – no change to SSC; no measurable ongoing deposition.
- 500 m to the tidal excursion buffer distance (spatially variable, see **Figure 17-23**) – zone of lesser but measurable SSC increase and no measurable thickness of deposition. Mainly fines (i.e. silt and clay sized material) that are maintained in suspension for more than one tidal cycle and are advected by ambient tidal currents. Plume dimensions and SSC are primarily controlled by the volume of sediment released, the patterns of current speed and direction at the place and time of release and where the plume moves to over the following 24 hours;
    - At the time of active disturbance – low to intermediate SSC increase (tens to low hundreds of mg/l) as a result of any remaining fines in suspension, only within a narrow plume (tens to a few hundreds of metres wide, SSC decreasing rapidly by dispersion to ambient values within one day after the end of active disturbance; fine sediment is unlikely to deposit in measurable thickness;
    - One to six hours after end of active disturbance – decreasing to low SSC increase (tens of mg/l); fine sediment is unlikely to deposit in measurable thickness;
    - Six to 24 hours after end of active disturbance – decreasing gradually through dispersion to background SSC (no measurable local increase); fine sediment is unlikely to deposit in measurable thickness; and
    - 24 to 48+ hours after end of active disturbance - no measurable change from baseline SSC.
- Beyond the tidal excursion buffer distance or anywhere not tidally aligned to the active sediment disturbance activity – there is no expected impact or change to SSC nor a measurable sediment deposition under the realistic worst case scenario. This holds for any release location and combination of sediment disturbance activities within the Array Area and/or OfECC.

97. **Figure 17-23** provides a summary of the maximum spatial extent of these zones in relation to the Offshore Development Area Boundary, including the Array Area and OfECC. The figure also provides an example schematic illustration of the footprint of effect for a single occurrence of an activity causing local sediment disturbance. In practice the MDS impact will be a limited number of discrete areas of effect (similar to that shown in the example), separated by areas of reduced impact.

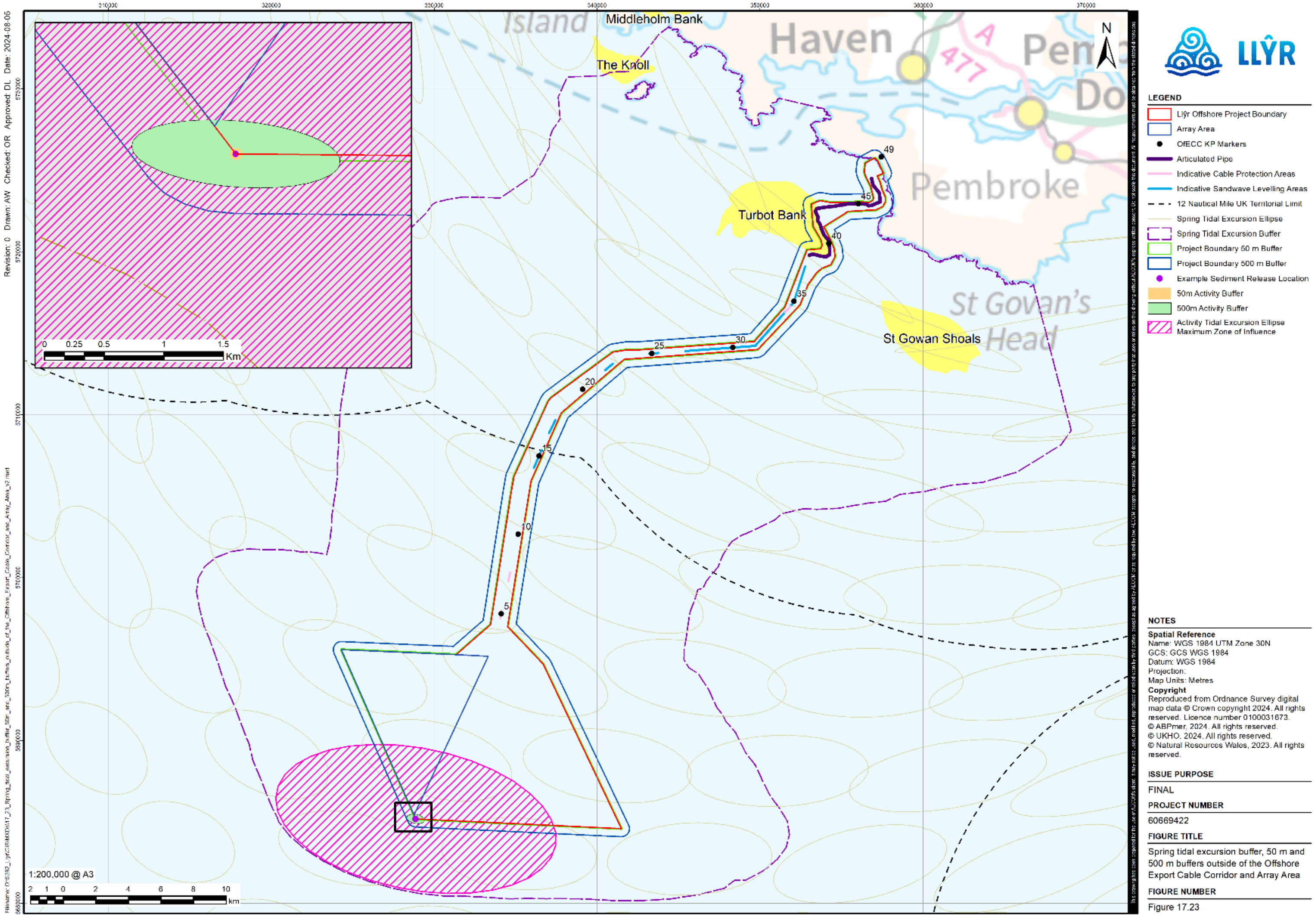


Figure 17-23. Spring tidal excursion buffer, 50 m and 500 m buffers outside of the Offshore Export Cable Corridor and Array Area and sediment SSC effect and deposition footprints associated with sediment disturbance at an example location at the outer edge the proposed Project boundary

98. A bespoke hydrodynamic (tide only) and sediment plume model was previously developed to assess the potential impact of fine sediment plumes on maerl beds in Milford Haven arising from Erebus cable installation activities. The model was based upon the calibrated ABPmer SEASTATES Tide and Surge Hindcast model (ABPmer, 2017), with results reported in Blue Gem Wind Ltd (2022). The sediment plume modelling showed that:

- Under neap tidal conditions, modelled increases in SSC within the area of live Maerl beds are negligible or zero at any time for all release scenarios considered.
- Under spring tidal conditions, cable trenching in the approaches to Milford Haven can cause a weak sediment plume to extend into the estuary and overlap with the known location of Maerl beds. However, the maximum modelled increase in SSC within the area of live Maerl beds is approximately 30 mg/l, with this peak effect only briefly observed (order of 10 minutes).
- Under all spring/neap release scenarios, the potential for measurable deposition of sediment on the Maerl Beds is negligible or zero.

99. Since the proposed Project OfECC is to the east of the Erebus cable corridor (and therefore further away from the Maerl Beds in Milford Haven), it follows that the potential for impacts to these features is also negligible or zero.

Sensitivity of the receptor

100. All of the identified physical environment receptors are insensitive to elevated levels of SSC and have therefore not been assigned a sensitivity rating.

Significance of the effect

101. All the identified physical environment receptors are insensitive to elevated levels of SSC. However, the potential for these changes to impact other EIA receptor groups is considered elsewhere within the ES, in particular:

- **Chapter 18: Marine Water Quality;**
- **Chapter 19: Benthic Ecology;**
- **Chapter 20: Fish & Shellfish Ecology;**
- **Chapter 21: Marine Mammals; and**
- **Chapter 22: Ornithology.**

Potential Changes to Sediment Transport Systems by Changes in Wave and Current Climate (Pathway)

102. The installation of offshore export cable protection, floating platform foundations with WTGs and/or the presence of anchoring structures all have the potential to result in a localised blockage of waves, tides and sediment transport. This blockage will commence when offshore construction begins, increasing incrementally up to the RWC, which is represented by the fully operational proposed Project. Construction of the proposed Project is expected to commence in 2027 and be complete within approximately two years.

103. All changes to sediment transport systems due to modification of the wave and current climate will be no greater than that identified for the operational phase (see **Section 17.8.2**) and, therefore, is not considered further here.

Potential Changes to the Morphology of the Seabed Including from Scour (Receptor)

104. The presence of anchoring structures and offshore export cable protection measures both have the potential to impact seabed morphology. This impact will commence when offshore

construction begins, increasing incrementally up to the RWC which is represented by the fully operational proposed Project. However, morphological change arising from the presence of these structures will be no greater than that identified for the operational phase (see **Paragraph 177 et seq.**) and, therefore, is not considered further here.

105. In addition to the above, some levelling of sandwaves is expected during the construction phase which has the potential to alter the local seabed morphology. This would be achieved by dredging (**Table 17-14**), although it is noted that any sediment removed from the seabed would, preferentially, be deposited close to the dredge location. The potential extent of change and likely timescales over which feature recovery may occur is considered further in this section.

Magnitude of impact

106. A detailed analysis and discussion of sandwave clearance and recovery, including numerous examples of pre-dredge, post-dredge and partial recovery surveys of the Race Bank Offshore Wind Farm was produced as part of the Habitats Regulation Appraisal (HRA) for the Hornsea Project Three Offshore Wind Farm (ABPmer, 2018b). Similar analysis was also undertaken for the Norfolk Vanguard and Norfolk Boreas export cable route (ABPmer, 2018c).

107. The assessment below draws on, and is consistent with, the evidence and conclusions presented in the above references with regards to the observed underlying mechanisms for sandwave recovery, whilst acknowledging and accounting for differences in the environmental setting that might affect the rate of recovery.

108. Similarities between these projects and the proposed Project, include the sediment type (predominantly sandy) and general mobility of sediments (sediments are regularly mobilised), peak current speeds (1 m/s to 1.25 m/s on a mean spring tide for Race Bank, compared to 0.8 m/s to 1.2 m/s for the locations of sandwaves to be potentially levelled in the OfECC). Differences mainly relate to water depth (10 m for Race Bank, but 45 to 60 m for the proposed Project OfECC). The greater depths associated within the proposed Project will mainly act to reduce the contribution of any wave action, and the effectiveness of currents, to cause sediment mobility and bedform evolution in the OfECC.

109. A summary of the available evidence is as follows:

- Where bedforms are present and mobile, this is the natural state of that environment; the processes that are active are conducive to the development and dynamic evolution of such features. Local perturbations to existing sandwaves that do not change the fundamental conditions of the setting (tidal and wave regime, volume of mobile sediment present) will continue to evolve through the same naturally occurring processes and will therefore recover towards a new equilibrium state over time;
- Bedform recovery occurs as a result of the ongoing sediment transport processes (local transport of sediment volume into the levelled area that is retained) and general bedform migration through the system. Estimated recovery rates for sandwaves at Race Bank were mainly the result of local sediment accretion and were projected to occur in the order of several years under similar tidal forcing conditions but based on a smaller displaced volume and in shallower water depths; and
- The sandwave levelling which is anticipated to be required for the proposed Project is not likely to pose a barrier to sediment transport within, or to locations beyond, the wider sandwave/sandbank system.

110. The volume of material to be displaced from individual sandwaves will vary according to the local dimensions of the sandwave (height, length and shape) and the level to which the

sandwave must be reduced (also accounting for stable sediment slope angles and the capabilities and requirements of the cable burial tool being used). Based on the available geophysical data, it is anticipated that the bedforms requiring localised levelling for the proposed Project are likely to be up to circa 6 m in height; the dimensions of the bedform in the actually levelled section may be smaller depending on the final cable routing. The RWC for levelling corridor dimensions and sediment disturbance by sandwave levelling prior to cable installation are set out in **Table 17-14,** with the locations for potential sandwave levelling activities shown in **Figure 17-23**.

111. The sediments comprising the sandwave features will be predominantly sand, although a small proportion of fines and gravel (each comprising up to <5% to 10%) may also be present. Individual sandwaves will require localised levelling by dredging to complete the required 30 m wide corridor. If dredging is undertaken, the preference is for the dredge spoil to be returned to the seabed in the vicinity of the dredged area.

112. Localised sandwave levelling totalling approximately 15,000 m^3 for individual sandwaves is proposed in a few locations around the middle of the OfECC (between approximately KP 14 and KP 37) (**Figure 17-23**). Larger bedforms such as sandwaves are not generally present in the Array Area and so the requirement for levelling in the Array Area is likely to be very limited. Localised levelling if and where required in the Array Area will be associated with the installation of mooring lines, anchors and offshore array cables; and/or in the OfECC will be associated with export cable burial. Whilst the total volume of sandwave levelling may be up to circa 900,520 m^3, the number of dredging cycles required and changes to SSC and seabed deposition associated with dredging for the individual sandwaves is likely to be small - (one to two cycles for a representative 11,000 m^3 dredger to dredge up to the full amount of around 15,000 m^3 per sandwave). It is noted her that this figure is conservative: it is expected that this volume will be reduced following more detailed geophysical and geotechnical analysis along with micro-siting within the OfECC.

113. The tidal current regime (peak current speeds on a mean spring tide of 0.7 m/s to 1.3 m/s along the OfECC) is sufficiently strong at and around each location requiring sandwave levelling to cause mobility of sand on a regular basis. Although direct evidence of sandwave migration from historical bathymetry difference mapping is inconclusive, the asymmetry of many of the mapped sandwaves does suggest at least some are actively migrating (**Figure 17-14**).

114. The tidal current regime will not measurably change as a result of the localised levelling, or as a result of any other aspect of the proposed Project. The volume of sediment available in each system will be locally redistributed by the levelling (carried out by a dredger) but will not change in an overall net sense. As the controlling factors will also not change, it the levelled areas and sandwave features have the potential to recover over time to a new (dynamically evolving) natural state.

115. The levelled area is considered to be ‘recovered’ in terms of form and function once the local crest level has re-established to a form that is within the range of natural variability observed in the other similarly sized surrounding bedforms, which may be of different dimensions than the original feature.

116. In the Array Area, sediments are regularly mobile and the megaripples that are present are considered likely to recover, reform and continue to migrate in a relatively short time period (weeks to months).

117. The rate and timescale of recovery for larger sandwave bedforms in the OfECC will vary in proportion to the rate of sediment transport and accumulation. Faster infill and recovery rates will be associated with periods of higher local flow speeds and more frequent wave influence at the seabed. The following factors will all influence the rate of recovery:

- In the OfECC: sediments are increasingly mobile towards the coast (up to 0.36 m^3/m/hr to 3.6 m^3/m/hr during peak spring tidal currents);
- The width of the dredged corridor (estimated in the order of 30 m); and
- The volume of sediment that is displaced (proportional to the local height and length of individual sandwave features) in comparison to the local rate of sediment transport.

118. The exact timescale for sandwave recovery cannot be calculated with certainty. Based only on the overall rate of observed bedform migration (which is not the main or only mechanism for recovery and is proportional to the long-term net sediment transport rate), the timescale for recovery in the more energetic parts of the OfECC is estimated to be in the order of 10 years or more. However, short-term sediment mobility will also contribute to local sandwave recovery, and these rates are known to be higher than negligible in these areas.

119. A shorter estimated timescale is obtained when considering the instantaneous rate of transport during higher flow periods. As shown by the detailed sand transport modelling, instantaneous transport rates (increasing along the OfECC) of 0.36 m^3/m/hr to 3.6 m^3/m/hr may be active up to four times per day (at peak flood and ebb) for a few days either side of the peak of spring tides. At a representative mid-level rate of 1 m^3/m/hr, and assuming a representative 30 m wide corridor and a volume of 15,000 m^3 sediment displaced, it could take in the order of (15,000 m^3/[1 m^3/m/hr x 30 m x 4 hr/day x 4 days]) 37.5 spring tidal cycles (~1.5 years) to move the displaced volume of sediment back into the levelled area. The rate of transport and so the rate of recovery can be around three times faster (than the mid-level rate) in the vicinity of Turbot Bank but also around three times slower in the Array Area. The overall rate of recovery would also vary in proportion to the volume displaced (relative to the representative value of 15,000 m^3).

120. The recovery may be gradual or episodic. Rates of sandwave bedform recovery are likely to be relatively faster closer to the landfall (higher current speeds and shallower depths lead to greater and/or more frequent sediment mobility). Varying states of partial recovery will be achieved in a shorter timescale. As the recovery is due to natural processes of sediment transport, the nature of the seabed surface sediments in the recovering area will not be measurably different to that on the surrounding seabed and adjacent sections of undisturbed sandwave. In all locations, surficial sediments will continue to be mobilised at the natural ambient rate and direction under sufficiently energetic current and wave conditions, with the associated development and migration of smaller (e.g., ripple and mega-ripple) bedforms. Where the dredge spoil is returned to the seabed in the vicinity of the dredged area, the volume and supply of sediment in the local system is not changed.

121. The final shape of the bedform following recovery may be similar to its original condition (e.g., rebuilding a single crest feature, although likely displaced in the direction of natural migration) or it might change (e.g., a single crest feature might bifurcate or merge with another nearby bedform). All such possible outcomes are consistent with the natural processes and bedform configurations that are already present in the wider Study Area and would not adversely affect the onward form and function of the individual bedform features.

122. The levelled areas are not considered likely to create a barrier to onward sediment transport. Evidence from aggregate dredging activities indicates that if any changes occur to the flow

conditions or wave regime, these are localised in close proximity to the dredge pocket (with widths and lengths of several kilometres) (e.g. TEDA, 2012). The proposed construction activities will be at a much smaller scale and footprint, with trench widths expected to be in the order of up to 25 m, in water depths of at least 30 m. This means there is likely to be little to no influence on the flow or wave regime, which in turn means little to no change to the regional scale sediment transport processes across the Array Area and OfECC.

123. On the basis of the discussion in this section, the magnitude of impact to designated areas of seabed resulting from levelling is considered **small**. This is because although direct impacts to the seabed will occur within a small footprint, the seabed is expected to recover over time in response to:

- The occurrence of short-term seabed mobility: this will occur during peak flood and ebb currents on spring tides in all locations, but also more frequently and at other times in parts of the OfECC closer to the coast; and
- Observed natural migration of bedforms in some locations with the OfECC.

Sensitivity of the receptor

124. The receptors under consideration are the Annex I sandbanks within and around the OfECC at Turbot Bank and St Gowan Shoals, and the seabed areas within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA. Preliminary design investigations suggest that some sandwave levelling may potentially be required along a 2.7 km stretch of the OfECC within the Pembrokeshire Marine SAC. However, this is regarded as a highly conservative RWC estimate and it is expected that the requirement will be greatly reduced following the acquisition of nearshore Project specific geophysical data. Although internationally designated, the seabed in these areas is highly dynamic and is assessed to have some capacity to recover from disturbance associated with sandwave levelling. Accordingly, the sensitivity of the receptor is assessed to be of **medium**.

Significance of the effect

125. The sensitivity of the receptor (i.e. Turbot Bank, St Gowan Shoals and the seabed areas within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA) is considered to be **medium** and the magnitude of the impact is assessed as **small**. Therefore, using the assessment matrix set out in **Table 17-8**, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Additional Mitigation and Residual Effect

126. None of the effects identified are major or moderate adverse (significant in EIA terms). Therefore, no additional mitigation is required and the significance of residual effects remain as detailed above.

Potential Changes in Morphology of the Coast (receptor)

127. The offshore export cable will make landfall at Freshwater West - an open coast sandy beach constrained by a rocky coast to the north, and a shingle bank and coastal dune system inland (**Figure 17-17**).

128. The preferred cable installation method at the landfall is HDD. Both the Excavation of HDD exit pits and HDD drilling operations are source/pathways via which the morphology of the landfall at Freshwater West that could theoretically be impacted. These are discussed individually, below. It is also noted that changes to the nearshore wave regime/sediment

transport due to the presence of cable protection measures is considered separately, within the Operations and Maintenance phase (**Paragraph 141 et seq.**).

Magnitude of impact

129. Excavation of HDD exit pits: The offshore export cable (prior to bundling in the OfECC) may require up to two exit pits to be excavated at the punch-out location. The HDD underwater exit pits will be located (approximately) 3 m to 8 m below LAT assumed to be (up to) 10 m long by 5 m wide by 3 m deep, with works lasting between 24 to 64 weeks (i.e. up to circa 15 months).

130. The potential mechanisms by which the presence of the HDD exit pits could theoretically impact the coast at the landfall are principally via the modification for waves and interception of sediment. Potential changes to the wave regime resulting from the presence of HDD exit pits in shallow subtidal areas are summarised as follows:

- Changes to short period, low amplitude wind waves will be largely immeasurable at all states of the tide as the likely depth and footprint dimensions of the temporary changes to water depths will be insufficient to measurably alter short wave characteristics;
- Longer period, higher amplitude storm waves could theoretically be more affected by the presence of the HDD exit pits, possibly resulting in some wave refraction. However, the dimensions of the HDD exit pits will be very small relative to the wavelengths of storm waves, greatly limiting the potential for measurable refraction. Any change to the wave regime will also diminish with increasing distance away from the HDD exit pits and at higher states of the tide when water depths are greater;
- The presence of the HDD exit pits could potentially enable wave energy associated with storm waves to propagate slightly further inshore at Freshwater West than would have been the case, as larger waves will shoal less, enabling them to remain marginally higher immediately in the lee of the HDD exit pits. However as larger waves travel inshore from the HDD exit pits across the beach, the shoreline gradient/water depths and rocky outcrops will increasingly become the limiting condition on wave form.

131. Given that the prevailing waves are from the southwest, the greatest change in wave climate will generally be to the northeast of the HDD exit pits. (Localised and minor changes to the wave regime may also occur to the east of the HDD exit pits as refraction of larger offshore southwesterly waves will mean these waves will have a slightly more westerly component as they arrive at the HDD exit pits). Depending on the exact location the cables make landfall, this area of potential change could either be the beach at Freshwater West or at Gravel Bay (which is flanked by rocky coastline with very limited surficial material) (**Figure 17-17**).

132. However, even with this refraction, it is probable that only some the waves reaching the beach at Freshwater West will have passed across the footprint of the HDD exit pits. Even allowing for the occurrence of waves passing across the footprint of the HDD exit pits, associated morphological change to the beach is expected to be limited:

- As larger waves travel inshore from the HDD exit pits towards the beach, the shoreline gradient/water depths and rocky outcrops will increasingly become the limiting condition on wave form;
- The extent of change will be greatly limited by the underlying hard rock geology which is generally at or close to the surface here; and
- Change across the upper beach will be associated with wave driven sediment transport at higher states of the tide. Importantly, owing to the macro tidal setting at the Landfall, water depths in the vicinity of the HDD exit pits will be approximately 10 m to 15 m,

since MHWS at the landfall is approximately 7 m above LAT (**Table 17-11**) and the HDD exit pits will occupy water depths between -3 m and -8 m LAT (**Figure 17-17**). In such depths of water, the potential for modification to waves as they propagate across the HDD exit pits will be very much reduced in comparison to equivalent size waves at low water. Accordingly, the wave energy reaching the upper beach will remain similar to baseline conditions with the HDD exit pits in place.

133. The HDD exit pits are expected to be located within the theoretical active shore profile, as defined by the 'Depth of Closure'. This means that during storm events, material removed from the beach may be transported across the location of the HDD exit pits. Given the likely high gradient of the pit side slopes, it is probable that any local material entering the pits could become trapped. This material would then not be available to replenish the beach during calmer conditions (when waves are generally constructive rather than destructive in nature).

134. The extent to which a very small section of beach morphology could potentially be altered by trapping of sediment will be dependent upon the frequency and magnitude of storms during the operational period of the HDD exit pits, and their dimensions. If the HDD exit pits were to be entirely infilled, this would represent up to only ~300 m³ (i.e. 10m length x 5 m width x 3 m depth for each exit pit) of material temporarily 'lost' from the local subtidal sedimentary system and beach. However, this is unlikely to happen given the relatively short duration of time that the HDD exit pits will be open and operational – (the landfall works are conservatively assumed to take up to 64 weeks), and their distance from the beach.

135. Given that winter storms may occur during the operational period of the HDD exit pits, it is theoretically possible that some maintenance dredging may be required prior to further access. Should this be required, any dredged material is likely to be deposited in reasonably close proximity the HDD exit pits. Accordingly, no mobile beach material will be lost from the local system but will instead remain available for beach resupply.

136. <u>HDD drilling operations:</u> HDD works will be used to create an underground conduit between the shallow subtidal (3 m to 8 m below LAT) and onshore parts of the route. HDD will cause minimal direct disturbance to the existing coastline because, if correctly designed, it will not interact directly with, or leave any infrastructure exposed, in the active parts of the beach (between the entry and exit points of the drill) and so will not impact upon littoral processes in these areas. Provided that the cables remain buried beyond the exit of the HDD, there is no possibility for the ducts to interact with, or have any effect on nearshore beach processes or morphology. The design of the HDD operation will take this into account.

137. On the basis of the discussion in this section, the magnitude of impact is predicted to be (no greater than) **small** for all of the impact source/pathways outlined in this section. Where direct disturbance takes place to the beach/shallow sub-tidal seabed (e.g., via trenching), the impact will only be present for the duration of the construction works and will therefore be temporary in nature. Indirect impacts of longer-term duration (e.g., any changes to the seabed/beach morphology arising from modification of the hydrodynamic/wave regime in response to cable protection) will be highly localised in nature.

Sensitivity of the receptor

138. The coast at Freshwater West is considered to be of **medium** sensitivity. Although nationally designated (within the Broomhill Burrows SSSI), the rocky outcrops will be insensitive to changes in waves, tides and sediment transport (as the rocky outcrops are resistant to erosion and there is little material to be transported). The pocket beach within the bay itself will be more sensitive to change (due to the fact sandy sediments are present which may be

mobilised by prevailing waves and tidal currents). However, it will have some capacity to recover from disturbance.

Significance of the effect

139. The overall level of effect significance has been determined by combining the assigned rating for receptor sensitivity (medium) and impact magnitude (small), as shown in **Table 17-8**. The result is a **minor adverse** effect, and therefore **not significant** in EIA terms.

Additional Mitigation and Residual Effect

140. None of effects identified above are major or moderate adverse (significant in EIA terms). Therefore, no additional mitigation is required and the significance of residual effects remain as detailed above.

17.8.2. Operation and Maintenance (O&M) Effects

Potential Changes to the Sediment Transport System by Changes in Wave and Current Climate (Pathway)

141. The presence of cable protection on the seabed, and the floating platforms with associated moorings and inter array cables in the water column, has the potential to present local blockage or resistance to the passage of currents and waves. The direct change is most likely to appear as a wake or shadow feature in the lee of the obstacle, where the baseline or ambient conditions may be modified. Due to the limited depth, height, or other dimensions of the obstacles being introduced as part of the proposed Project, relative to the water depths in the local and wider Study Area, changes are likely to be of limited scale and extent.

142. As a result, indirect changes to sediment transport rate and direction, controlled by the current and wave regimes, are also not likely (where measurable changes to currents and waves do not extend to the seabed), or would be limited to the same relatively small scale and local extent (up to tens of metres for cable protection and hundreds of metres for floating platforms).

143. The potential for offshore export cable protection to cause changes to coastal morphology at the landfall are assessed separately in this section (in **Table 17-16**).

Magnitude of impact

144. <u>Presence of cable protection within the Array Area and along the OfECC:</u> the offshore export cables will be buried to a target depth of burial of 1.2 m wherever possible, however in a worst-case scenario, up to 2,400 m (4.9%) of the offshore export cables have been assumed to require standard cable protection measures such as rock protection, grout bags or concrete mattresses, and an additional 6,200 m (12.7%) of the offshore export cables nearshore assumed to require iron articulated pipe protection. The locations where cable protection may be required are shown in **Figure 17-23.** It should be noted that these parameters represent the worst-case scenario and during detailed design the requirement for cable protection will be reviewed and presented in detail within the Cable Burial Risk Assessment (CBRA) developed post-consent.

145. A number of cable protection measures are under consideration, however, as a realistic worst case the form of a rock berm is assessed, with the realistic worst case parameters of up to 5 m base width. The height of the protection will be up to 1.5 m with sloped sides up to a flat berm crest. In practice, there is likely to be variations in these parameters for the final design, however, all design options under consideration will have dimensions less than these realistic

worst case assumptions assessed. Cable protection berm options typically comprise either concrete mattresses, rock placement or rock bags with clast sizes in the approximate range 2 cm to 30 cm.

146. The purpose of mechanical cable protection is to achieve the target depth of cover to provide protection to the cable from exposure, impact or abrasion damage, and to reduce risk of cable snagging by vessel anchors or fishing gear. It is also designed to prevent sediment scour that might otherwise undermine the cable resulting in free spanning sections. Where mechanical cable protection is applied, no scour will be caused by the protected cable itself, however, a small amount of localised secondary scour may form at the edges of the applied mechanical protection, in proportion to the overall dimensions and the clast size used.

147. Water depths are approximately 68 m to 72 m below LAT within the Array Area, approximately 50 m to 70 m below LAT in offshore areas of the OfECC, 40 m to 50 m below LAT in the approaches to Turbot Bank; and 10 to 20 m below LAT in the approaches to Freshwater West. Potential changes to physical environmental processes due to the presence of cable protection in these areas are described below. For the purpose of this description the type of mechanical cable protection used is rock placement, as described above.

148. **In the Array Area and offshore areas of the OfECC (water depths >50 m below LAT; more than 10 km offshore):**

- The cable protection height (assumed up to 1.5 m) is only a very small proportion of the total water depth. On the limited occasions, during large storm events, when waves are sufficiently large to interact with the berm, it is still unlikely that the berm will present a sufficient obstacle to cause changes to the wave size or direction;
- The long axis of any potential berm may be more or less aligned to the main tidal current axis, depending on exact location within the Array Area or along the OfECC. However, the cable protection height (assumed 1.5 m) is a very small proportion of the total water depth and so, together with the sloped sides of the berm, will present a minimal obstruction to tidal currents (no measurable effect more than a few tens of metres from the berm and restricted only to the near-bed);
- The long axis of any potential berm may therefore also be more or less aligned to the natural local direction sediment transport pathways, which may present a similarly minor obstruction to sediment transport as bedload (sediment transport in suspension will not be affected);
- With regards to the area around Turbot Bank, **Figure 17-22** demonstrates that the proposed orientation of the cable (and therefore any protection if and where applied) is broadly aligned to the direction of net sediment transport circulation around the western end of Turbot Bank.
- An initial period of sediment accumulation may occur within and around the berm, as a small volume of sediment in bedload transport is trapped within any open surface voids. A surface accumulation of sediment may develop over the updrift side (appearing similar to a groyne on a beach). The volume of sediment accumulated will vary in proportion to the size of the open surface voids and the clast size used (anticipated 2 cm to 30 cm). This accumulated sediment will be of small absolute volume and is expected to occur in a relatively short period of time (order of weeks to a few months). The side slopes of typical berm designs are deliberately less than the range of naturally stable bed slopes (<32˚ for sands). When sufficient sediment volume has been accumulated on the updrift surface to present a naturally stable sediment slope and surface, sediment transport will thereafter continue over the berm at the natural ambient rate and direction;

- No measurable change to the seabed is expected more than a few metres from the updrift edge of the berm. A small local depression (scour) of proportionally small dimensions (i.e., a few tens of centimetres depth and within a few metres of the berm edge) may form on the downdrift side of the berm as a result of the temporary reduction in sediment supply during the initial accumulation process;
- The patterns and dimensions of sediment accumulation or scour may vary over the operational lifetime of the berm, due to natural fluctuations in sediment supply and transport rates and directions. Changes may be seasonal or episodic in nature (e.g., during or following larger storms, then gradually returning to another state associated with purely tidal conditions); and
- The nature of the seabed (sediment type and texture) around the berm, including within any areas of local accretion or scour, is not expected to be measurably different to the surrounding seabed.

149. **Seabed areas in the approaches to Turbot Bank (water depths around 40 m to 50 m below LAT; 5 km to 10 km offshore):**

- If and where used, the maximum cable protection height (1.5 m) is only a small proportion (5%) of the total water depth (at LAT). Where currents and waves interact with the berm, it is unlikely that the berm will present a sufficient obstacle to cause changes to their magnitude or direction beyond the very local near-bed area;
- Where the berm axis is more closely aligned to the sediment transport direction, little to no measurable change to the seabed is expected more than a few metres from the edges of the berm. A small volume of sediment might accumulate gradually in the surface voids of the berm, but not likely in sufficient quantities to cause measurable changes to the surrounding seabed level. Where the berm axis is at a more acute angle to the sediment transport direction, see the description above (**Paragraph 148**) for offshore areas; and
- Any changes to waves, tides, and sediment transport are expected to be localised and will therefore not extend to the adjacent coast. Similarly, any changes to waves, tides and sediment transport associated with the presence of cable protection will not extend to Turbot Bank or St Gowan Shoals which at the closest point (as defined by the Article 17 boundary), are approximately 0.5 km and 2.5 km away, respectively.

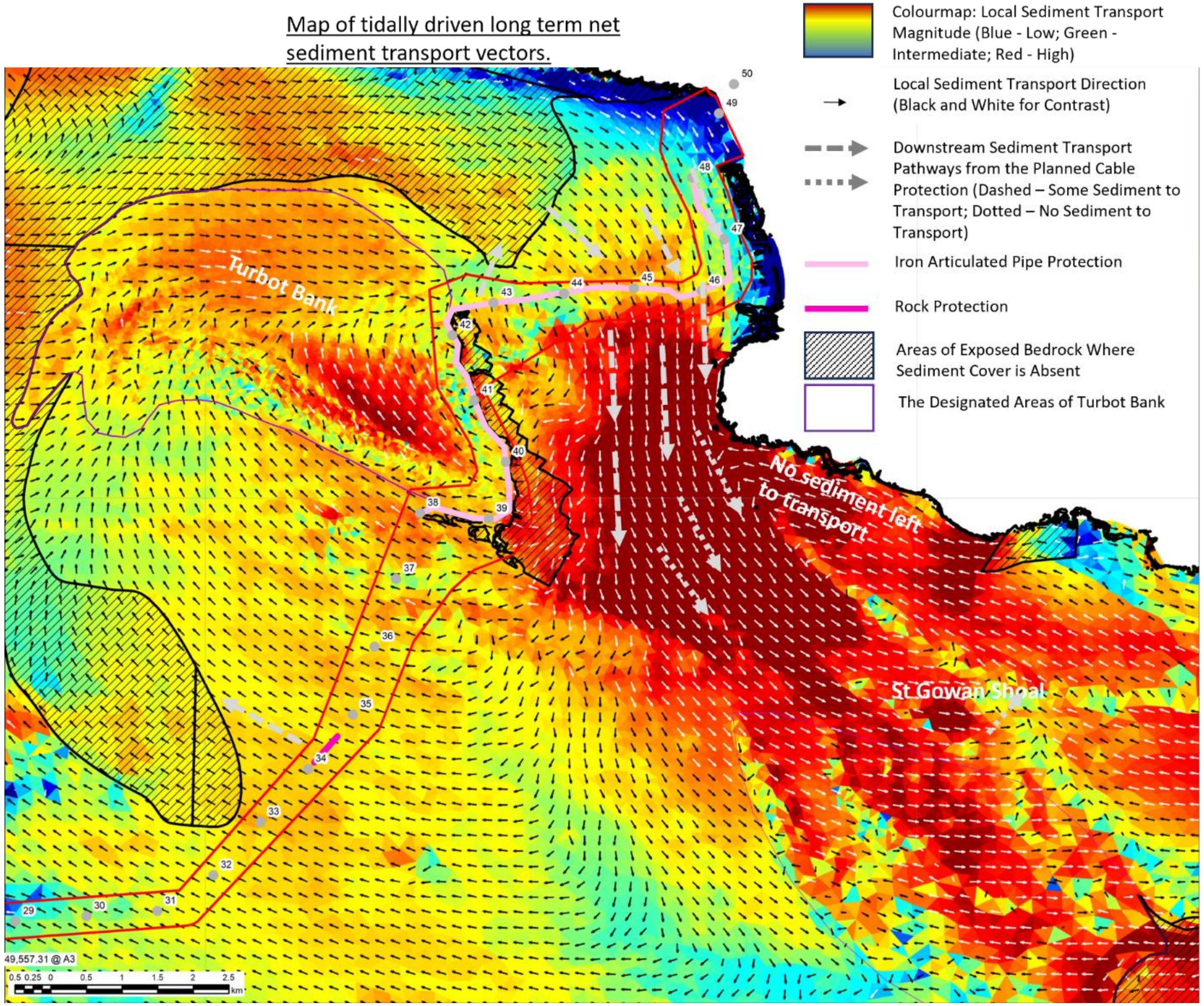
150. **Nearshore, to the east of Turbot Bank, and in the approaches to Freshwater West (water depths from less than 20 m below LAT; 1 km to 5 km offshore):**

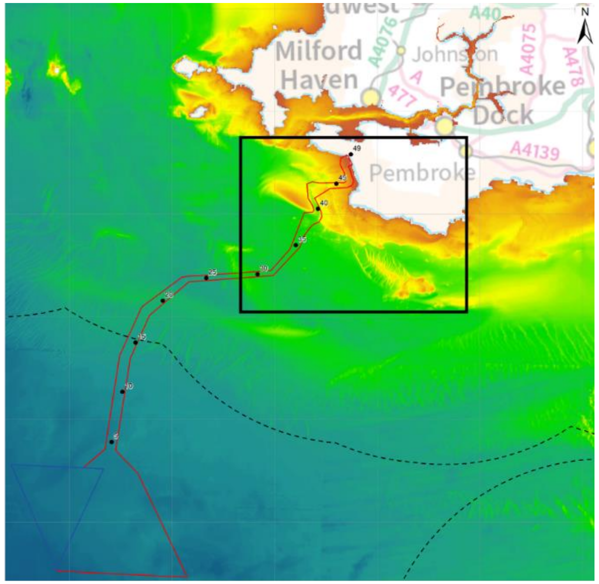
- The cable is assumed to be encased in iron articulated pipe from the southeastern corner of Turbot Bank (KP 38) to the HDD exit location (KP 48). The articulated pipe type armour will only slightly increase the diameter of the cable and will therefore not cause any measurable blockage if surface laid, or buried but later exposed. No measurable changes to waves or tidal patterns are likely. Any changes to sediment transport are expected to be very localised (e.g. sediment scour up to 0.5 m deep within less than 1-3 m from the armoured cable – see Whitehouse (1998)) and will therefore not have any effect on the wider seabed, Turbot Bank, or the adjacent coast. It is noted here that the articulated pipe would only be surface laid in areas where sufficient burial depth would not be possible (i.e. where surficial sediment cover is thin or absent). In such settings, the potential for scour will likely be greatly limited by the presence of the hard substrate at/very near the bed.
- Where the articulated iron pipe runs down the southeastern margin of Turbot Bank, sediment transport is expected to be broadly towards the bank (**Figure 17-24**). However, the area of seabed immediately to the east of the bank is characterised by hard substrate

and is denuded of sediment. Accordingly, little material is being delivered to the bank in this location.

151. **At Freshwater West (the Landfall) - (water depths from less than 20 m below LAT):**

- Sediment cover is presently thin in some nearshore areas with seasonal movement of sediments over the rocky platform. However as stated above the cable will be encased in iron articulated pipe in this nearshore area, from the southeastern corner of Turbot Bank (KP 38) to the HDD exit location (KP 48). This will slightly increase the diameter of the cable from 200 mm to 500 mm but will not cause any measurable blockage if surface laid, or buried but later exposed). No larger dimension mechanical protection (e.g. rock placement berms) is proposed in this area. No measurable changes to waves or tidal patterns are likely. Any changes to sediment transport are expected to be very localised (e.g. sediment scour up to 0.5 m deep within less than 1-3 m from the armoured cable) and will therefore not have any effect on the wider seabed, or the adjacent coast or beach.
- The landfall is located in a macro-tidal setting, with a mean spring range in excess of 6 m. Waves are unlikely to interact with or be affected by any relatively small and localised change in total water depth due to cable in articulated pipe type armour; and
- Tidal current speeds very close to shore at Freshwater West are so low that they do not contribute measurably to sediment transport. Any local obstacle presented by a cable in articulated pipe type armour or other near-bed cable infrastructure will not cause any meaningful change in tidal current speed or direction.





The downstream sediment transport pathways from the potential locations of the iron articulated pipe protection and cable berms do not intersect the main accumulations of sediment in Turbot Bank.

The dimensions of the iron articulated pipe protection and berms are not sufficiently large to measurably affect patterns of currents or waves, or therefore to indirectly change the regional patterns of sediment transport shown.

Figure 17-24 Orientation of the OfECC in relation to net sediment transport patterns around Turbot Bank and St Gowan Shoal

152. Presence of floating platforms and presence of anchoring systems: The effect of the floating platforms on tidal currents within the Array Area will be to locally reduce current speed and increase turbulence in a narrow wake behind the cross section of the floating platform. The worst case design scenario is set out in **Table 17-14** and is represented by an array comprising ten concrete semi-submersibles.

153. Currents underneath the foundations will not be directly affected by the main structure but will interact to a much lesser extent with the very small blockage presented by the mooring lines (up to eight per foundation, assumed in the order of 0.3 m diameter) and electrical cable (assumed in the order of 200 mm diameter) between the base of each foundation and the seabed. The majority of any mooring chain length will be on the seabed and will not interact with currents. The majority of any pile and all of any embedment anchors, will be buried, and so will not interact with currents. However, it is conservatively assumed that the top of drilled or driven piles may remain above the seabed and so may interact with currents locally. The exposed ends of drilled anchors will have a diameter of up to 3.5 m and be up to 4 m above the seabed whilst the exposed ends of driven pile anchors will have a diameter of up to 3 m and be up to 3 m above the seabed.

154. Other mooring elements such as chain links, clump weights and mechanical cable protection that are above seabed and interact with near-bed currents may result in local flow patterns and seabed scour effects (considered in **Paragraph 166**), however, these are individually of relatively small scale and so are unlikely to cause a change in overall patterns of flow or sediment transport through the Array Area. Measurable effects on currents are therefore likely to only be associated with the main floating platforms and so largely confined to surface and near surface waters. Therefore, any change to currents caused by individual foundations or the array will have no consequential effect on the overall rate or direction of sediment transport at the seabed.

155. The wake features/effects behind each foundation will recover rapidly with distance downstream, likely becoming not measurable within a few hundred metres (less than the distance between the floating platforms). The maximum distance to which any (cumulative) effect might propagate from the Array Area is, in any case, limited to one tidal excursion distance (the distance over which water is displaced during one flood or ebb tidal cycle), approximately 9 km to 11 km under mean spring conditions for the Array Area (**Figure 17-5**).

156. The local effects of the floating platforms on waves will be limited to an area downwind of the Array Area, to a distance up to approximately the width of the site (relative to the wave coming direction). Beyond that distance, the sea state will recover to the ambient condition through natural spreading and dispersion of wave energy (see OWF wave impact modelling studies, recent examples including RWE (2023a) (Rampion 2); RWE (2023b) (Five Estuaries) and RWE (2022b) (Awel y Môr).

157. A larger proportion of smaller waves (wave periods <8 s) are more likely to be blocked (by reflection or breaking) within the cross section presented by the floating platform; whereas larger waves (wave periods >10 s) will tend to bypass the floating platform with less interaction and consequential energy loss. For the majority of time, waves over the Array Area will not be large enough (in comparison to the relatively large water depth) to cause any measurable contribution to sediment transport, therefore, any change to waves that are caused by the floating platforms are unlikely to have any consequential effect on the rate or direction of sediment transport.

158. All of the changes described in this section are to 'pathways' as opposed to receptors and therefore magnitude ratings have not been assigned.

Table 17-16. Summary of Potential Impact on Sediment Transport Processes

<table>
<tr><th>Project Component</th><th>Location</th><th>Summary of Potential Impact on Sediment Transport Processes</th></tr>
<tr><td>Export and/or array mechanical cable protection</td><td>Array Area and OfECC (more than 10 km offshore Milford Haven)</td><td rowspan="2">Changes in sediment transport extending (up to) tens of metres from any locally installed mechanical cable protection.
Water depths are too great for mechanical cable protection measures to measurably alter the passage of waves and tides</td></tr>
<tr><td>Export cable protection</td><td>OfECC Inshore (approximately 5 km to 10 km offshore of Freshwater West)</td></tr>
<tr><td>Export cable mechanical protection</td><td>OfECC Nearshore (1 km to 5 km offshore of Freshwater West)</td><td rowspan="2">Localised changes to waves and hydrodynamics immediately within the vicinity of the mechanical protection (iron articulated pipe section) and exit point rock berms. But associated morphological change limited by the small scale/low profile of the rock protection, iron articulated pipe section, the macrotidal setting and very low current speeds.</td></tr>
<tr><td>HDD exit point rock berm</td><td>Landfall</td></tr>
<tr><td>Floating foundations and associated anchors</td><td>Array Area</td><td>Wake effects extending (up to) hundreds of metres from platforms and associated mooring/anchor systems. Associated changes in sediment transport theoretically possible in this footprint
Local scour around the exposed top end of driven or drilled piles; scour pit extending (up to) several metres from the structure.</td></tr>
</table>

Sensitivity of the receptor

159. All of the changes described in this section are to 'pathways' as opposed to receptors and therefore sensitivity ratings have not been assigned.

Assessment of Significance

160. The changes described in this section are to 'pathways' as opposed to receptors. The significance of potential impacts to marine and coastal processes receptors arising from

modification of the sediment transport regime is considered in the next section **Paragraph 161 et seq.**

Potential Changes to the Morphology of the Seabed Including from Scour (Receptor)

161. This section describes impacts to seabed morphology focusing on areas within designated sites arising from changes to sediment transport associated with the presence of cable protection, anchoring systems and the semi-submersible floating platforms during the operational phase of the proposed Project. The receptors under consideration are the Annex I sandbanks within and around the OfECC at Turbot Bank and St Gowan Shoals, and the seabed areas within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA.

Magnitude of impact

162. Installation of mechanical cable protection: the presence of mechanical cable protection (rock berms) during the operational phase has the potential to cause changes to the local seabed level (scour) as a result of local flow interaction between the body and surface of the berm, and any near-bed current and wave action. The potential for cable protection to cause larger scale changes to the tidal, wave or sediment transport regimes is very limited in any case. 500 mm diameter articulated pipe type armour (slightly increasing the diameter of the cable from 200 mm and not causing any measurable blockage if surface laid, or buried but later exposed) would be used instead of rock berms in the approaches to the landfall, as discussed in **Paragraph 141 et seq.**

163. The purpose of cable protection is to provide mechanical protection from impact or interaction with the marine environment, and to maintain stable cover over the lifetime of the proposed Project; external cable protection is used where cable burial is not possible or inadequate for the same purpose. By design, it aims to minimise the risk of scour associated with both the Offshore Export Cable and the protection itself. Berm dimensions (5 m base width x 1.5 m height and sloped sides) typically (by design) result in slope angles less than the angle of repose for sand and a small overall height relative to the water depth, which limits the potential for form-related flow disturbance and scour, even when currents are perpendicular to the berm.

164. The individual rock armour units that comprise cable protection berms are typically approximately 2 cm to 30 cm in diameter. Turbulence may become locally elevated in water flowing close to the surface of the berm, which may result in a limited depth and extent of secondary scour (order of a few tens of centimetres deep and up a few metres from the berm). The seabed surface in the scoured area will generally be similar to the surrounding seabed but the texture may coarsen due to preferential winnowing of finer sediment grains.

165. As discussed in the previous section (**Paragraph 141 et seq.**), any localised changes to waves, tides and sediment transport associated with the installation of offshore export cable protection in the OfECC is unlikely to extend to Turbot Bank or St Gowan Shoals which at the closest point (as defined by the Article 17 boundary), are approximately 0.5 km and 2.5 km away, respectively. Accordingly, no morphological change to either bank is expected to occur with cable protection in place.

166. Presence of floating platforms and associated mooring/anchoring systems: the presence of the floating platforms during the operational phase has the potential to cause changes to the local seabed level (scour) as a result of local flow interaction between the near-bed elements of the foundation moorings and electrical cables, and any near-bed current and wave action.

The potential for the main body of the semi-submersible floating platforms themselves to cause larger scale changes to the tidal, wave or sediment transport regimes is very limited, as discussed in the previous section (**Paragraph 141 et seq.**).

167. The main body of the floating platform is located in the upper water column and is too distant from the seabed to cause a change in the near-bed local flow field or, therefore, any local scour. Where the moorings meet the seabed, the moorings will comprise large chain links (dimensions assumed up to 1 m) with 15 to 25 clump weights (dimensions assumed up to 2 m).

168. Buried sections of the chain, clump weights, buried sections of pile anchors and any embedment anchors (also completely buried) will not interact at all with the local flow field and so will not cause any scour. Where the chain links and clump weights are partially or completely exposed, increased flow turbulence may cause local scour in proportion to the size of the object, (order of a few tens of centimetres deep and up a few metres from the obstacle).

169. Exposed ends of drilled anchors (up to 3.5 m diameter, up to 4 m above seabed) or driven pile anchors (up to 3 m diameter, up to 3 m above seabed) may cause a greater depth of local scour in proportion to their diameter; however, the limited height of these obstacles disrupts and limits the patterns of flow acceleration that can form, reducing the likely maximum dimensions of scour to the order of a few metres depth and up to ten metres extent, which is less than would be expected from a full water column height obstacle.

170. Localised sections of mooring chain may occasionally move in response to the movement of the semi-submersible floating platform, the ‘swept area’ is assumed to be up to 700 m^2 for each foundation and 7,000 m^3 in total (for ten foundations). The frequency and distance of movement for individual moorings will depend on the particular mooring configuration and the scale and direction of the force being applied to the floating platform. The movement of the chain over or through the seabed is expected to be generally slow (not causing energetic sediment resuspension) and may include both lateral and vertical movement.

171. This action may cause a ‘ploughing’ or ‘sweeping’ of sediment, redistributing sediment volume locally into linear accumulations with a maximum height proportional to the dimensions of the chain and clump weights (up to 2 m high). The net effect may be an area of disturbed seabed morphology in the swept area (up to approximately 700 m^2 per foundation in a sector or arc shaped pattern). Any patterns formed will be continuously and gradually redistributed back towards a natural state by ambient sediment transport processes. The nature of the seabed sediments and the rate of sediment transport through the affected area are unlikely to be changed by this process.

172. On the basis of the discussion in this section, the magnitude of impact to either Turbot Bank, St Gowan Shoal and/or designated areas of seabed (within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA) resulting from the presence of any cable protection is **small**. This is because no measurable change to the morphology of the seabed is expected more than a few metres either side of the rock protection berm.

173. With regards to morphological impacts to designated areas of seabed arising from the presence of floating platforms and associated mooring/anchor systems, impacts are expected to be **negligible**. This is because changes to tidal currents and waves are expected to be very small and therefore any related changes to the surrounding seabed are expected to be difficult to discern from those which may occur under baseline conditions. The assertion that changes to hydrodynamics, waves and sediment transport will be very small in absolute and relative

terms is entirely consistent with numerical modelling and observational evidence from wind farms constructed with monopiles whose total water column blockage far exceeds that of the proposed Project (e.g. Dong Energy, 2013).

Sensitivity of the receptor

174. The receptors under consideration are Turbot Bank, St Gowan Shoal and designated seabed areas within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA, with Offshore export cable protection potentially required within the boundary of all these designated sites. Although internationally designated, the seabed in these areas is naturally mobile and is therefore likely to accommodate and recover from any localised disturbance. Accordingly, it is assessed to be of **medium** sensitivity.

Significance of the effect

175. The sensitivity of the receptors (seabed areas within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA, Turbot Bank and St Gown Shoal) is considered to be **medium** and the magnitude of the impact is assessed as no greater than **small**. Therefore, using the assessment matrix set out in **Table 17-8,** the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Additional Mitigation and Residual Effect

176. None of the effects identified above are major or moderate adverse (significant in EIA terms). Therefore, no additional mitigation is required and the significance of residual effects remain as detailed above.

Potential Changes in Morphology of the Coast (Receptor)

177. This section describes potential impacts to seabed morphology at the coastline near to the landfall, arising from changes to currents, waves and associated sediment transport (or other coastal processes) potentially caused by the presence of hard infrastructure within 5 km of the coast, namely cable protection.

178. Potential impacts on the morphology of the coast from other proposed Project infrastructure >5 km from the coast (including all the infrastructure within the Array Area) have been scoped out. This is due to the distance between any effects created by these structures and adjacent coastlines which are beyond the range of any potential impact.

Magnitude of impact

179. <u>Cable protection:</u> where the Offshore Export Cable is buried in the seabed and not protected, there is no potential for cable related scour to occur. If the Offshore Export Cable becomes exposed, then a small, localised, area of scour may occur as a result of currents interacting with the exposed part of the cable. The exact dimensions of the scour will depend on the height of the Offshore Export Cable relative to the seabed but will be in proportion to the small diameter of the cable (typically up to 0.3 m diameter) and no more than the dimensions of scour described for the cable protection **Paragraph 141 et seq.).**

180. The use of cable protection could, theoretically, cause measurable changes to currents, waves and associated sediment transport during the operational phase. However, the dimensions of such infrastructure in terms of both plan area and height above the seabed relative to water depth are small (likely to be in the order of up to 1.5 m overall height). They have been assessed earlier in **Section 17.8.2** to have a very limited potential to cause more than a small

scale of local change (order of metres to tens of metres) to waves, tides and sediment transport processes.

181. The potential for morphological change to the Freshwater West coast in response to the use of cable protection is therefore considered **small**. It is also the case that the adjacent coastline immediately to the north is rocky and is therefore not sensitive to such minor changes to waves.

Sensitivity of the receptor

182. The coast at Freshwater West is considered to be of **medium** sensitivity. Although nationally designated (within the Broomhill Burrows SSSI), the rocky outcrops will be insensitive to changes in waves, tides and sediment transport (as the rocky outcrops are resistant to erosion and there is little material to be transported). The pocket beach within the bay itself will be more sensitive to change (due to the fact sandy sediments are present which may be mobilised by prevailing waves and tidal currents). However, it will have some capacity to recover from disturbance.

Significance of the effect

183. The sensitivity of the receptor (the coast) is considered to be **medium** and the magnitude of the impact is assessed as **small**. Therefore, using the assessment matrix set out in **Table 17-8**, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Additional Mitigation and Residual Effect

184. None of effects identified above are major or moderate adverse (significant in EIA terms). Therefore, no additional mitigation is required and the significance of residual effects remain as detailed above.

Potential Increases in SSC (Pathway) Via Cable Repairs/Remediation

185. Occasional local cable repairs and/or remedial reburial of locally exposed cables may be required during the lifetime of the proposed Project (30 years). The expected maximum number of cable repairs is not presently known.

Magnitude of impact

186. Offshore Export Cable repairs and/or remedial activities will require some localised seabed disturbance, causing a localised and temporary increase in SSC and associated changes to bed levels due to resettlement. It is expected that equipment and techniques similar to that used to install the Offshore Export Cable will be used for re-burial if and where needed.

187. The local changes in SSC and associated changes to bed levels are expected to be no greater than that associated with initial cable burial during construction (assessed in **Paragraph 89 et seq.**), with sediment disturbance events also considerably less frequent than during the construction period.

188. Physical environment receptors are entirely insensitive to elevated levels of SSC and as such, it is not appropriate to carry out an assessment of significance which considers the magnitude of impact to a receptor and the sensitivity of that receptor.

Sensitivity of the receptor

189. All of the identified physical environment receptors are insensitive to elevated levels of SSC and have therefore not been assigned a sensitivity rating.

Significance of effect

190. All of the identified marine and coastal processes receptors will be insensitive to elevated levels of SSC and localised changes in bed level. However, the potential for these changes to impact other EIA receptor groups are considered elsewhere within the ES, in particular:

- **Chapter 18: Marine Water Quality;**
- **Chapter 19: Benthic Ecology;**
- **Chapter 20: Fish & Shellfish Ecology;**
- **Chapter 21: Marine Mammals; and**
- **Chapter 22: Ornithology.**

17.8.3. Decommissioning Effects

Potential Increases in SSC (Pathway).

191. The following decommissioning activities could potentially give rise to increases in SSC and associated deposition of material within the Array Area and OfECC:

- Removal of WTG mooring/anchoring systems;
- Removal of cable protection; and
- (Possible) removal of array and Offshore Export Cable from the seabed.

Magnitude of impact

192. The removal of WTG mooring/anchoring systems is expected to result in some localised seabed disturbance accompanied by temporary increases in SSC. For the purposes of the EIA and to provide a worst-case assessment, it has been assumed that all Offshore Export Cables will be removed from the intertidal zone and seabed during decommissioning. It is probable that equipment similar to that used to install the Offshore Export Cable, could be used to reverse the burial process and expose the Offshore Export Cable. Accordingly, the area of seabed impacted during the removal of the Offshore Export Cable would be similar to the area impacted during the installation of the Offshore Export Cable.

193. For all of the above, the changes in SSC and accompanying changes to bed levels associated with decommissioning activities are expected to be no greater than that associated with construction. Further information is provided in the construction phase assessment (**Paragraph 89 et seq.**).

194. As previously stated, physical environment receptors are entirely insensitive to elevated levels of SSC and as such, it is not appropriate to carry out an assessment of significance which considers the magnitude of impact to a receptor and the sensitivity of that receptor.

Sensitivity of the receptor

195. All of the identified physical environment receptors are insensitive to elevated levels of SSC and have therefore not been assigned a sensitivity rating.

Significance of the effect

196. All of the identified marine and coastal processes receptors will be insensitive to elevated levels of SSC and associated changes to bed levels. However, the potential for these changes to impact other EIA receptor groups are considered elsewhere within the ES, in particular:

- **Chapter 18: Marine Water Quality;**
- **Chapter 19: Benthic Ecology;**

- **Chapter 20: Fish & Shellfish Ecology;**
- **Chapter 21: Marine Mammals; and**
- **Chapter 22: Ornithology.**

Potential Changes to Sediment Transport System by Changes in Wave and Current (Pathway)

197. Mechanical cable protection, floating platforms and/or the presence of anchoring structures all have the potential to result in a localised blockage of waves, tides and sediment transport. During decommissioning it is assumed that the number of installed structures (and therefore overall blockage) will be gradually reduced towards zero and will, therefore, at no point be greater than that already assessed for the operational phase (**Paragraph 177 et seq**.).

Magnitude of impact

198. Changes described in this section are to 'pathways' as opposed to receptors and therefore magnitude ratings have not been assigned.

Sensitivity of the receptor

199. All of the changes described in this section are to 'pathways' as opposed to receptors and therefore sensitivity ratings have not been assigned.

Significance of the effect

200. The changes described in this section are to 'pathways' as opposed to receptors. The significance of potential impacts to marine and coastal processes receptors arising from modification of the sediment transport regime is considered in **Paragraph 161 et seq.**

Potential Changes to the Morphology of the Seabed Including From Scour (Receptor)

201. This section describes impacts to local seabed morphology in designated sites arising from local changes to flow and sediment transport (scour) associated with the removal of all seabed infrastructure during the decommissioning phase.

Magnitude of impact

202. The potential dimensions of local scour as a result of the mechanical cable protection, semi-submersible floating platforms and associated moorings present during the operational phase are assessed in **Paragraph 161 et seq.** Where cable protection and foundation moorings are removed during the decommissioning process, the physical obstacle and associated flow conditions which potentially caused scour during the operational phase will be removed. Some physical impression may be initially visible within the operational footprint of the berm or mooring line. For cable protection, some individual protection clasts (2 cm to 30 cm diameter) may remain on or within the seabed. For moorings, the removal of more deeply buried chain and anchors may cause a morphological disturbance to the seabed with dimensions proportional to the items being removed).

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

204. On the basis of the discussion in this section, the magnitude of impact to the seabed resulting from the removal of cable protection measures and anchoring structures is considered **small**

to **negligible**. This is because changes to hydrodynamics, waves and associated patterns of sediment transport are expected to be very small and therefore any related changes to the surrounding seabed are expected to be difficult to discern from those which may occur under baseline conditions.

Sensitivity of the receptor

205. The receptors under consideration are the seabed areas within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA. Although internationally designated, the seabed in these areas is highly dynamic and is assessed to have some capacity to recover from disturbance associated with sandwave levelling. Accordingly, the sensitivity of the receptor is assessed to be of **medium**.

Significance of the effect

206. The sensitivity of the receptor (seabed areas within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA) is considered to be **medium** and the magnitude of the impact is assessed as **small** to **negligible**. Therefore, using the assessment matrix set out in **Table 17-8**, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Additional Mitigation and Residual Effect

207. None of effects identified above are major or moderate adverse (significant in EIA terms). Therefore, no additional mitigation is required and the significance of residual effects remain as detailed above.

Potential Changes in Morphology and Sediment Transport at the Coast (Receptor)

208. The realistic worst case in terms of the potential for impacts to coastal feature receptors would be the total removal of all Offshore Export Cables and associated infrastructure at the landfall.

Magnitude of impact

209. Should the Offshore Export Cable require removal at the end of its operational life, it will be removed through the same soils and sediments disturbed during installation. This removal process does not necessarily require the same scale of sediment displacement (trenching or sandwave levelling) as for installation. This process could, however, result in short-term elevations in SSC and localised changes in bed level (i.e., within the near-field).

210. It is anticipated that the working areas for removal will also be restricted to the same area used for installation; accordingly, any impacts would be no greater in magnitude or extent than for the construction phase.

211. Where infrastructure is removed from very nearshore or intertidal areas during the decommissioning process, the physical obstacle and associated potential modification to current and wave conditions during the operational phase will be removed. Some physical impression may be initially visible within the original footprint of a berm or other structure. For cable protection, some individual protection clasts (typically 2 cm to 30 cm diameter) may remain on or within the seabed.

212. The removal of more deeply buried hard infrastructure may cause a morphological disturbance to the seabed, with maximum dimensions proportional to the items being removed. Any impression left, and any initially remaining scour, will be no larger than the original footprint. Depressions will become infilled and high points (comprising accumulated mobile sediment) will be levelled out by ambient sediment transport over time. The seabed

sediment type will either remain or return to the ambient baseline condition within a similar or shorter time period as new sediment is deposited or underlying (previously undisturbed) sediments are exposed.

213. If the installed infrastructure caused measurable changes to currents, waves and associated sediment transport or other coastal processes that extended to the adjacent seabed or coastline during the operational phase, then the morphology in and around the affected area could have evolved in dynamic equilibrium with that change. If some, or all of the installed infrastructure is removed during decommissioning, then the affected seabed or coastline will evolve instead towards a new equilibrium state within the future baseline environment.

214. The dimensions of such infrastructure in terms of both plan area and height above the seabed are, however, relatively small and have been assessed in **Paragraph 141 et seq.** to have a very limited potential to cause more than a small scale of local change.

215. Given the rocky nature of much of the coastline adjacent to the landfall, such changes are likely to be related to the particular distribution of mobile sediment on the seabed and intertidal area, in the approaches to and on Freshwater West beach. As such, the new equilibrium state of the local seabed and beach is likely to be achieved within a relatively short time of the infrastructure being removed, estimated to be in the order of days to weeks of tidal inundation, or following one or more larger storm events.

216. On the basis of the discussion in this section, the magnitude of impact is predicted to be no greater than that anticipated for the construction phase i.e. **small**, see **Paragraph 141 et seq.**). This is because all impacts associated with cable removal activities will be of short-term duration and/or highly localised in nature.

Sensitivity of the receptor

217. The coast at Freshwater West is considered to be of **medium** sensitivity. Although nationally designated (within the Broomhill Burrows SSSI), the rocky outcrops will be insensitive to changes in waves, tides and sediment transport (as the rocky outcrops are resistant to erosion and there is little material to be transported). The pocket beach within the bay itself will be more sensitive to change (due to the fact sandy sediments are present which may be mobilised by prevailing waves and tidal currents). However, it will have some capacity to recover from disturbance.

Significance of the effect

218. The sensitivity of the receptor (the coast) is considered to be **medium** and the magnitude of the impact is assessed as no greater than **small**. Therefore, using the assessment matrix set out in **Table 17-8**, the effect will be of **minor adverse** significance, which is **not significant** in EIA terms.

Additional Mitigation and Residual Effect

219. None of effects identified above are major or moderate adverse (significant in EIA terms). Therefore, no additional mitigation is required and the significance of residual effects remain as detailed above.

17.8.4. Summary of Residual Environmental Effects

220. This chapter of the ES has assessed the potential environmental effects on the physical environment from the construction, operation and maintenance and decommissioning phases of the proposed Project.

221. **Table 17-17** summarises the impact assessment undertaken and confirms the significance of any residual effects, following the application of additional mitigation. Potential impacts that have no sensitive physical environment receptors are included as potential pathways of effect, to be considered where relevant to other receptors in other chapters.

17.9 Summary of Additional Mitigation Measures

222. Based on the conclusion of significant effects (summarised in **Table 17-17**, which account for a range of embedded mitigation and good practice measures summarised in **Section 17.717.7**), no additional mitigation or enhancement measures are required with respect to potential physical environmental impacts.

17.9.1. Monitoring

223. Based on the conclusion of significant effects (summarised in **Table 17-17**, which account for a range of embedded mitigation and good practice measures summarised in **Section 17.717.717.7**), no monitoring requirements have been identified.

17.10 Summary of Effects and Conclusions

224. This section summarises the residual significant effects of the proposed Project on the physical environment following the implementation of mitigation.

225. A wide range of potential changes to the physical environment have been considered, including short-term sediment disturbance due to construction activities, potential impacts from cable installation at the Landfall and the potential for changes to designated bank systems, arising from the interruption of sediment transport pathways.

226. Even using a realistic worst case approach for the EIA, it has been found that for all receptor groups, the level of effect significance is no greater than minor for all phases of development (**Table 17-17**). Accordingly, all of the potential effects to physical environment receptors are therefore Not Significant in terms of the EIA Regulations (**Chapter 05: EIA Approaches and Methodology**).

Table 17-17. Appraisal summary

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of impact	Significance of effect	Additional Mitigation	Residual Significance of Effect
Construction						
Potential increases in SSC and associated changes to seabed substrate.	No sensitive Physical Environment receptors	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	None required	N/A [Potential pathway of effect for other topics]
Potential changes to sediment transport system by changes in wave and current climate	No sensitive Physical Environment receptors.	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	None required	N/A [Potential pathway of effect for other topics]
Potential changes to the morphology of the seabed	Annex I sandbanks within and around the OfECC (Turbot Bank and St Gowan Shoal), and the seabed areas within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA	Medium	Small	Minor Adverse (not significant)	None required	Minor Adverse (not significant)

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of impact	Significance of effect	Additional Mitigation	Residual Significance of Effect
Potential changes in morphology of the coast.	The coast at the landfall within the Broomhill Burrows SSSI (Freshwater West).	Medium	Small	Minor Adverse (not significant)	None required	Minor Adverse (not significant)
Operation and Maintenance						
Potential changes to sediment transport system by changes in wave and current climate.	No sensitive Physical Environment receptors.	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	None required	N/A [Potential pathway of effect for other topics]
Potential changes to the morphology of the seabed (including scour).	Annex I sandbank within and around the OfECC (Turbot Bank and St Gowan Shoal), and the seabed areas within the Pembrokeshire Marine SAC, West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA	Medium	Negligible	Minor Adverse (not significant)	None required	Minor Adverse (not significant)

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of impact	Significance of effect	Additional Mitigation	Residual Significance of Effect
Potential changes in morphology of the coast.	The coast at the landfall within the Broomhill Burrows SSSI (Freshwater West).	Medium	Small	Minor Adverse (not significant)	None required	Minor Adverse (not significant)
Potential Increases in SSC (Pathway) Via Cable Repairs/Remediation	No sensitive Physical Environment receptors.	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	None required	N/A [Potential pathway of effect for other topics]
Decommissioning						
Potential increases in SSC and associated changes to seabed substrate.	No sensitive Physical Environment receptors.	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	None required	N/A [Potential pathway of effect for other topics]
Potential changes to sediment transport system by changes in wave and current climate	No sensitive Physical Environment receptors.	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	N/A [Potential pathway of effect for other topics]	None required	N/A [Potential pathway of effect for other topics]
Potential changes to the morphology of the seabed (including scour).	Annex I sandbank within and around the OfECC (Turbot Bank and St Gowan Shoal), and the seabed areas within the Pembrokeshire Marine SAC,	Medium	Small to Negligible	Minor Adverse (not significant)	None required	Minor Adverse (not significant)

Potential Impact	Receptor	Receptor Sensitivity	Magnitude of impact	Significance of effect	Additional Mitigation	Residual Significance of Effect
	West Wales Marine SAC and the Skomer, Skokholm and the Seas off Pembrokeshire SPA					
Potential changes in morphology of the coast	The coast at the landfall within the Broomhill Burrows SSSI (Freshwater West).	Medium	Small	Minor Adverse (not significant)	None required	Minor Adverse (not significant)

17.11 Cumulative Effects of the proposed Project

17.11.1. Introduction

227. Cumulative effects are those effects upon receptors arising from the proposed Project alongside all existing, and/ or reasonably foreseeable projects, plans and activities that result in cumulative effects with any element of the proposed Project. Existing projects are generally considered as part of the baseline and as such are considered within the impact assessment presented in **Section 17.8** above.

228. This section assesses potential cumulative effects on the physical environment from identified projects, plans and activities that have the potential to act cumulatively with the proposed Project.

229. PINS Advice 17: Cumulative Effects Assessment (2019) suggests that the Cumulative Effects Assessment (CEA) follows a four-stage process. The aim of this approach is to accurately determine relevant projects and associated relationships with scoped in receptors identified in the ES, to be included within the interproject CEA.

230. The approach to the assessment of cumulative effects is detailed in **Appendix 5B: Approach to Cumulative Effects Assessment** and is also summarised in **Table 17-18**.

Table 17-18. PINS Advice 17 Stages of the CEA process

CEA Stage	Activity
Stage 1	Determine a zone of influence (ZoI) via desk study for each topic receptor scoped into the ES. This will establish a *long list* of projects within each ZoI that will be shortlisted in Stage 2. This list of plans and projects/activities is drawn up through a desk study of planning applications, development plan documents, relevant development frameworks and any other available sources to identify 'other development' within the ZoI. Information on each project (location, development type, status, etc.) is documented, along with the certainty or tier assigned to the 'other development' (i.e. confidence it will take place in the current form and when it will take place in relation to the project). PINS notes that the project should then consult with the relevant planning authority/ authorities and statutory consultees regarding the long list.
Stage 2	Screening of the long list identified in Stage 1, to establish a short list for the CEA. Screening is based on the criteria presented in the scoping report and subsequent comments by the regulator and statutory consultees. PINS has provided inclusions/ exclusion threshold criteria, against which the potential for 'other development to give rise to significant cumulative effects by virtue of overlaps in temporal scope, the scale and nature of the 'other developments' and /or receiving environment, or any other relevant factors is assessed. From this assessment, a shortlist of 'other developments' to be included in the CEA is produced. It is noted that documented information on each of the 'other developments' is likely to be high level at this stage, outlining the key issues to take forward.
Stage 3	Gathering of all information available on short listed projects generated in Stage 2. At this stage all available data and information about the shortlisted projects that will be included in the CEA is collected to inform the assessment. This should utilise the most current information for each project in the public domain, and assess the assumptions and limitations of the information collected on each shortlisted project.
Stage 4	Each of the shortlisted projects are reviewed in turn by the different topics to assess whether cumulative effects may arise and the nature of those effects (i.e.

CEA Stage	Activity
	beneficial or adverse). The significance of the effects on environmental receptors is established within each ES technical chapters. Where significant adverse cumulative effects are identified, mitigation measures are also considered within the CEA alongside the mechanism to secure that mitigation, e.g. consent condition requirements.

231. PINS Advice Note 17 provides criteria that may be used to indicate the certainty that can be applied to other plans and projects to be considered in the CEA. The criteria are assigned in tiers which descend from Tier 1 (most certain) to Tier 3 (least certain) and reflect a diminishing degree of certainty which can be assigned to each development.

Tier 1

- Under construction;
- Permitted application(s), whether under the PA2008 or other regimes, but not yet implemented; and
- Submitted application(s) whether under the PA2008 or other regimes but not yet determined.

Tier 2

- Projects on the Planning Inspectorate's Programme of Projects where a scoping report has been submitted.

Tier 3

- Projects on the Planning Inspectorate's Programme of Projects where a scoping report has not been submitted;
- Identified in the relevant Development Plan (and emerging Development Plans – with appropriate weight being given as they move closer to adoption) recognising that there will be limited information available on the relevant proposals;
- Identified in other plans and programmes (as appropriate) which set the framework for future development consents/approvals, where such development is reasonably likely to come forward.

17.11.2. Scope of Physical Environment Cumulative Effects Assessment

232. The following impacts have been scoped into the CEA for the physical environment. For sediment disturbance related changes (associated with the potential interaction between sediment plumes), those projects within a mean spring tidal excursion ellipse of the proposed Project have been considered. This approach is consistent with the guidance set out in Brooks et al. (2018) and in NRW Guidance GN041 (NRW, 2020). The mean spring tidal excursion is representative of the larger tidal ranges throughout the year. The majority of individual tides (i.e. most days of the year) have tidal excursion distance similar to or less than the mean spring value. Only a small proportion of individual tides are relatively (slightly) larger than the mean spring condition; the single largest tidal excursion in the year (the largest astronomical range or maximum spring range excursion) only occurs very infrequently and so is very unlikely to coincide with any given activity. The mean spring tidal excursion buffer around the proposed Project is shown in **Figure 17-25** and defines the limit to which meaningful interaction of sediment plumes could theoretically occur. For blockage related changes (associated with the interruption of waves, tides and sediment transport processes), expert judgment has been used to consider the reasonable worst case distance to which change could theoretically propagate from installed infrastructure.

Construction

- Potential cumulative increases in SSC and associated changes in bed level during construction (pathway).

Operation and Maintenance

- Potential cumulative changes in waves, tides and sediment transport during operation, resulting in impacts to designated areas of seabed and or the coast (receptor).

Decommissioning

- None identified.

233. **Table 17-19** presents the short list of projects identified and included within the CEA for the physical environment. Their locations are shown in **Figure 17-25**.

Table 17-19. List of projects considered for the Physical Environment cumulative effects assessment

Project Name/Developer	Project Type	Tier and Status	Approx. distance from the proposed Project
Milford Haven Two Disposal Site	Maintenance Dredge Disposal	Tier 1	4 km
Erebus FLOW (array)	Offshore Wind Farm (Floating)	Tier 1	5 km
Erebus FLOW (export cable)	Offshore Wind Farm (Floating)	Tier 1	<1 km
Marine Energy Test Area (META) Phase 2 East Pickard Bay	Marine Energy	Tier 1	<1 km
META Phase 2 Dale Roads	Marine Energy	Tier 1	6 km
Greenlink Interconnector	Interconnector	Tier 1	<1 km
South Pembrokeshire Demonstration Zone	Wave energy	Tier 2	11 km
Wave Dragon Project -Milla Fjord Site	Wave energy	Tier 2	6 km
Trivane Demonstrator	Offshore Wind Farm (Floating)	Tier 3	15 km
Dragon Energy Project	Inshore energy (pipeline)	Tier 3	7 km
The Crown Estate Round 5 FLOW	Offshore Wind Farm (Floating)	Tier 3	<1 km

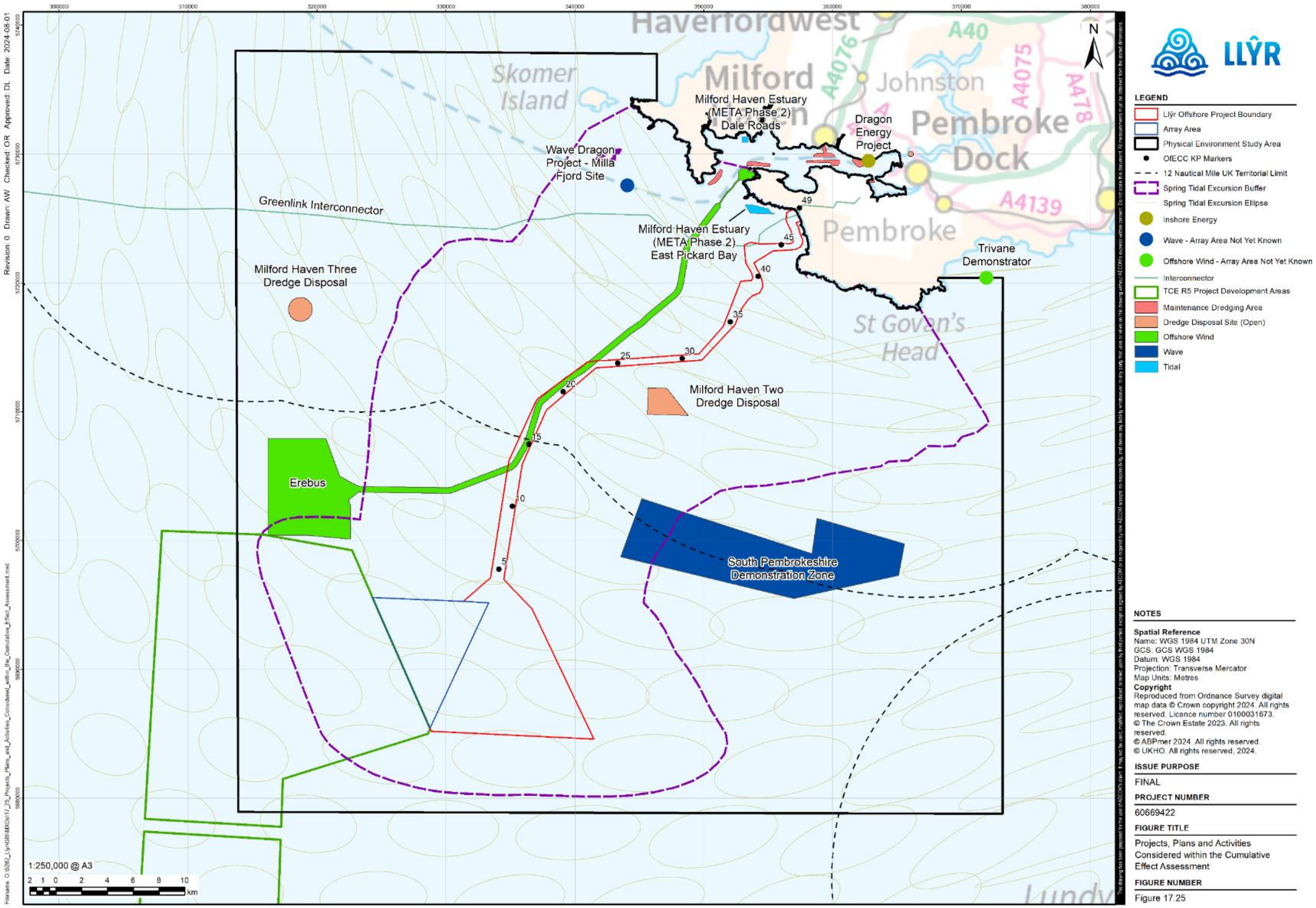


Figure 17-25 Projects, plans and activities considered within the cumulative effects assessment.

17.11.3. *Cumulative Effect Assessment*

Construction

Potential cumulative increases in SSC and associated changes in bed level during construction (pathway)

234. All of the projects, plans and activities set out in **Table 17-19** and **Figure 17-25** have the potential to cause localised temporary increases in SSC due to the installation or removal of structures on the bed and/or through the dredging and disposal of material. Because these plans and activities are within a mean spring tidal excursion ellipse distance from the proposed Project, it is theoretically possible that if these activities were occurring at the same time as construction (or decommissioning) works for the proposed Project, there may be potential for cumulative increases in SSC and associated changes in bed levels. Although the likelihood of temporal overlap between activities is very low, the potential for this cumulative change is assessed further below.

235. Sediment plume interaction generally has the potential to occur if the activities generating the sediment plumes are located within one spring tidal excursion ellipse from one another and occur at the same time. The tidal excursion distance is the approximate distance over which water (or a section of plume with elevated SSC) is advected during one flood or ebb tide. Under mean spring conditions, this is approximately:

- 10 km around the Array Area;
- 14 km around the middle of the OfECC; and
- 19 km around 5 km offshore.

236. Areas beyond the tidal excursion distance and footprint are unlikely to experience any measurable change in SSC from a sediment plume. The interaction between sediment plumes generated by proposed Project-related sediment disturbance activities and those from other nearby plans and activities could theoretically occur in two ways:

- Where plumes generated from the two different activities meet and coalesce to form one larger plume; or
- Where sediment disturbance occurs within the plume generated by the proposed Project construction (or decommissioning) activities (or vice versa).

237. For two or more separately formed plumes that meet and coalesce, the physical laws of dispersion theory mean concentrations within the plumes are not additive but instead a larger plume is created with regions of potentially differing concentration representative of the separate respective plumes. In contrast, where material is released into suspension within the footprint of an existing plume – for instance, plumes formed by a dredging vessel operating within the plume created during cable installation activities (or *vice versa*), the two plumes would be additive, creating a plume with higher SSC.

238. For the most part, the sediment disturbance activities associated with the proposed Project are likely to involve the release of coarse-grained material, although it is acknowledged that drilling associated with the installation of mooring systems could potentially release some finer material into suspension. On the basis of the results presented in **Paragraph 89 et seq.**, it is found that the sediment plumes associated with coarser grained material are expected to be spatially constrained as the material drops out of suspension more quickly. Elevated levels of SSC are therefore expected to return to background levels within a distance of hundreds of

metres from the sediment disturbance location. The analysis also shows that any fine-grained sediment plume will be subject to rapid dispersion, both laterally and vertically, to near-background levels (tens of mg/l) within hundreds to a few thousands of metres at the point of release.

239. Given the above information and the fact that any two sediment disturbance activities are generally located several km apart, for the most part any cumulative increase in either the spatial footprint or peak concentration of sediment plumes are expected to be indistinguishable from background levels. Any associated changes in bed level can also be expected to be immeasurable.

240. A possible exception to the above could occur if the construction programmes for either Erebus and/or the proposed Project were to change, resulting in temporal overlap. The export cable corridors for both projects are near one another between (approximately) KP 13 to KP 23 (**Figure 17-25**). Given the very close proximity of the two activities, it is considered that both types of plume interaction could occur. However, it is noted that in line with UNCLOS (The United Nations Convention on the Law of the Sea) cable installation vessels typically request a 1 nautical mile (circa 1.85 km) vessel safety zone when installing or handling cables. Accordingly, whilst plume interaction may still occur, the potential for much higher concentration and more persistent plumes than that previously described in the proposed Project-alone assessments of SSC (**Paragraph 89 et seq.**) is considered to be small.

241. This section has focused on describing the spatial and temporal characteristics of potential sediment plumes, which are a ‘pathway’ connecting an impact source (i.e. construction activities) with potential receptors (such as designated benthic habitats). As previously stated, Physical Environment receptors are entirely insensitive to elevated levels of SSC and as such, it is not appropriate to carry out an assessment of significance which considers the magnitude of impact to a receptor and the sensitivity of that receptor. However, the potential for these changes to impact other EIA receptor groups is considered elsewhere within the ES, in particular:

- **Chapter 18: Marine Water Quality;**
- **Chapter 19: Benthic Ecology;**
- **Chapter 20: Fish & Shellfish Ecology;**
- **Chapter 21: Marine Mammals; and**
- **Chapter 22: Ornithology.**

Operation and Maintenance

Potential cumulative changes in waves, tides and sediment transport during operation, resulting in impacts to designated areas of seabed and or the coast (receptor)

242. This section focuses on the potential for cumulative changes in waves, tides and sediment transport arising from interaction between cable protection measures associated with the OfECC and that installed to protect subsea cables associated with the developments set out in **Table 17-19** and **Figure 17-25**. These changes could theoretically result in morphological impacts to designated areas of seabed as well the coast.

243. The potential for cumulative changes in waves, tides and associated patterns of sediment transport arising from the Array Area with any of the identified developments is extremely low. This is due to the highly localised nature of blockage related change arising from the proposed Project (see **Paragraph 141 et seq.**). It is also noted that where the OfECC passes

between Turbot Bank and St Gowan Shoals, in addition to the very low (1.5 m high) profile of the berms there are no continuous sediment transport pathways connecting areas of cable protection for the proposed Project, the Greenlink Interconnector and the sandbank features. Accordingly, this has not been assessed further here.

17.12 Inter-related Effects of the Proposed Project

244. The term 'Inter-related' considers the environmental interactions ('inter-relationships') with other receptors within the proposed Project. These are referred to in the Infrastructure Planning (EIA) Regulations 2009 and further described in **Chapter 31: Inter-related Effect Assessment**.

245. As set out in PINS Advice Note 17 (PINS), 2019, inter-related project effects, or ‘interrelationships between topics’, derive from combinations of different project specific impacts which, when acting together on the same receptor, could result in a new or different effect, or an effect of greater significance than the project effects, when considered in isolation.

246. Inter-related effects comprise the following:

- **Project lifetime effects:** effects that have the potential to occur during more than one phase of the proposed Project (i.e. construction, operation and maintenance and decommissioning) and to interact in a way that could potentially create a more significant effect than if it was assessed in isolation.
- **Receptor-led effects:** effects that have the potential to interact, spatially and temporally, to create inter-related effects on a receptor.

247. **Chapter 31: Inter-related Effects Assessment** details the approach to the inter-related effects assessment and includes a description of the likely inter-related effects that may occur because of the proposed Project on the physical environment.

248. The physical environment has been scoped out of the inter-related effects assessment. The reason for this is because the different marine and coastal processes studied are themselves inter-related and the information on changes to marine and coastal processes has been used to inform other EIA topics including those set out below:

- **Chapter 18: Marine Water Quality;**
- **Chapter 19: Benthic Ecology;**
- **Chapter 20: Fish & Shellfish Ecology;**
- **Chapter 21: Marine Mammals; and**
- **Chapter 22: Ornithology.**

249. Assessments have been undertaken separately within these individual topic Chapters and are not reported again here as additional inter-relationships.

17.13 Transboundary Effects

250. A transboundary effect refers to the impacts or effects of a project that extend beyond the boundaries of the United Kingdom and have the potential to affect the environment of other countries within the European Economic Area (EEA). These effects can occur either from the proposed Project on its own or when combined with the effects of other projects or activities in the wider geographical area.

In terms of the impacts on physical environment receptors, impacts will be localised to the extent of the Study Area. Given the intervening distance to neighbouring EEA states, there is no potential for transboundary impacts and resultant effects to occur.

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