Arklow Bank Wind Park 2

Environmental Impact Assessment Report

Volume II, Chapter 6: Coastal Processes

SSE Renewables

Revision	Date	Status	Author	Reviewed by	Approved by
1.0	13/05/2024	Final (External)	GoBe Consultants	GoBe Consultants	Sure Partners Limited

Statement of Authority

Experts	Qualifications	Experience
GoBe/ APEM: Claire Hinton (Author)	BSc (Hons) Marine Sciences at Southampton University, Southampton (1996) Doctorate on the 'Decadal morphodynamic behaviour of the Holland shoreface' from the Flood Hazard Research Centre, Middlesex University (2000)	Dr Claire Hinton has over 18 years' experience in marine environmental consultancy, specifically in the field of physical processes and numerical modelling. As a Principal Consultant, she has acted as Project Director, Project Manager and Technical Expert for a wide range of projects within the Offshore Wind and Oil & Gas sectors. Within commercial projects, she has contributed to Environmental Impact Assessments and associated requirements, from conception through to decommissioning. She has also contributed to guidance for regulators and decision-makers.
GoBe/ APEM: Sammy Sheldon (Technical Reviewer)	MSci (Hons) Oceanography at University of Southampton (2011)	Sammy is an environmental consultant with thirteen years commercial experience, including project management, with a background in oceanography. Sammy has practical experience of field work, statistical analysis of data, report writing and mapping in ArcGIS. She has worked extensively across a range of marine sectors include renewables, oil and gas, ports and harbours and marine water quality. She has also contributed to technical chapters and reports for incorporation into Environmental Statements including physical processes, marine water and sediment quality and Water Framework Directive assessments.

		Furthermore, her experience of the production of post-consent compliance documentation includes drafting of pre-construction documents and environmental appraisals of revised construction methods to gain regulatory approval. In her previous employment she specialised as a numerical modeller in marine and coastal settings. This entailed the construction, calibration and application of hydrodynamic and wave models. These models were used for a range of applications including quantifying changes to physical process regimes and water quality. In addition, Sammy has undertaken numerous metocean studies for a range of marine sectors, including simple weather downtime assessments through to extreme value analysis of winds and waves.
GoBe/ APEM: Anna Kalish (Technical Reviewer)	BSc (Hons) Geography, Newcastle University, First Class MSc Oceanography, University of Southampton, Distinction	Anna joined GoBe having graduated from the University of Southampton in September 2021 with a Distinction in MSc Oceanography, specialising in Physical Oceanography and Climate. Throughout her studies she has developed a comprehensive understanding of the interaction of oceanographic and sedimentary processes occurring in coastal regions, as well as the risks posed to these systems from anthropogenic impacts. She has experience in statistical analysis, climate modelling, GIS, and the processing and interpretation of marine and geophysical datasets. At GoBe, Anna has contributed to a number of offshore wind farm Physical Processes studies, including the preparation of scoping reports, technical appendices, and PEIR and EIA

chapters across English, Scottish and Irish jurisdictions.

She also has experience writing and contributing to technical assessments for incorporation into Environmental Statements for Marine Water & Sediment Quality and Infrastructure & Other Marine Users.

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Glossary

Term	Meaning
Amphidromic point	A geographical location where the tidal range is zero, i.e. the harmonic constituents of the tide has zero amplitude. So, the tidal range increases with distance from this location. An amphidromic point is said to be degenerate when its centre appears to be located over land rather than water.
An Bord Pleanála (ABP)	The independent statutory body that decides on appeals from planning decisions made by local authorities in Ireland. An Bord Pleanála also decides major strategic infrastructural projects under the provisions of the Planning and Development (Strategic Infrastructure) Act 2006 and will have responsibility for determining planning permission for certain classes of development within the maritime area and for the generality of offshore development beyond the nearshore.
Arklow Bank Wind Park 1 (ABWP1)	Arklow Bank Wind Park 1 consists of seven wind turbines, offshore export cable and inter-array cables. Arklow Bank Wind Park 1 has a capacity of 25.2 MW. Arklow Bank Wind Park 1 was constructed in 2003/04 and is owned and operated by Arklow Energy Limited. It remains the first and only operational offshore wind farm in Ireland.
Arklow Bank Wind Park 2 – Offshore Infrastructure	"The Proposed Development", Arklow Bank Wind Park 2 Offshore Infrastructure: This includes all elements under the existing Maritime Area Consent.
Arklow Bank Wind Park 2 (ABWP2) (the Project)	Arklow Bank Wind Park 2 (ABWP2) (The Project) is the onshore and offshore infrastructure. This EIAR is being prepared for the Offshore Infrastructure. Consents for the Onshore Grid Infrastructure (Planning Reference 310090) and Operations Maintenance Facility (Planning Reference 211316) has been granted on 26th May 2022 and 20th July 2022, respectively. • Arklow Bank Wind Park 2 Offshore Infrastructure: This includes all elements to be consented in accordance with the Maritime Area Consent. This is the subject of this EIAR and will be referred to as 'the Proposed Development' in the EIAR. • Arklow Bank Wind Park 2 Onshore Grid Infrastructure: This relates to the onshore grid infrastructure for which planning permission has been granted. • Arklow Bank Wind Park 2 Operations and Maintenance Facility (OMF): This includes the onshore and nearshore infrastructure at the OMF, for which planning permission has been granted. • Arklow Bank Wind Park 2 EirGrid Upgrade Works: any non-contestable grid upgrade works, consent to be sought and works to be completed by EirGrid.
Array Area	The Array Area is the area within which the Wind Turbine Generators (WTGs), the Offshore Substation Platforms (OSPs), and associated cables

Term	Meaning
	(export, inter- array and interconnector cabling) and foundations will be installed.
Cable Corridor and Working Area	The Cable Corridor and Working Area is the area where cabling will be installed and will link the Array Area to the Landfall north of Arklow.. This area will also facilitate vessel jacking operations associated with installation of WTG structures and associated foundations within the Array Area.
Cable protection	External armouring applied to exposed cables or used at cable crossings, typically comprised of rock (berms or bags), ducting (polyurethane, steel, High Density Polyethylene (HDPE), cast iron or plastic) or concrete mattresses.
Concrete mattressing	A solution for providing protection to cables from dropped objects, fishing trawl boards and scour (Subsea Protection Systems, 2020). Typically, several metres wide and long, cast of articulated concrete blocks which are linked by a polypropylene rope lattice which are placed on and/or around structures to stabilise the seabed and inhibit erosion.
Coastal Processes	Marine processes, below the High-Water Mark (HWM) which include the following elements: • Morphology, including bathymetry, geology, surficial sediments and seabed form; • Hydrodynamics, including tidal, non-tidal influences and waves; and • Sediment transport, including bedload, littoral and suspended sediment transport.
Coastal Processes Study Area	The MAC area with an additional buffer zone (known as the Zone of Influence) defined by tidal ellipses and sediment plume modelling.
Environmental Impact Assessment (EIA)	An Environmental Impact Assessment (EIA) is a statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment as amended by Directive 2014/52/EU of the European Parliament and of the Council (EIA Directive).
Environmental Impact Assessment Report (EIAR)	An Environmental Impact Assessment Report (EIAR) is a report of the effects, if any, which the proposed project, if carried out, would have on the environment. It is prepared by the developer to inform the EIA process.
EIAR Scoping Report	The EIAR Scoping Report sets out the proposed scope of work and methods to be applied in the development of an Environmental Impact Assessment Report (EIAR).

Term	Meaning
Foundation	The load carrying support structure for the wind turbine generator tower or offshore substation platform topside. The foundation is the part of the structure from the interfacing flange with the turbine tower or topside-foundation interface, down to below seabed. This includes any secondary steel items associated with the structure. For the purposes of the EIAR the term 'foundation' includes the structure from the WTG tower or topside interface down to the lower end of the monopile commonly known as the 'substructure' and encompasses monopiles and transition pieces.
Landfall	The area in which the offshore export cables make landfall and is the transitional area between the offshore cabling and the onshore cabling.
Maritime Area Consent (MAC)	A consent to occupy a specific part of the maritime area on a non-exclusive basis for the purpose of carrying out a Permitted Maritime Usage strictly in accordance with the conditions attached to the MAC granted on 22nd December 2022 with reference number 2022-MAC-002.
Megaripples	Flow-transverse bed forms with a typical length of 5 m to 20 m and crest heights of 0.2 m to 1.5 m (definition aligned with that presented in Partrac (2022)).
Mitigation measure	Measure which would avoid, reduce, or offset an impact.
Permitted Maritime Usage	The construction and operation of an offshore wind farm and associated infrastructure (including decommissioning and other works required on foot of any permission for such offshore wind farm).
Sandwaves	Flow-transverse marine subaqueous dunes, often with superimposed megaripples, with a typical length of 100 m to 800 m and crest heights of several metres (definition aligned with that presented in Partrac (2022)).
Scour protection	A solution for preventing scour around subsea structures, typically comprised of rock or concrete mattresses.
Semi-diurnal	Two high and two low tides each day, with both highs and both lows of roughly equal height
Permitted Maritime Usage	The construction and operation of an offshore wind farm and associated infrastructure (including decommissioning and other works required on foot of any permission for such offshore wind farm).
The Application	The full set of documents that will be submitted to An Bord Pleanála in support of the consent.
The Developer	Sure Partners Ltd.

Term	Meaning
Trenchless techniques	Trenchless techniques include steerable direct pipe thrusting and Horizontal Directional Drilling (HDD)which allow cable ducts to be installed underground without the need to excavate trenches.
Zone of Influence (ZoI)	Area within which an environmental impact upon Coastal Processes may occur – defined using tidal ellipses and sediment plume modelling.

Acronyms

Term	Meaning
AA	Appropriate Assessment
ABP	An Bord Pleanála
ABWP1	Arklow Bank Wind Park 1
ABWP2	Arklow Bank Wind Park 2
BSI	British Standards Institution
CD	Chart Datum
Cefas	Centre for Environment, Fisheries and Aquaculture Sciences
CFE	Controlled Flow Excavator
CIA	Cumulative Impact Assessment
CPT	Cone Penetration Test
DAS	Dumping at Sea
DCCAE	Department of Communications, Climate Action and Environment
DECC	Department of Energy and Climate Change
DHPLG	Department of Housing, Planning and Local Government
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
HAT	Highest Astronomical Tide
HDD	Horizontal Directional Drilling
Hs	Significant wave height

Term	Meaning
HWM	High-Water Mark
INFOMAR	Integrated Mapping for the Sustainable Development of Ireland's Marine Resource
LAT	Lowest Astronomical Tide
MAC	Maritime Area Consent
MDS	Maximum Design Scenario
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MSFD	Marine Strategy Framework Directive
MSL	Mean Sea Level
NAO	North Atlantic Oscillation
NIS	Natura Impact Statement
NPWS	National Parks and Wildlife Service
NRW	Natural Resources Wales
OGI	Onshore Grid Infrastructure
OMF	Operations and Maintenance Facility
OPW	Office of Public Works
OREDP	Offshore Renewable Energy Development Plan
ORESG	Offshore Renewable Energy Steering Group
OSP	Offshore Substation Platform

Term	Meaning
OWF	Offshore Wind Farm
RCP	Representative Concentration Pathway
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
SECPA	South East Coastal Protection Alliance
SPM	Suspended Particulate Matter
SSC	Suspended Sediment Concentration
Tp	Peak wave period
TSHD	Trailing Suction Hopper Dredger
Tz	Zero-peak wave crossing period
UKHO	United Kingdom Hydrographic Office
WTG	Wind Turbine Generator
ZoI	Zone of Influence

Units

Unit	Description
km	Kilometres
m	Metres
m^2	square metres
m/s	metres per second
mm	Millimetres
nm	nautical miles
µm	micrometre

6 Coastal Processes

6.1 Introduction

6.1.1.1 This chapter of the Environmental Impact Assessment Report (EIAR) presents the assessment of the potential impacts of the Arklow Bank Wind Park 2 (ABWP2) Offshore Infrastructure (hereafter referred to as 'the Proposed Development') on Coastal Processes. Specifically, this chapter considers the potential impact of the Proposed Development below the High-Water Mark (HWM) during the construction, operation and maintenance, and decommissioning phases.

6.1.1.2 For the purposes of both this EIAR chapter and the associated Technical Report, Coastal Processes includes the following elements:

- Morphology, including bathymetry, geology, surficial sediments and seabed form;
- Hydrodynamics, including tidal and non-tidal influences, and waves; and
- Sediment transport, including bedload, littoral and suspended sediment transport.

6.1.1.3 This chapter should be read in conjunction with the following chapters from Volume II:

- Chapter 4: Description of Development;
- Chapter 7: Marine Water and Sediment Quality;
- Chapter 9: Benthic Subtidal and Intertidal Ecology;
- Chapter 10: Fish, Shellfish and Sea Turtle Ecology;
- Chapter 11: Marine Mammals; and
- Chapter 18: Marine Archaeology.

6.1.1.4 This chapter draws upon information contained within Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling.

6.2 Regulatory background

6.2.1.1 The assessment of potential impacts upon Coastal Processes has been made with specific reference to the relevant legislation, plans and policies (Table 6.1). Full details are provided in Volume II, Chapter 2: Policy and Legislation.

6.2.1.2 In addition, a number of other guidance documents specific to the consideration of Coastal Processes are available from jurisdictions with established offshore renewable energy sectors where comprehensive guidance has been developed. This guidance will be used to inform the assessment of the potential impacts.

Table 6.1: Summary of regulatory background

Publisher	Name of document incl. reference	Key provisions
Statutory		
Legislation		
European Commission, 2011	European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011);	Transposes EU Directive 2008/56/EC (Marine Strategy Framework Directive) into Irish law.
Minister for Housing, Local Government and Heritage, 2000	Planning and Development Act 2000 (as amended)	The Planning and Development Act 2000 (as amended) establishes the foundation for planning in Ireland and combines a wide range of legislation relating to different sectors in one place. The Act sets out the process for applying for and attaining planning permission which includes the requirements for an Environmental Impact Assessment (EIA). The main regulations that underpin the Act are the Planning and Development Regulations 2001 (S.I. No. 600 of 2001). The Regulations have been amended and are collectively called the Planning and Development Regulations 2001 to 2023.
UK Government 2017	Conservation of Habitats and Species Regulations 2017	Maintain or, where appropriate, restore habitats and species listed in Annexes I and II of the Habitats Directive to a favourable conservation status.
European Commission, 1992	European Union (EU) Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (the 'Habitats Directive')	Protects habitats and species of European nature conservation importance through the establishment of a network of designated sites.
European Commission, 2008	Marine Strategy Framework Directive (MSFD) (EU, 2008)	Descriptors of Good Environmental Status, Descriptor 6: Seafloor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected. Descriptors of Good Environmental Status, Descriptor 7: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.

Publisher	Name of document incl. reference	Key provisions
Planning Policy and Development Control		
DECC, 2022	Strategic Environmental Assessment (SEA) of the Offshore Renewable Energy Development Plan (OREDPII) in Ireland: Environmental Report https://www.gov.ie/en/publication/71e36-offshore-renewable-energy-development-plan-ii-oredp-ii/#environmental-assessments	Contains the AA screening process and SEA scoping report of the Maritime area associated with OREDPI and OREDPII. This resource has some important information on existing baseline conditions in the maritime area.
The Department of Housing, Planning and Local Government (DHPLG), 2021	National Marine Planning Framework https://www.gov.ie/en/publication/60e57-national-marine-planning-framework/	Provides a suite of National Marine Planning Policies, which are aligned with descriptors provided within the Marine Strategy Framework Directive (MSFD 2008/56/EC).Those with relevance to coastal processes Include: • *Sea-floor and water column integrity* (An assessment of the Proposed Development upon these descriptors is provided in Section's 6.10.1,6.10.2,6.11.1 and 6.11.2 of this EIAR Chapter)*:* – *Policy 1 - Proposals that incorporate measures to support the resilience of marine habitats will be supported, subject to the outcome of statutory environmental assessment processes and subsequent decision by the competent authority and where they contribute to the policies and objectives of this National Marine Planning Framework. Proposals which may have significant adverse impacts on marine, particularly deep sea, habitats must demonstrate that they will, in order of preference and in accordance with legal requirements:* *a) avoid,* *b) minimise, or* *c) mitigate significant adverse impacts on marine habitats,or* *d) if it is not possible to mitigate significant adverse impacts on marine habitats must set out the reasons for proceeding;* • *Climate change* (An assessment of the Proposed Development upon these descriptors is provided in Sections 6.10.2 and 6.11.2 of this EIAR Chapter, in addition to Volume II, Chapter 9: Benthic Subtidal and Intertidal Ecology of this EIAR document); – *Policy 1 - Proposals should demonstrate how they:*

Publisher	Name of document incl. reference	Key provisions
		• *avoid contribution to adverse changes to physical features of the coast;* • *enhance, restore or recreate habitats that provide a flood defence or carbon sequestration ecosystem services where possible.* *Where potential significant adverse impacts upon habitats that provide a flood defence or carbon sequestration ecosystem services are identified, these must be in order of preference and in accordance with legal requirements:* *a) avoided,* *b) minimised,* *c) mitigated,* *d) if it is not possible to mitigate significant adverse impacts, the reasons for proceeding must be set out.* *This policy should be included as part of statutory environmental assessments where such assessments are required.*
DCCAE, 2018.	Offshore Renewable Energy Development Plan (OREDP) Interim Review https://www.gov.ie/en/publication/71e36-offshore-renewable-energy-development-plan-ii-oredp-ii/	Providing an assessment of progress on the key policy actions set out in the 2014 OREDP. Including Action 9: Environmental Monitoring.
DHPLG and Office of Public Works (OPW), 2023.	Coastal Change Management Strategy Report https://www.gov.ie/en/publication/9a967-report-of-the-inter-departmental-group-on-national-coastal-change-management-strategy/	Report detailing the outcome from scoping a National Coastal Change Management Strategy, which included a suit of recommendations. These included recommendations for: • coastal monitoring and data collection; • coastal asset database; • coastal change research programme; and • national assessment of coastal change risk.
Guidelines and technical standards		

Publisher	Name of document incl. reference	Key provisions
EPA, 2022	Guidelines on the Information to be Contained in Environmental Impact Assessment Reports https://www.epa.ie/publications/monitoring--assessment/assessment/EIAR_Guidelines_2022_Web.pdf	These Guidelines apply to the preparation of all Environmental Impact Assessment Reports undertaken in the State (Ireland). Guidance is provided on the expected scope of the Baseline Scenario.
(Environmental Working Group of the Offshore Renewable Energy Steering Group (ORESG) and the Department of Communications, Climate Action and Environment (DCCAE), 2017)	Guidance on Environmental Impact Statement (EIS) and Natura Impact Statement (NIS) Preparation for Offshore Renewable Energy Projects. https://www.gov.ie/en/publication/3d6efb-guidance-documents-for-offshore-renewable-energy-developers/#	Guidance on the EIS processes and documentation, including the requirements for descriptions of the receiving environment, assessment of likely significant effects. Including specific Guidance on Coastal Processes: '*Depending on the location there are potential significant effects from offshore renewable energy projects associated with marine Coastal Processes relating to sedimentation, wave impacts and coastal erosion. In addition to sediment sampling, hydrographic, geophysical and tidal current surveys are often required to support the assessments. A variety of model simulations relating to sediment dispersal, tidal flow and wave impacts can be used in determining the likely significant effects*.'
Non-Statutory		
Guidelines and technical standards		
Lambkin *et al*., 2009	Coastal Process Modelling for Offshore Windfarm Environmental Impact Assessment: Best Practice Guide	Best practice on the identification, development, calibration, validation and scenarios to be applied for OWF projects.
Judd, 2012	Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects	Generic advice for the acquisition of data to support environmental assessments for offshore renewable energy developments. Guidance is provided in the design, review and implementation of environmental data collection and analytical activities associated with all stages of offshore renewable energy developments.

Publisher	Name of document incl. reference	Key provisions
Brooks *et al.,* 2018	National Resources Wales (NRW) Monitoring 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	Guidance on marine, coastal and estuarine physical processes developed from a review of existing published guidance relevant to physical processes EIA studies, consideration of project examples and from the experience gained by the authors during work on large scale marine developments. Information is included on: • EIA baseline survey and monitoring requirements for – hydrodynamics (waves, tidal currents and water levels); – sediments, sediment transport and geology; and – morphology. • pathways for change and potential impacts for each of the development stages; • potential magnitude of these changes, identifying for which development types and development stages they are likely to be greatest.
BERR, 2008	Review of Cabling Techniques and Environmental Effects applicable to the Offshore Windfarm Industry. Department for Business Enterprise and Regulatory Reform in association with Defra	Provides a description of the range of techniques used to install and maintain subsea cables. Information is also provided on a range of commonly applied cable protection measures, in addition to the technical information on cable design and installation. Discussion is also afforded on the physical changes or effects to the seabed and sub-surface sediments expected to occur during cabling activities are also described. This includes consideration of the relative extent/ magnitude of sediment disturbance that is likely to occur during cable burial for each technique as well as potential sediment plume characteristics. The latter is discussed with reference to direct field monitoring during cable installation activities.
Natural England and Joint Nature Conservation Committee, 2022.	Nature conservation considerations and environmental best practice for subsea cables for English Inshore and UK offshore waters	Identifies the main pressures, sensitive habitats, and best practice for the placement, installation and maintenance of subsea cables in English Inshore and UK offshore waters.
Natural England, 2018	Offshore wind cabling: ten years experience and recommendations	Presents Natural England's position with respect to the environmental impacts of power cable installation and highlighting any concern for nature conservation.

Publisher	Name of document incl. reference	Key provisions
Marine Management Organisation (MMO), 2014	Review of environmental data associated with post-consent monitoring of licence conditions of Offshore Wind Farms (OWFs). MMO Project No: 1031	Provides outcomes and conclusions from monitoring campaigns, with specific consideration to physical processes monitoring, with a focus on: • scour; • suspended sediments; • current/wave effects; and • monitoring of coastal morphology.
Natural England, 2022	Best Practice Advice for Evidence and Data Standards for offshore renewables projects	Provision of best practice advice on the use of data and evidence to support OWF development and consenting in English waters. Focus is made on the key ecological receptors which pose a consenting risk for projects, namely seabirds, marine mammals, seafloor habitats and species and fish.
ABPmer *et al*., 2010	Further review of sediment monitoring data. (COWRIE ScourSed-09)	Provides a review of available physical processes monitoring data, any lessons learnt and recommendations for future sediment monitoring. The review focuses upon: • suspended sediments, • seabed morphology and • scour. Monitoring data available from within built arrays is considered and recommendations are provided for refining monitoring strategies (e.g. that associated with bathymetric survey timing, consistency and extent) to enable robust determination of change between pre- and post-construction survey.
HR Wallingford *et al*., 2007	Dynamics of scour pits and scour protection - Synthesis report and recommendations. (Sed02)	Provides a synthesis of the following: • Identification, collation and review of all available field evidence for scour from Round 1 wind farm projects and other relevant European marine projects; • UK and European research relating to scour and scour protection for the wind farm industry; • Publications and guidance relating to scour and scour protection within other marine industries, including types of scour protection and their potential impact on coastal processes and navigation;

Publisher	Name of document incl. reference	Key provisions
		• Design and installation of scour protection for Scroby Sands against the performance as recorded by previous Data, Technology and Innovation funded investigations; • Design and installation of scour protection for other UK and European sites, potentially including scour in relation to cabling as well as foundations; • Gaps in the scour and scour protection knowledge base, especially on mobile sandbanks.
ABPmer and METOC, 2002	Potential effects of offshore wind developments on Coastal Processes.	Identifies, reviews and assesses the potential effects on coastal from UK Round 1 OWF developments, including: • appropriate baseline characterisation to enable robust assessment of potential effects • key data requirements for each coastal process parameter, including information on measurement frequency and duration.

6.3 Consultation

6.3.1.1 Consultation responses received specific to Coastal Processes are provided in Table 6.2.

6.3.1.2 Consultation responses in relation to the potential impacts on specific environmental receptors, arising from the effects of changes to Coastal Processes, are presented in Volume II, Chapter 7: Marine Water and Sediment Quality; Volume II, Chapter 9: Benthic Subtidal and Intertidal Ecology; Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology; Volume II, Chapter 11: Marine Mammals; and Volume II, Chapter 12: Offshore Ornithology.

Table 6.2: Summary of consultation relating to Coastal Processes

Date	Consultation type	Consultation and key issue raised	Section where provision is addressed
March 2023	Public Event	Concerns raised about the impacts of the development upon the sandbank and nearby beaches.	An assessment of the Proposed Development upon seabed morphology and coastal processes is provided in Sections 6.10.1, 6.10.2, 6.11.1 and 6.11.2 of this EIAR Chapter.
8th April 2023	ABWP2 Pre-Scoping Consultation – South East Coastal Protection Alliance (SECPA)	SECPA consider that an OWF development on the Arklow Sandbank (or any sandbank, for that matter) will inevitably lead to significant, irreversible damage to the natural ecosystems that exists there and on the proximate coastline. SECPA also consider that the presence of a wind farm would cause and accelerate coastal erosion.	Considerations of the ecosystem impacts of the Proposed Development are provided in: • Volume II, Chapter 9: Benthic Subtidal and Intertidal Ecology; • Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology; • Volume II, Chapter 11: Marine Mammals; • Volume II, Chapter 12: Offshore Ornithology An assessment of the Proposed Development upon the proximate coastline, including coastal behaviour, is provided in Sections 6.10.1, 6.10.2, 6.11.1 and 6.11.2 of this EIAR Chapter.
13th June 2023	An Bord Pleanála (ABP) pre application meeting	ABP's representatives stated that coastal processes, stability issues, sediment release or potential changes to tidal patterns and possible erosion need to be addressed in the application.	An assessment of the Proposed Development upon coastal processes is provided in Sections 6.10.1, 6.10.2, 6.11.1 and 6.11.2 of this EIAR Chapter. An assessment of the potential effects upon the hydrodynamic regime, including tides and consequential seabed changes, is provided in Section 6.10.2 and paragraph 6.11.2.6.
8th August 2023	ABWP2 Scoping Consultation – Environmental Health Service	A detailed assessment/ sampling of the current ground stability of the seabed to confirm seabed sediment type, existing contamination status and faunal community	Considerations of the existing seabed sediment regime is provided in paragraph 6.6.1.13 of this EIAR Chapter. A consideration of sediment contamination is provided in Volume II, Chapter 7: Marine Water and

Date	Consultation type	Consultation and key issue raised	Section where provision is addressed
		type for the proposed renewable energy development. The assessment should include the impact construction work may have on the future stability of the seabed, taking into consideration scouring and extreme weather events i.e. waves and the potential erosion.	Sediment Quality with faunal communities discussed in Volume II, Chapter 9: Benthic Subtidal and Intertidal Ecology. An assessment of the potential impact of the Proposed Development upon seabed receptors is provided in Sections 6.10.1, 6.10.2, 6.11.1 and 6.11.2 of this EIAR Chapter.
8th August 2023	ABWP2 Scoping Consultation. – Environmental Health Service	All proposed mitigation measures should be detailed in the EIAR. Information should be provided on the make and model of the turbines and on construction details for the turbine foundations, including the depth and volume of concrete required in the seabed.	Volume II, Chapter 4, Description of Development, provides detail on the characteristics of the Proposed Development, including mitigation measures. Those mitigation measures relevant for Coastal Processes are provided in Section 6.8.3 of this EIAR Chapter.
8th August 2023	ABWP2 Scoping Consultation. – Environmental Health Service	The Environmental Health Service recommends that a detailed Stability/ Seabed Assessment/ Sampling of the proposed site should be undertaken to assess the suitability of the seabed for the Proposed Development. The EIAR should include provision for a stability monitoring programme to identify early signs of potential slides.	A seabed mobility assessment has been undertaken for the Proposed Development: Partrac, 2022. Arklow Bank Wind Park Morphodynamic Study Interpretative Report.
8th August 2023	ABWP2 Scoping Consultation. – Environmental Health Service	All existing or proposed wind farm developments in the vicinity should be clearly identified in the EIAR. The impact on sensitive receptors of the Proposed Development combined with any other wind farm/ renewable energy developments in the vicinity should be considered. The EIAR should include a detailed assessment of any likely significant cumulative impacts of the proposed renewable energy development.	All existing/ proposed wind farm developments within the vicinity of the Proposed Development and relevant to the Cumulative Impacts Assessment (CIA) presented in Section 6.12 of this EIAR Chapter are based upon the results of a screening exercise (Volume III, Appendix 3.2: CIA Screening).

6.4 Study area

6.4.1.1 This description of the existing (baseline) environment provides a regional (far-field) overview prior to focusing on the Coastal Processes Study Area and in recognition of the different elements of the Proposed Development. As such descriptions are provided for the following sub-areas:

- Array Area (including Wind Turbine Generators (WTGs), Offshore Substation Platforms (OSPs) inter-array cables, export cables and interconnectors cables);
- Cable Corridor and Working Area (including export, interconnectors, inter-array cables and working area for construction activities), which includes the transition from offshore to nearshore marine process environmental conditions; and
- Landfall.

6.4.1.2 The Coastal Processes Study Area is presented in Figure 6.1 and includes buffer zones to represent a "Zone of Influence (ZoI)" for potential impacts that might be created within the main areas of activity. Using a precautionary approach, the buffer zones are scaled to conservatively represent the equivalent distance of two tidal excursions on a mean spring tide and comprise a distance of, approximately, 20 km in a north-south direction from the Proposed Development's boundary, corresponding with the direction of the tidal flow (paragraph 6.6.1.4 *et seq*).

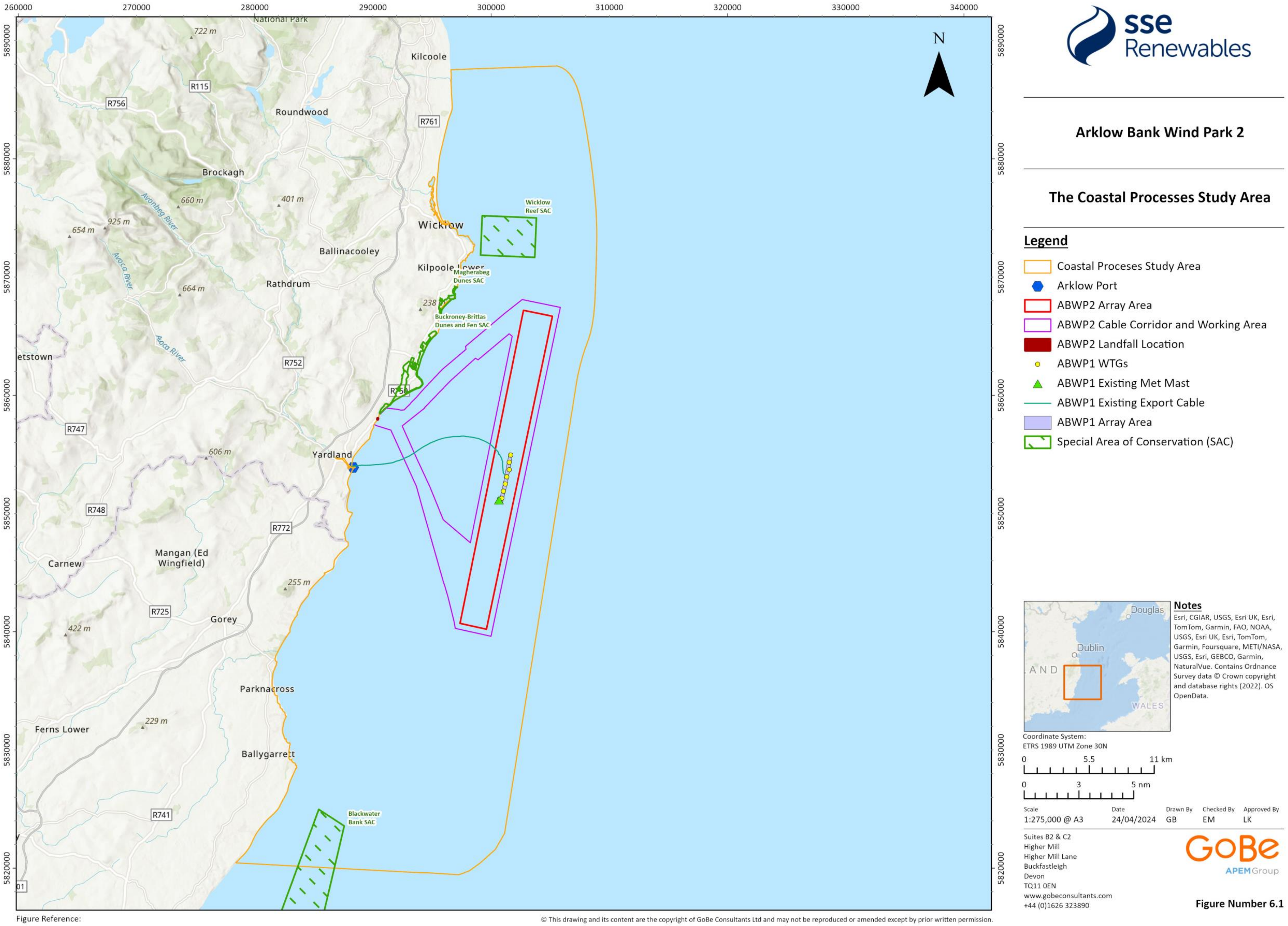

Figure 6.1: The Coastal Processes Study Area

6.5 Methodology

6.5.1 Methodology to inform the baseline

Desktop studies

6.5.1.1 Information on the baseline environment within the Coastal Processes Study Area was collected through a detailed desktop review of existing studies and datasets. Those sources which have been identified as providing useful information regarding Coastal Processes within the study area, including those which provide detail regarding past behaviour, for example historic coastal behaviour, are presented in Table 6.3 and include:

- Data available from a number of marine data portals, including the Integrated Mapping for the Sustainable Development of Ireland's Marine Resource (INFOMAR) (https://www.infomar.ie/ [Accessed February 2024]) and the Marine Institute (http://www.marine.ie [Accessed January 2024]);
- Existing marine process investigations from across the Coastal Processes Study Area, including the EIAR and supporting documentation for Arklow Bank Wind Park 1 (ABWP1), noting that ABWP1 is part of the existing (baseline) environment ; and
- Numerical modelling of hydrodynamic, wave and sediment transport processes developed to inform this assessment.

Site specific surveys

6.5.1.2 In order to inform the EIAR, site-specific surveys were undertaken. A summary of the surveys used to inform the Coastal Processes impact assessment is outlined in Table 6.4.

Table 6.3: Summary of key desktop reports and data resources

Title	Source	Year	Author
Coastal morphological modelling to assess the dynamics of Arklow Bank, Ireland	International Journal of Science Research	2009	Panigrahi J.K., Ananth P.N. and Umesh P.A.
Strategic Environmental Assessment (SEA) of the Offshore Renewable Energy Development Plan (OREDPI and OREDPII) in the Republic of Ireland	Department of the Environment, Climate and Communication (DECC)	2010	DECC
Irish Coastal Protection Strategy Study and Catchment Flood Risk Assessment Management Studies	Office of Public Works (OPW)	2010	RPS Group Ltd
Iarnród Éireann East Coast Erosion Study	OPW	2020	Ove Arup & Partners Ireland Ltd
Morphological Modelling to Investigate the Role of External Sediment Sources and Wind and Wave-Induced Flow on Sandbank Sustainability: An Arklow Bank Case Study	Journal of Marine Science and Engineering	2023	Creane, S., O'Shea, M., Coughlan., Murphy, J.
Development and Dynamics of Sediment Waves in a Complex Morphological and Tidal Dominant System: Southern Irish Sea.	Journal of Geosciences	2022	Creane, S., Coughlan, M., O'Shea, M., Murphy, J.
Dumping at Sea Permit Application: Material Analysis Report	EPA	2016	Arklow Energy Limited
Arklow Bank Wind Farm 1: monitoring survey 2004 - 2022	Arklow Energy Limited	Multiple	GE Wind Energy
Stratigraphic model of the Quaternary sediments of the Western Irish Sea Mud Belt from core, geotechnical and acoustic data	Geo-Marine Letters	2019	Coughlan, M,. Wheeler, A.J., Dorschel, B., Long, M., Doherty, P. and Morz, T.
Seabed Mapping Programme	Integrated Mapping for the Sustainable Development of Ireland's Marine Resource (INFOMAR)	Multiple	INFOMAR

Table 6.4: Site specific information

Data source	Date(s) of survey	Overview of survey/ report	Survey contractor
ABWP2			
Geophysics and Hydrographic Data Processing and Interpretation Report.	2023	Information regarding the survey details and associated analysis of the project specific geophysical survey.	Green Rebel Ltd
Arklow Bank Wind Park Morphodynamic Study Interpretative Report.	2022	Detailed assessment report on sediment transport and morphological change within the Array Area, Cable Corridor and Working Area and wider region. Based on historical data, project specific survey results and numerical models.	Partrac
Field Operations and Preliminary Results Report (ISO Part 1) Arklow Bank Wind Park – Geotechnical Borehole Survey 2022	2022	Results from the project -specific borehole survey.	Sure Partners Ltd
Arklow Bank Wind Park: LF2 Landfall Feasibility Study	2022	Feasibility Study to demonstrate a cable Landfall by using a Horizontal Directional Drilling technique at a site located to the north of Arklow	Waterman Infrastructure & Environment Limited
Effect of Wind Farm Structures on the Arklow Bank Seabed	2001	Assessment of the potential impacts of the presence of wind farm structures on Arklow Bank, based on available data.	Murphy J. and Dollard B.
Arklow Bank Offshore Windfarm Environmental Monitoring. Benthic Ecology Survey Report	2021	Information regarding the survey details and associated analysis of the project specific benthic survey.	Aquatic Services Unit MS210201
Arklow Offshore Wind Farm Metocean Study, Final Data Report.	2021	Half hourly data, for temperature, conductivity, salinity, density, turbidity, waves, water level, currents, at five locations on Arklow Bank.	Fugro GB Marine

Data source	Date(s) of survey	Overview of survey/ report	Survey contractor
Arklow Bank Wind Park II. Cable Landfall: Feasibility Study	2020	Feasibility Study to determine suitable cable Landfall methods, and the preferred Landfall site, through a process of Options Appraisal.	Waterman Infrastructure & Environment Limited
Exploratory Borehole Records: 2000	2000	Results from an initial, project -specific borehole survey.	Sure Partners Ltd
Arklow Bank Wind Park Export cable route: Results Report	2019	Information regarding the survey details and associated analysis of the project specific geophysical survey. For a Cable Corridor and Working Area defined prior to refinement.	Ultrabeam Hydrographic Ltd
Arklow Bank Wind Park Array Area: Results Report	2019	Information regarding the survey details and associated analysis of the project specific geophysical survey. For an Array Area defined prior to refinement.	Ultrabeam Hydrographic Ltd
Geological and Geotechnical Desk Top Study	2018	Presentation of a geological and geotechnical understanding of the Array Area and Cable Corridor and Working Area, prior to the collection of project specific data	Cathie Associates Ltd

Identification of designated sites

6.5.1.3 All designated sites within the Coastal Processes Study Area and qualifying interests that could be affected by the construction, operational and maintenance, and decommissioning phases of the Proposed Development were identified using the three-step process described below:

- *Step 1: All designated sites of international, national and local importance within the Coastal Processes Study Area were identified using a number of sources. These included the Environmental Protection Agency (EPA) and National Parks and Wildlife Service (NPWS) websites.*
- *Step 2: Information was compiled on the relevant qualifying interest for each of these sites which may make them a sensitive receptor in terms of Coastal Processes. For example, wave blockage effects may result in coastline changes*
- *Step 3: Using the above information and expert judgement, sites were included for further consideration if:*
  - *A designated site directly overlaps with the Proposed Development; or*
  - *Sites and associated qualifying interests were located within the ZoI for potential impacts associated with the Proposed Development.*

6.5.1.4 Those designated sites that are considered within this Coastal Processes EIAR are presented in Table 6.5 and shown in Figure 6.2.

Table 6.5: Designated sites for the Coastal Processes

Designated Site	Closest Distance to (km)		Relevant Qualifying Interest
	Array Area	Cable Corridor and Working Area	
Marine: below the High Water Mark			
Wicklow Reef SAC	4.5	3.6	• Reefs (formation on areas subject to scour) • *Reefs are unable to recover morphologically from physical impacts i.e. cable activities that damage or physically change rock features (Natural England and JNCC, 2022)*
Blackwater Bank SAC	19.7	19.1	• Annex I habitat 'Sandbanks which are slightly covered by sea water all the time'. • *Sandbanks are sensitive to activities which alter the processes required to maintain the features' 'form and function'.*
Terrestrial: above the High Water Mark			
Magherabeg Dunes SAC	5.9	3.4	• Dunes • *Dunes are naturally dynamic systems that require continuous supply and circulation of sand. The construction of physical barriers such as sea defences can interrupt longshore drift, leading to beach starvation and increased rates of erosion. Sediment circulation and erosion also has a role to play in the more stabilised dune habitats. Cycles of erosion and stabilisation are part of a naturally functioning dune system (NPWS, 2017a).*

Designated Site	Closest Distance to (km)		Relevant Qualifying Interest
	Array Area	Cable Corridor and Working Area	
Buckroney-Brittas Dunes and Fen SAC	6.8	0.1	• Dunes; shingle beaches; saltmarshes; alkaline fens • *The health and on-going development of this habitat relies on a continuing supply of shingle sediment. This may occur sporadically as a response to storm events rather than continuously. Interference with the natural coastal processes, through offshore extraction or coastal defence structures in particular, can interrupt the supply of sediment and lead to beach starvation (NPWS, 2017b).* • *Accretion and erosion are natural elements of saltmarsh systems. Maintaining the sediment supply is vital for the continued development and natural functioning of a saltmarsh system. Interruption to the sediment circulation through physical structures can starve the system and lead to accelerated erosion rates (NPWS, 2017b).* • *Dunes are naturally dynamic systems that require continuous supply and circulation of sand. The construction of physical barriers such as sea defences can interrupt longshore drift, leading to beach starvation and increased rates of erosion. Sediment circulation and erosion also has a role to play in the more stabilised dune habitats. Cycles of erosion and stabilisation are part of a naturally functioning dune system (NPWS, 2017b).*

6.5.1.5 In addition to the identification of designated sites, a number of qualifying features have been identified which can be considered Coastal Process receptors, as presented in Table 6.6.

Table 6.6: Relevant qualifying features for the Coastal Processes

Relevant feature	Closest Distance to (km)		Relevant Qualifying Interest
	Array Area	Cable Corridor and Working Area	
Offshore sandbanks:			• *Sandbanks are sensitive to activities which alter the processes required to maintain the features' 'form and function'.*
• Arklow Bank	0	0	
• Seven Fathom Bank	2.04	0	

Relevant feature	Closest Distance to (km)		Relevant Qualifying Interest
	Array Area	Cable Corridor and Working Area	
Coastline below High-Water Mark	5.87	0	• *The coastal zone is sensitive to activities which change the hydrodynamic forcing (waves; tides) at the shoreline. This in turn can alter the erosive/ accretive tendencies of the coast in addition to littoral transport.*

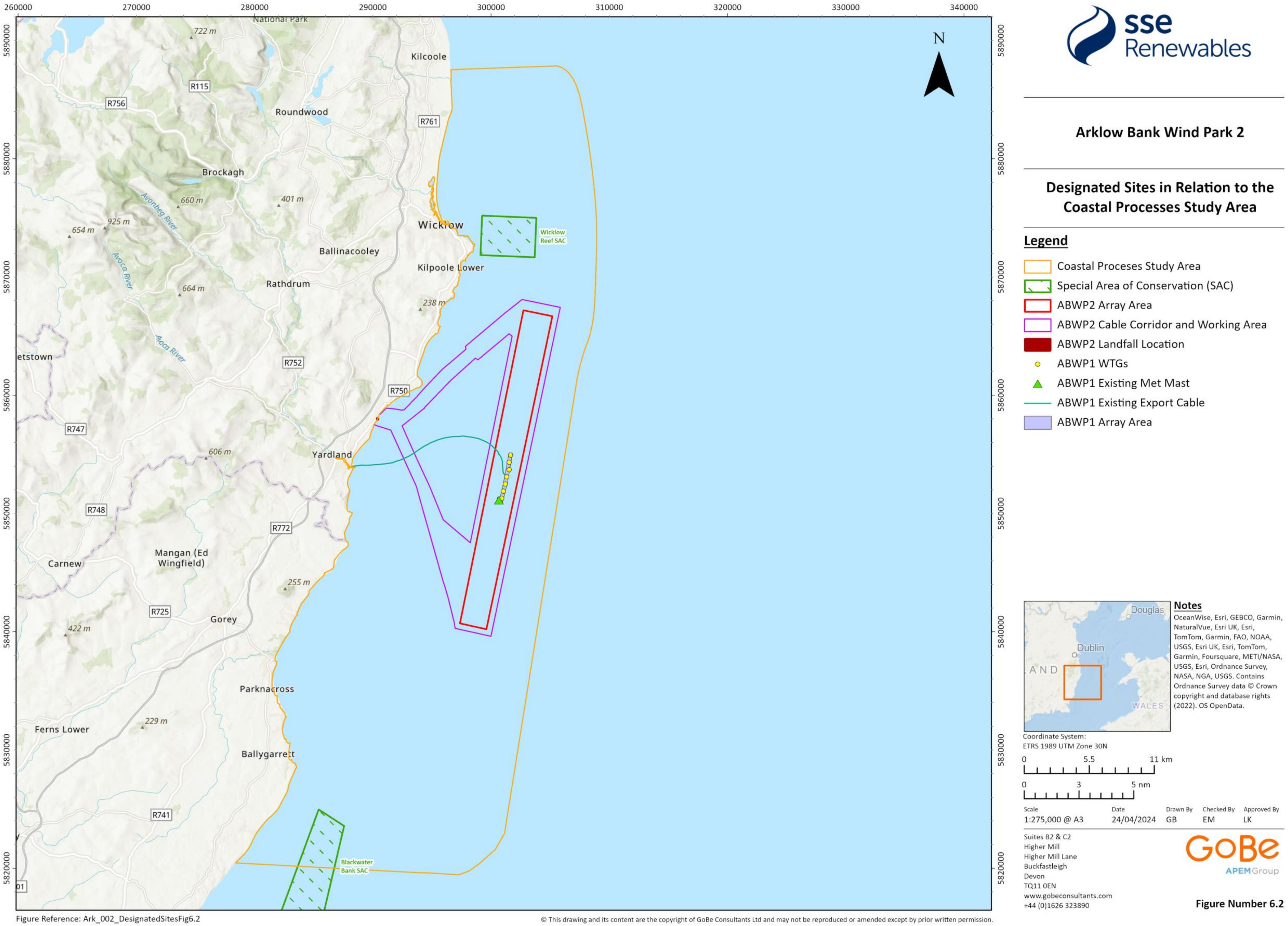

Figure 6.2: Designated sites in relation to the Coastal Processes Study Area

6.6 Baseline environment

6.6.1 The Array Area

Hydrodynamics

TIDAL REGIME

6.6.1.1 The Irish Sea tides are semi-diurnal. The tidal range varies in the Irish Sea from large tidal ranges (such as in Liverpool Bay, UK) to a very small tidal range near the degenerate amphidromic point near Co.Wicklow and Co.Wexford (Howarth, 2005). The mean spring tidal range is between 4 and 5 m near the median line of Ireland/ UK, decreasing to the Irish Coast to, approximately 2 m.

6.6.1.2 The tidal range at the Proposed Development is influenced by the presence of a degenerate amphidromic point located in the eastern Irish coast at Courtown, resulting in a near-zero tidal range (Creane *et al.*, 2022), classified as a micro-tidal setting.

6.6.1.3 Metocean surveys undertaken for the Proposed Development between 2019 and 2021 have shown that the tidal range within the Array Area, Cable Corridor and Working Area are greatest at the northern tip of Arklow Bank, where a range of 2.71 m was recorded (Fugro, 2021). The influence of the amphidromic point upon tidal range has been observed from the data collected at the five locations, with the closest measurements exhibiting more obvious double high water' effects (Partrac, 2022). Tide levels within the Array Area are presented in Table 6.7.

Table 6.7: Tidal level information for within the Array Area

Parameter	Tide level, referenced to LAT (m)	
	North Array Area	South Array Area
Lowest Astronomical Tide (LAT)	0.0	0.0
Mean Low Water Springs (MLWS)	0.58	0.46
Mean Low Water Neaps (MLWN)	0.95	0.79
Mean Sea Level (MSL)	1.34	0.89
Mean High Water Neaps (MHWN)	1.73	0.99
Mean High Water Springs (MHWS)	2.1	1.32
Highest Astronomical Tide (HAT)	2.42	1.83

6.6.1.4 Peak spring tidal currents can exceed 2 m/s to the northwest of Anglesey, whilst weak tidal currents occur to the southwest of the Isle of Man, towards Dundrum and Dundalk Bays (less than 0.25 m/s at spring tides) and between the Isle of Man and the Cumbrian coast (approximately 0.5 m/s) as a consequence of the standing wave that occurs here (where two tidal waves meet) (Howarth, 2005). Slack water typically occurs at high and low water in the Irish Sea as a consequence of the standing wave phenomena.

6.6.1.5 Strong tidal currents are experienced within the site and coincide with the presence of the Arklow Bank sandbank feature. The general flow direction is towards the north-northeast during the flood tide and towards the south-southwest during the ebb (Creane *et al.*, 2022; Panigrahi *et al.*, 2009). Spring tidal current speeds are in excess of 2 m/s towards the north end of the sandbank on both flood and ebb tides, whilst to the south the peak tidal currents are of the order of 1.4 m/s (Fugro, 2021). The greater speeds to the north of the Array Area have been hypothesised to be a function of the local bathymetry, specifically Wicklow Trough to the north focussing flows to the south towards Arklow Bank (Partrac, 2022). As would be expected, the metocean survey showed that current speeds are greater at the water surface than near-bed (Fugro, 2021).

6.6.1.6 Current direction recorded within the metocean survey clearly show that the tides are recti-linear[1], along a north northeast (flood tide) to south southwest (ebb tide) (Fugro, 2021).

6.6.1.7 The residual tidal current on the Arklow Bank has been found by Horrillo-Caraballo *et al.* (2021) to have a, generally, clockwise circulation, with a residual flow northward on the western flank and a southward direction of the residual flow on the eastern flank. Modelling results by Creane *et al.* (2023) and Partrac (2022) identified a flood and ebb tidal current dominance on the west and east side of the bank, respectively. Further, numerical modelling has also shown a net cross-bank flow in an easterly direction over the central portion of the bank (Partrac, 2022). Of note is that it is suggested that the strength and direction of the tidal current residuals vary on a monthly basis (with implications on Arklow Bank's morphodynamic behaviour – see paragraph 6.6.1.18 *et seq.*) (Creane *et al.*, 2023). High values of vorticity maxima in the tidal residual flow (an indicator of sediment transport and water movement) within the Array Area are predicted and align with the presence of the sandbank (Horrillo-Caraballo *et al.,* 2021).

6.6.1.8 Superimposed upon regular tidal behaviours are various non-tidal influences, which mainly originate from meteorological effects. An example is surges, formed by rapid changes in atmospheric pressure causing the water levels to fluctuate considerably above or below the tidal level. This effect can be further impacted by the wind strength and direction. Moving low pressure systems and associated strong and persistent wind fields may generate strong positive surges, often referred to as a 'storm surge'. Storm surges may cause short-term modification of astronomically driven tidal currents. The 1 in 50-year return period storm surge at the site is of the order of 1.0 m (Flather *et al.*,1998). Under an extreme (1 in 50-year return period) storm surge, current speeds may be more than twice that encountered under normal peak spring tide conditions (Flather *et al.*,1998).

[1] Tidal currents that ebb and flood in opposite directions

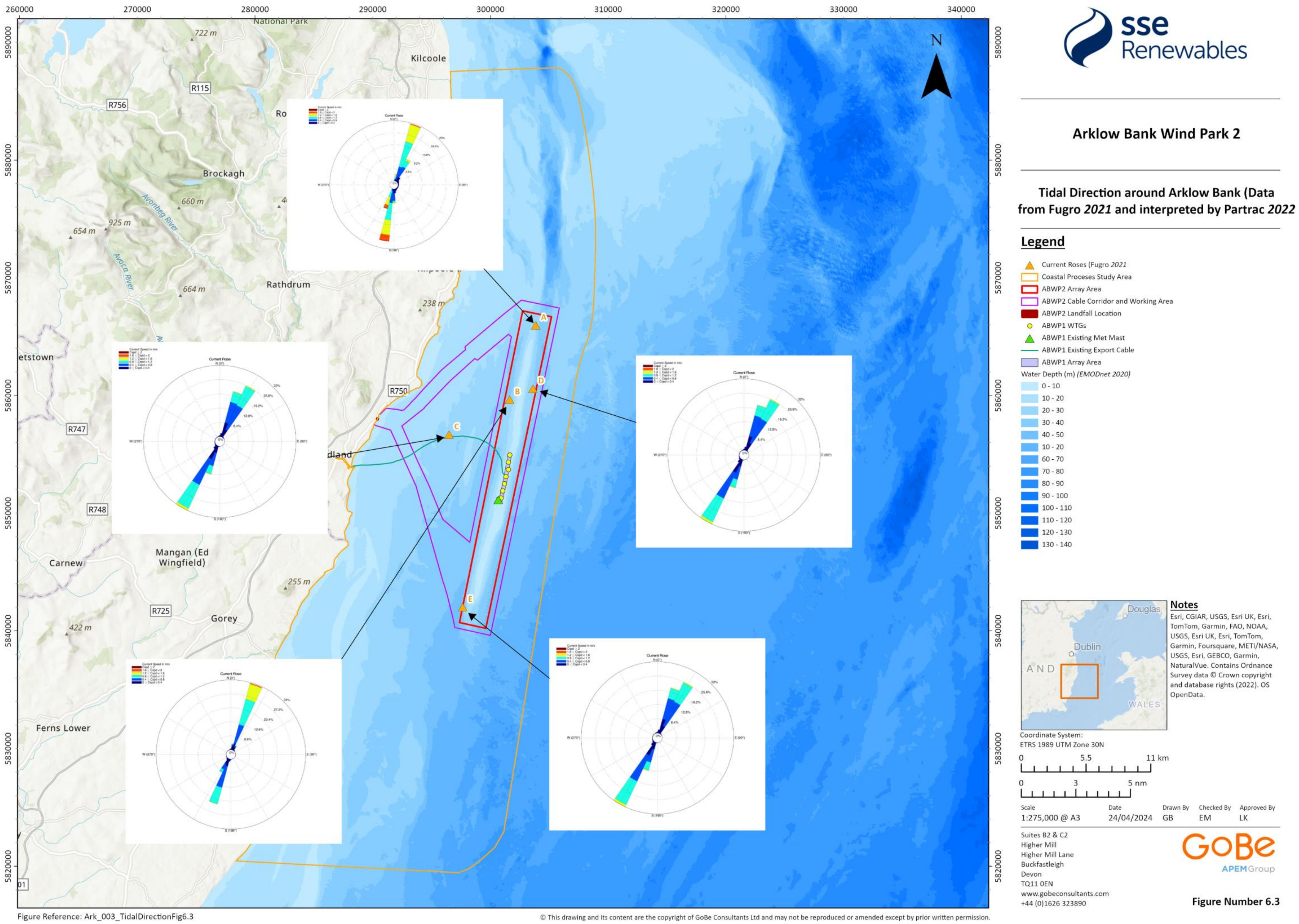

Figure 6.3: Tidal speeds vs direction around Arklow Bank (data from Fugro (2021) and interpretated by Partrac (2022)[2])

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[2] Array Area information has been superseded since publication of this figure in 2022 and as such is not relevant for the purposes of this EIAR

WAVE REGIME

6.6.1.9 The wave regime consists of a combination of swell waves moving into, and propagating through, the Coastal Processes Study Area, in addition to more locally generated wind-waves. Swell waves are long-crested, uniformly symmetrical waves which are generated remotely from the Coastal Processes Study Area, whilst wind-waves result from the transfer of wind energy to the water surface. The Irish Sea is constrained by two narrow channels (the Northern Channel and the St. George's Channel), and as such waves are predominantly locally generated (Howarth, 1999). Swell waves are present near the entrances and southern end of the St. George's Channel, and can propagate inwards (Howarth, 2005; Horrillo-Caraballo *et al.*, 2021). Due to the relative proximity of the Proposed Development to the St. George’s Channel, a proportion of the wave regime experienced at the site is under the influence of North Atlantic swell waves.

6.6.1.10 Ireland is positioned on the path of major North Atlantic storms. This greatly influences wind directions and wave heights in Irish coastal waters which are exposed to strong wave energy and regular low-pressure systems. Consequently, storm surges in the Irish Sea are associated with major Atlantic depressions, usually from a westerly direction (Sweeney, 2000). Storms are experienced mostly during the winter months, with the most common directions of storms being southwest and northwest.

6.6.1.11 As waves enter the Irish Sea, they are influenced by shallowing water depths and are refracted towards the coast, with most waves coming from the south-southwest, southwest and south-southeast sectors. A secondary peak in the wave direction, as recorded during the metocean campaign, was for waves originating from the north-east (Fugro, 2021).

6.6.1.12 Data collected during the metocean survey undertaken for the Proposed Development, recorded the maximum wave height of 6.83 m at the south of Arklow Bank (Deployment Site E on Figure 6.3) (Fugro, 2021). Further, the largest significant wave height was also recorded at the south of Arklow Bank at 4.62 m (Fugro, 2021). The primary wave parameters at each of the five metocean deployment locations has been calculated by Partrac (2022) and is shown in Table 6.8 and Figure 6.4 for completeness.

Table 6.8: Wave parameters calculated from the metocean campaign (collected by Fugro (2021), calculated by Partrac (2022).

Wave Parameter	Statistic	Frame[3]				
		A	B	C[4]	D	E
Significant wave height5 (Hs; m)	Minimum	0.19	0.09	0.15	0.17	0.12
	Mean	1.09	0.91	0.95	0.96	1.03
	Maximum	3.74	3.23	3.24	3.67	4.62
Mean wave period6 (Tp; s)	Minimum	1.07	1.38	1.47	1.04	1.73
	Mean	5.24	5.11	5.69	5.34	6.50
	Maximum	15.43	14.23	18.21	16.67	16.02
Zero-crossing wave period7 (Tz; s)	Minimum	1.61	1.77	1.75	1.68	2.04
	Mean	3.57	3.53	3.69	3.73	4.07
	Maximum	7.88	6.20	6.42	7.18	8.29

[3] Location of frame shown in Figure 6.4

[4] Noting frame C is located within the Cable Corridor and Working Area

[5] the average of the highest one-third (33%) of waves (measured from trough to crest) that occur in a given period.

[6] the mean of all wave periods that occur in a given period.

[7] the time in seconds between one zero up-crossing of the average water level line and the next

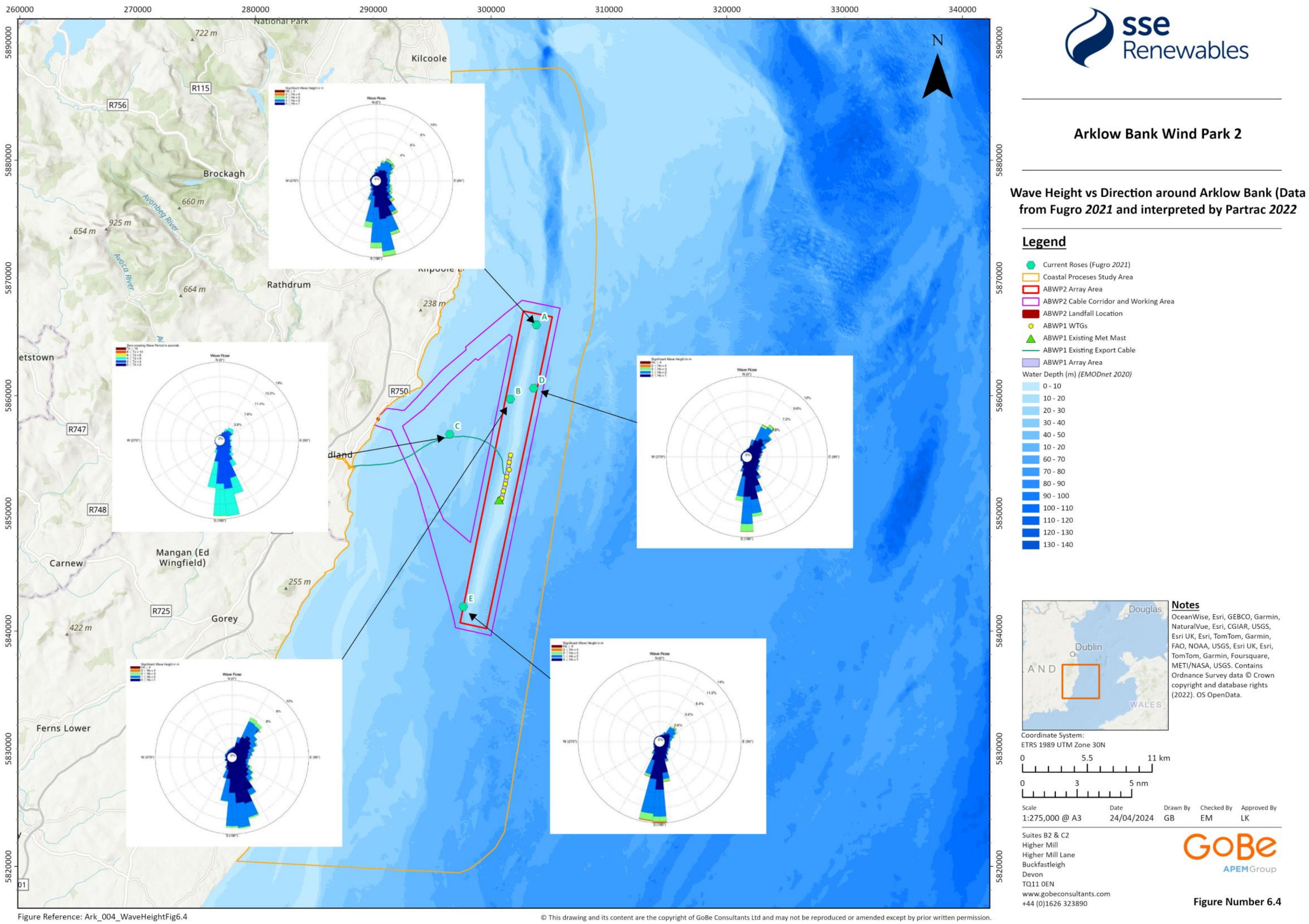

Figure 6.4: Wave height vs direction around Arklow Bank (data from Fugro (2021) and interpreted by Partrac (2022))[8]

[8] Array Area information has been superseded since publication of this figure in 2022 and as such is not relevant for the purposes of this EIAR

Sedimentological Regime

6.6.1.13 The geology of the site can be generally characterised (Coughlan *et al*., 2020) by:

- Coarse-lag sediments, comprised of re-worked glacial sediments. The sediments are typically Holocene, with the underlying units classified as the Upper Till member and Chaotic Facies; and
- Mobile sediments, identified by mobile sandwaves and the presence of sandbanks, such as Arklow Bank.

6.6.1.14 Site-specific surveys and studies (Murphy Dollard, 2001; GEOQUIP, 2021; Waterman Infrastructure and Environmental Ltd, 2020; 2022; Fugro GeoServices Ltd, 2022) undertaken for the Proposed Development also indicate that below the bank core, quaternary soils predominantly consist of very dense sand, gravel and gravelly sand. A thin clay layer was encountered in one borehole at the north end of the bank. A series of boreholes (Fugro GeoServices Ltd, 2022) undertaken within the Array Area indicate the presence of four key geological strata, which include several layers of sands, gravel and till sediments overlaying a series of Lower Palaeozoic Rocks.

6.6.1.15 The surficial seabed sediments within the regional area are characterised by sand and gravel material, as illustrated in Figure 6.5. Project specific surveys indicate that sediments are heterogenous, composed of mobile sands, slightly gravelly sands and gravelly sands present on Arklow Bank (Sure Partners Ltd., 2000; Aquatic Services Unit, 2012; 2021). Medium sand is mainly located at upper levels (less than 15 m water depth) with a gravel-sand with gravel fractions located at greater depths. The substratum ranges from sandy shell to gravel to the west, north and south of the bank to coarse shell and gravel and some rock to the east of the bank. The bank itself consists of mainly sand, cobbles with shells and pebbles at the northern end of the bank and fine sand at the southern end.

6.6.1.16 Sediment in the Array Area is dominated by sand or slightly gravelly sand. Recent sampling campaigns (Arklow Energy Ltd., 2016) in the area confirm that the bank is comprised of sandy sediments with around 90% of the sediment composition being between 2 mm and 63 µm. The significant proportion of relatively fine material coupled with the high energy environment in the region would indicate an area with high sediment mobility.

6.6.1.17 The Centre for Environment, Fisheries and Aquaculture Sciences (Cefas) Climatology Report 2016 (Cefas, 2016) shows the spatial distribution of average non-algal Suspended Particulate Matter (SPM) for the majority of the UK continental shelf. Using this study, it is estimated that the average SPM associated with the Arklow Bank over this period is approximately less than 2.5 mg/l (Figure 6.6). The higher levels are experienced more commonly in the winter months. Superimposed on the inter-annual variability is year-to-year variability, where Suspended Sediment Concentrations (SSC) are shown to indicate a correlation between changes in the mean annual regional wind strength and the storm index across the Irish Sea (White *et al*., 2003).

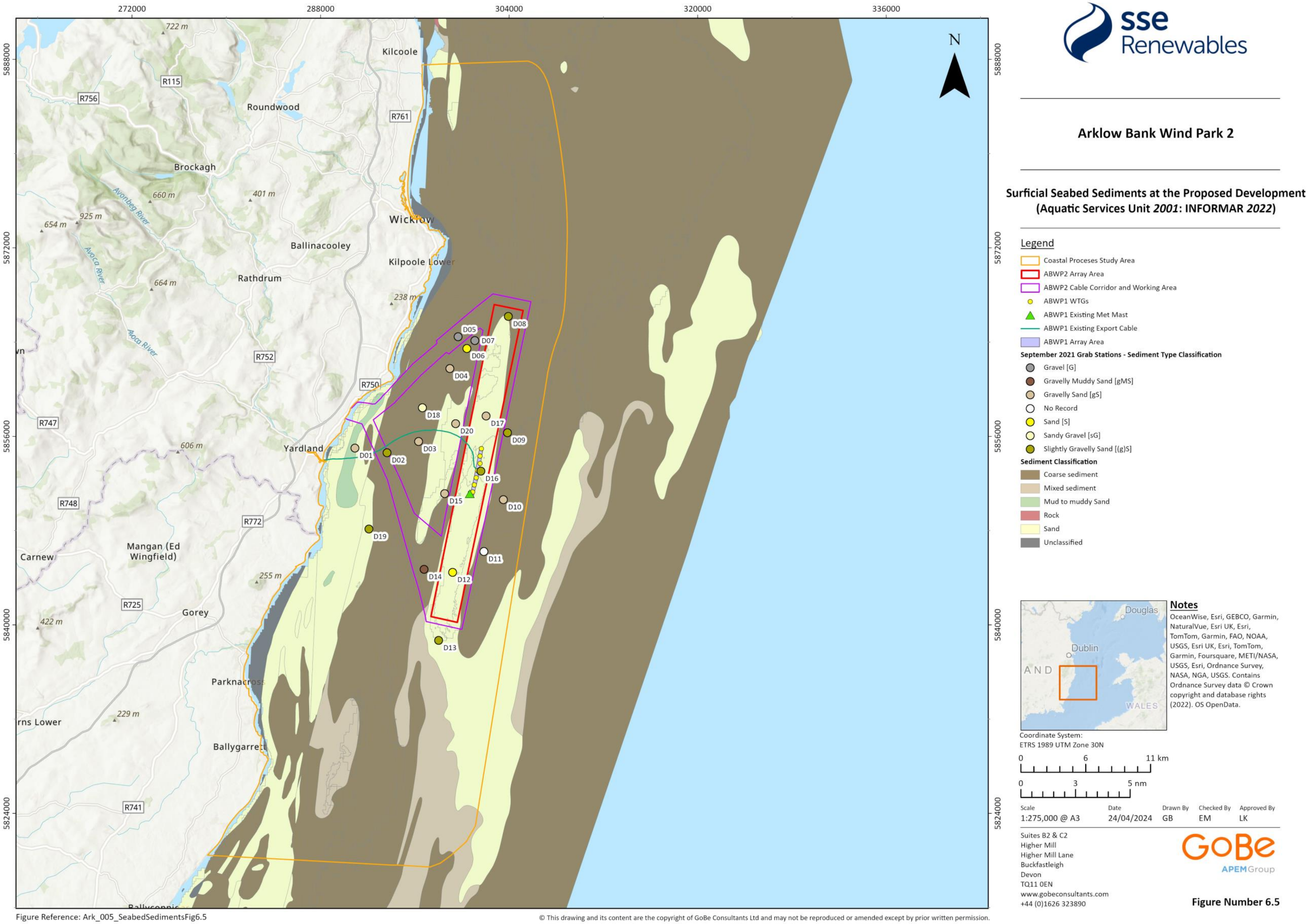

Figure 6.5: Surficial seabed sediments at the Proposed Development (Aquatic Services Unit, 2021; INFOMAR, 2022)

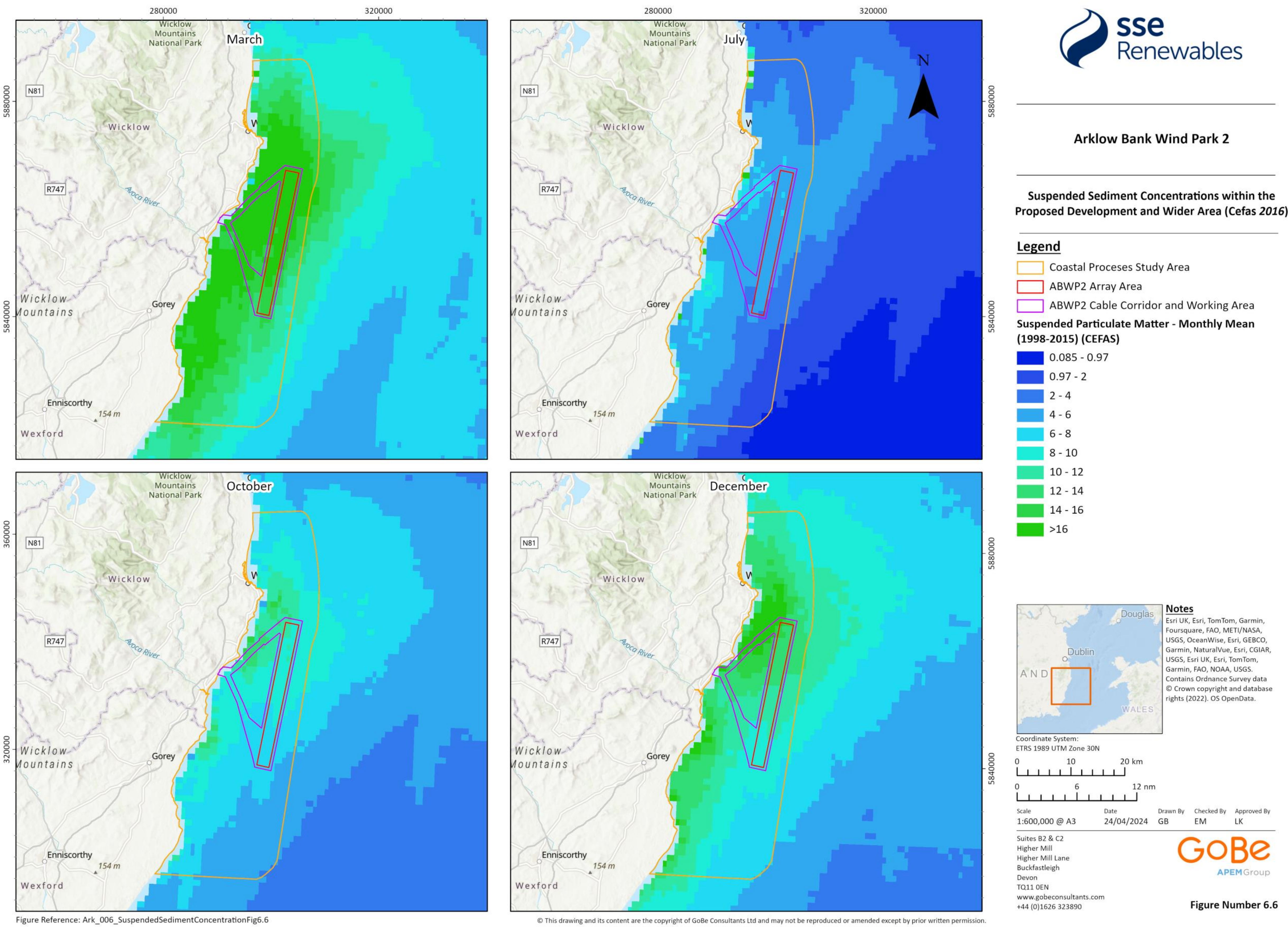

Figure 6.6: Suspended sediment concentrations within the Proposed Development and wider area (Cefas, 2016)

Morphology

6.6.1.18 Across the Array Area, water depths range between 0.6 m and 50 m (relative to Lowest Astronomical Tide (LAT) which is Chart Datum (CD) Arklow), with the shallower depths corresponding to the prominent bathymetric feature, Arklow Bank. At the location of the proposed WTG structures, the water depths are in the range 18.56 m to 41.77 m. This feature is an open-shelf linear sandbank situated, approximately, 6 km to 15 km off the Irish coast near Arklow. The sandbank is, approximately, 25 km long, orientated roughly north-south and experiences strong tidal currents, breaking waves and active sediment transport. Superimposed on both the sandbank flanks and crest are sandwaves, with wavelengths of up to 150 m and amplitudes of 10 m (Ultrabeam Hydrographic Ltd, 2019).

6.6.1.19 The base of the sandbank exhibits long-term stability with mobile bedforms, under the influence of both tidal and wave forcing, present on the upper layers (Creane *et al.*, 2023). Noting that the wave influence occurs in the shallower water depths (Creane *et al.*, 2023).This is supported by comparison of the 2019 project specific bathymetric surveys against 2016 INFOMAR data, which indicates that whilst there is active bedform (sandwave) migration on the sandbank, both the banks' crest and alignment have remained stable. The sandbank crest consists of a smooth seabed with areas of localised bedforms, attributed to the high current regime. Water depths vary along the north-south orientated bank crest varying between 0.6 m and 4.0 m (LAT). Beyond the bank crest, water depths increase, with the angle of the crest slope being more pronounced on the eastern side.

6.6.1.20 Bathymetric analysis suggests the mobile bedform behaviour is such that seabed level changes of the order of +14.5 m to -11 m occur over an annual period. However, this does not include for, potentially larger, morphological changes of the sandbank occurring over shorter timescales, with variation between individual lunar months (Creane *et al.*, 2023). Confirmation of seabed mobility upon Arklow Bank is provided from ABWP1 bathymetric monitoring surveys (Table 6.3) which clearly show areas of erosion and accretion, resulting from bedform migration throughout the site, in addition to areas of deposition and erosion due to localised flow perturbations around the monopile structures. The highly mobile bedforms and energetic tidal regime (Figure 6.3) present upon Arklow Bank were demonstrated following the installation of the 5 m diameter ABWP1 monopiles, but prior to the installation of scour protection. During this time, scour holes developed around the monopiles due to the tidal flow (Whitehouse *et al.*, 2008), with available data suggesting the scour had developed to 3.2 m (Whitehouse *et a*l., 2011).

6.6.1.21 Analysis of sandwaves alongside conceptual numerical modelling (hydrodynamic; sedimentological) confirms the presence of an active sediment transport system around Arklow Bank which is predominately under the control of tidal currents (Figure 6.7) (Creane *et al.*, 2022; 2023). A flood and ebb tidal dominance is evident on the west and east side of the bank, respectively, generating a residual anticlockwise tidal current eddy encompassing the entire bank and ultimately recycling sediment material within the bank cell. Water depths at the location of the proposed array structures (paragraph 6.6.1.18) are such that storm events are unlikely to induce sediment transport (the 1 in 50 wave event is shown to be 5.84 m and 7.84 sec (significant wave height and associated wave period, respectively) (Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling)).

6.6.1.22 An assessment of the mobile bedforms (sandwaves) of Arklow Bank confirms the directionality of bedload sediment transport (Creane *et al*, 2023):

- *'sandwaves with a mean height and wave length of 3 m and 140 m, respectively, migrate southwards at a mean rate of 23 m/year on the south-eastern side of the bank; and*
- *sandwaves on the south-western side of the bank display a mean height and wave length of 2.3 m and 123.5 m, respectively, and migrate northwards at a rate of 32.7 m/year.'*

6.6.1.23 Arklow Bank has been shown to be divided into eight unique sub-cells with different hydrodynamic and morphological features, although they fit together as one linear sandbank, with high upper slope mobility and long-term bank base stability. The presence of off-bank anticlockwise residual tidal eddies have also been shown not only to control the long-term stability of Arklow Bank, but also sediment transport in and out of the local sediment transport system (Creane *et al.*, 2023).

6.6.1.24 Sediment volume analysis undertaken for Arklow Bank indicates that there is no contemporary sediment supply and that this feature is a semi-closed sediment cell (Partrac, 2022). Sediment is both supplied to the head of the bank from (i) Wicklow Trough (to the north) and (ii) from the south-west and south-east, in addition to being and lost from the tail (to the south) (Creane *et al.*, 2023; Partrac *et al.*, 2022[9])). Numerical modelling (Creane *et al.*, 2023) indicates that, of the total external sediment supply, the sediment exchange:

- to the north of Arklow Bank represents a net gain of 27.64%;
- to the south of the sandbank represents a net gain of 0.77%;
- along the western flank represents a net gain of 18.25%; and
- along the eastern flank represents a net loss of 45.94%.

6.6.1.25 Analysis of bed shear stress indicates that there is a less mobile seabed area between the coast and bank, which in turn supports previous hypotheses that there is no sediment exchange between them (Partrac, 2002).

[9] Of relevance to this discussion is the slight disparity in sediment sources, sinks and pathways relevant to Arklow Bank between the recent publications.

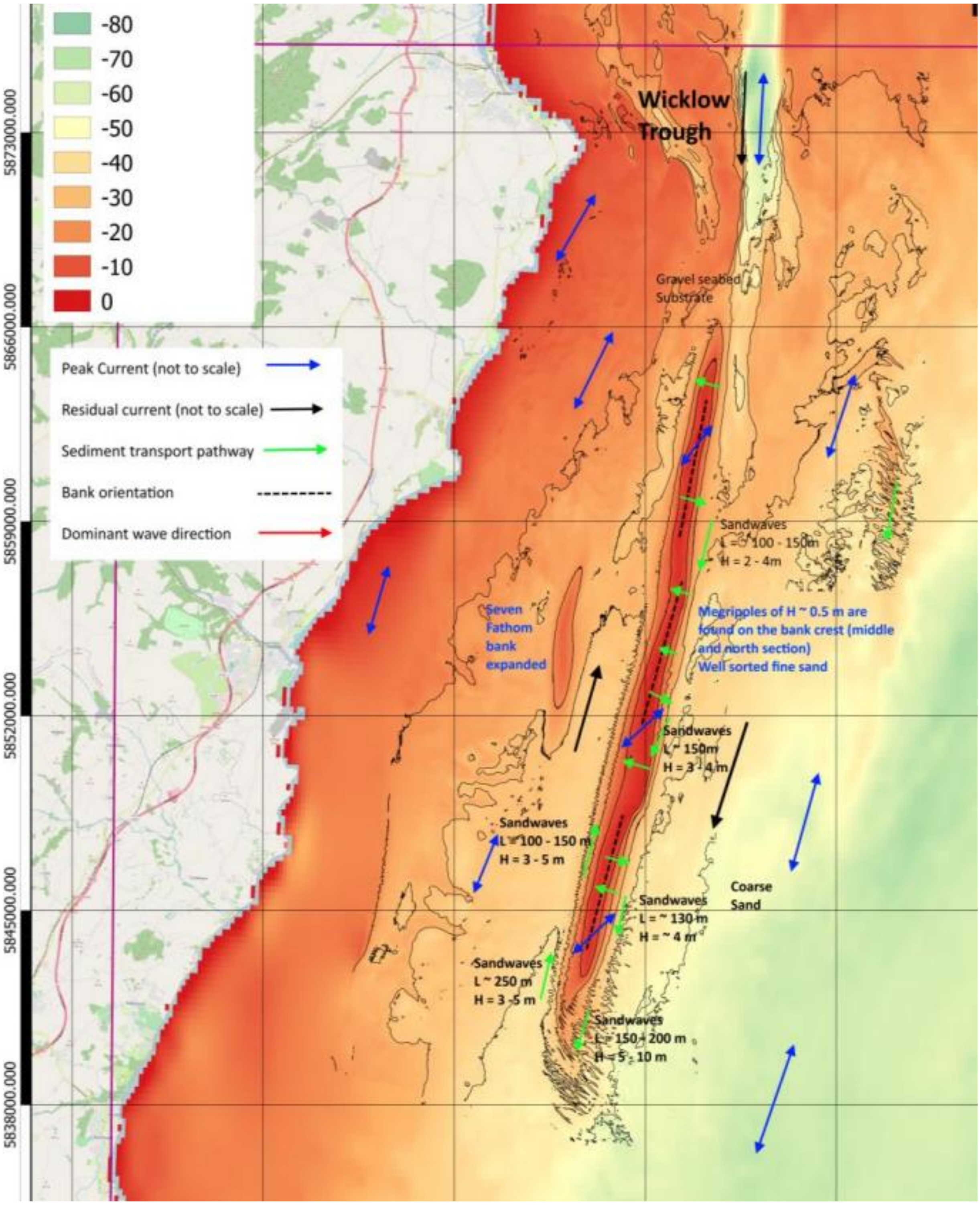

Figure 6.7: Tidal circulation and associated sediment transport pathways around Arklow Bank, the surrounding seabed and within the nearshore (Partrac, 2022)

6.6.2 Cable Corridor and Working Area

Hydrodynamics

6.6.2.1 The tidal range along the Cable Corridor and Working Area and towards the coast is also influenced by the degenerate amphidromic point located in the eastern Irish coast at Courtown; the UK Hydrographic Office (UKHO) tide gauge located within Arklow Port (Figure 6.1) indicates a tidal range of circa 0.5 m (Table 6.9).

Table 6.9: Tidal information from the UKHO tide gauge at Arklow Port

Parameter	Tide level, referenced to CD (m)
LAT	0.2
MLWS	0.6
MLWN	0.9
MSL	1.0
MHWN	1.2
MHWS	1.4
HAT	1.6

Admiralty Chart 1787 Carnsore Point to Wicklow Head, UK Hydrographic Office.

6.6.2.2 Current meter data closer to shore and south of the Cable Corridor and Working Area (approximately, 1 km east northeast of Arklow Harbour) indicates a limited slack water period closer to shore and more benign tidal currents in comparison with those on Arklow Bank, with mean spring flood and ebb current speeds of 0.66 m/s and 0.59 m/s (Arup, 2018).

6.6.2.3 Due to the shallow bathymetry at the Arklow Bank, a large proportion of the waves break when reaching the bank, even during low swell conditions. The bank therefore acts as a natural breakwater and influences the wave climate. Whilst the wave direction diverges slightly after passing over the bank, owing to the combined effect of refraction and shoaling, it still continues to propagate inshore. In general, the bank does not significantly alter the wave directionality, however wave heights are significantly reduced by the presence of this feature. This is confirmed by the project specific metocean campaign (Fugro, 2021) which shows that, at measurement location C[10] within the Cable Corridor and Working Area, the significant wave height is much reduced from location on the eastern side and tips of the bank (Table 6.8).

Sedimentological Regime

6.6.2.4 The offshore geology identified within both the Array Area, and at Landfall, can be broadly expected to be present within the Cable Corridor and Working Area. The majority of cable corridor lengths are underlain by Ordovician Slate overlain by reworked glacial and post-glacial sediments (Green Rebel, 2023). Towards Landfall, whilst sands and gravels predominant, there is an increased presence of finer sediments (Aquatic Services Unit, 2021) suggesting a more benign tidal regime than experienced further offshore and within the Array Area.

[10] Location shown in Figure 6.4

Morphology

6.6.2.5 Along the Cable Corridor and Working Area, depths typically shallow in a landward direction from 40m (CD), with no notable large-scale bathymetric features with the exception of Seven Fathom Bank. Located, approximately, 8.5 km from the coast in water depths of circa 13 m to 16 m, Seven Fathom Bank is non-designated and identified as a sandbank '*permanently covered by water, at depths of less than 20 m below chart datum*' (The Marine Institute, 2020; National Parks and Wildlife Service). Similarities between the alignment and shape of Seven Fathom Bank and Arklow Bank suggests that the former can be considered to a satellite bank to the latter (Partrac, 2022). Numerical modelling indicates current flow connectivity between Seven Fathom Bank and Arklow Bank (Creane *et al.*, 2023), although Arklow Bank does provide a sheltering effect from the predominant wave directions (Figure 6.4) for Seven Fathom Bank (Partrac, 2022).

6.6.2.6 Geophysical surveys (Green Rebel, 2023) indicate the limited presence of mobile bedforms (sandwaves) within the Cable Corridor and Working Area (Figure 6.8); bathymetric change between 2011 and 2019 has shown that the seabed within the Cable Corridor and Working Area to be relatively minor when compared to the Array Area (Partrac, 2022). However, of note is that the ABWP1 export cable has been shown to be exposed in places; it is assumed that this is within the isolated sandwave areas along the route (Aquatic Services Unit, 2021).

6.6.2.7 Whilst outside the Array Area and Cable Corridor and Working Area, a morphological feature within the ZoI is the Wicklow Trough (Figure 6.1), a seabed depression hypothesised to constrain the position of the north of Arklow Bank and provide the primary sediment source to the bank (Partrac, 2022).

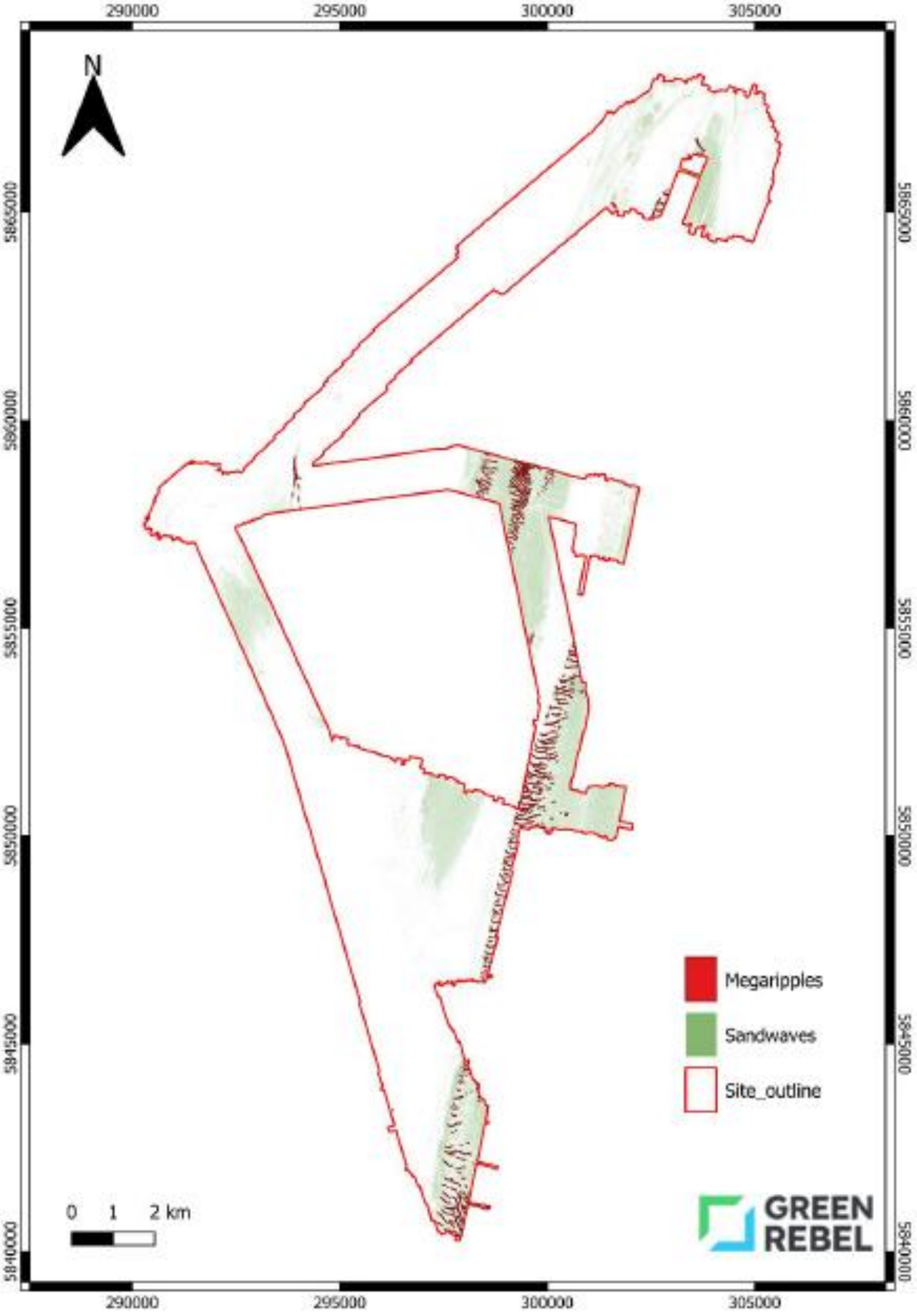

Figure 6.8: Bedforms within the Cable Corridor and Working Area (Green Rebel, 2023)[11]

[11] Array Area information has been superseded since publication of this figure in 2022 and as such is not relevant for the purposes of this EIAR

6.6.3 Coastal

Sedimentological Regime

6.6.3.1 The geology experienced at the Landfall consists of marine deposits of silt, sand and gravel over Mudstone, Siltstone, Slate and Volcanoclastic igneous rock. This can be summarised (Waterman Infrastructure and Environmental Ltd, 2020; 2022) as follows:

- A thin layer of topsoil (up to 30 cm) overlying Glacial Till of firm, reddish brown, slightly sandy gravelly Clay with occasional cobbles and boulders overlying bedrock of the Oakland Formation, of predominantly steeply dipping schist.
- A number of quartzite veins are present within the schist at the outcrop exposures. A probable igneous, possibly rhyolite, intrusion was visible in the southern bay.

6.6.3.2 The surficial sediments present at the Landfall can be summarised as sand and shingle storm deposits characterising the foreshore, seaward of isolated rocky cliffs (Waterman Infrastructure and Environmental Ltd, 2020; 2022).

Morphology

6.6.3.3 The Arklow coastline shoreward of the Proposed Development is composed of rocky headlands and sandy beaches (Figure 6.9). A mix of foreshore cliffs, dunes and vegetated marshlands, typically located above the HWM, are found on the shoreward side of the sandy beaches (Waterman Infrastructure and Environmental Ltd, 2020; 2022; EMODnet, 2021)).

6.6.3.4 The depth of closure, which identifies the depth[12] along a beach profile where sediment transport is very small/ non-existent, has been calculated to be between the 5.5 m and 7.0 m water depths (Partrac, 2022).

6.6.3.5 Between Arklow and Ardanary, the southern stretch of the coastline towards Arklow has been classified as being potentially vulnerable to wave overtopping (RPS, 2021). A future consideration of coastal behaviour is given in paragraph 6.6.4 *et seq*. Coastal process assessments undertaken for a proposed wastewater treatment plant at Arklow show that, based on the data available, erosive characteristics of the shoreline have been present since (at least) 1985 (Arup, 2018). Furthermore, between 1985 and 2016, seabed erosion is shown to occur to, approximately, 400 m (approximately 6 m water depth) offshore (Arup, 2018). This publication also states '*the previously existing (Arklow) beach presented continuous erosion of about 1.5 m between 1930 and 1980*' (Arup, 2018).

6.6.3.6 The coast at Courtown, south of Arklow, currently protected in places by rock armour, also exhibits erosion and has done so since the mid-1980's such that by 2000 the beach is reported to have 'disappeared' (Philips, 2022; Philips *et al.*, 2022)

6.6.3.7 The presence of both Seven Fathom Bank and Arklow Bank afford some protection to the shoreline, acting as a natural breaker for incoming waves (RPS, 2010). Further, through a detailed assessment of sediment transport pathways along the coast and offshore which has included an assessment of particle tracking pathways, it has been shown (Figure 6.7) that there is limited connectivity between the offshore banks and the coast (Partrac, 2022). This would infer that any littoral sediment transport relies on sediment sources other than the offshore sandbanks.

[12] Based on wave height and period

Figure 6.9: Coastal form: (Waterman Infrastructure and Environmental Ltd, 2020)

6.6.4 'Do nothing' scenario

6.6.4.1 Annex IV of the EIA Directive sets out the information required to be included in an EIAR. This includes "*a description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the project as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge*". In the event that the Proposed Development does not proceed, an assessment of the future baseline conditions has been carried out and is described within this section.

6.6.4.2 A consideration of the future baseline, including the associated variation, is provided in the context of the operating lifetime of the Proposed Development. For the current purposes of this EIAR Chapter, the Representative Concentration Pathway (RCP) 8.5 (high emissions) scenario (Palmer *et al*., 2018) has been presented. UKCP18 suggests that an increase in mean sea level (MSL) of 0.6 to 0.8 m at 2100 along the eastern coast of Ireland (Palmer *et al*., 2018). Extreme sea level (RCP 8.5; 100-year event) of 3.28 m at 2100 at the nearest data point (approximately 25 km north from Arklow) has been predicted (Vousdoukas *et al*., 2018).

6.6.4.3 Wave energy is predicted to increase, such that by 2100 an increase of up to 5% of the 100-year return period has been modelled in the Celtic Sea (RCP8.5 scenario; Meucci *et al*., 2020). Of note however, is that there is no significant increase in the frequency of occurrence of these events over the same period (Met Office, 2024; Meucci *et al*., 2020). Assessments of historical wave buoy data has shown a general increase in storminess around Ireland since 2004 (RPS, 2020). Storminess has also been linked to the cyclic behaviour of the North Atlantic Oscillation (NAO), with pronounced cyclical frequency changes occurring since the 1940s at a quasi-decadal scale (Devoy, 2009).

6.6.4.4 The coast, specifically between Arklow and 4 km to the north, is predicted to undergo erosion by 2050, based on existing management and climate conditions (Office of Public Works, 2023; Vousdoukas *et al*., 2020).

6.6.5 Data limitations

6.6.5.1 Whilst many of the baseline characteristics are well understood, in some instances, data sources or assumptions are less well studied and/ or quantified for the Coastal Processes Study Area. This section seeks to identify those areas of uncertainty and any potential data gaps.

6.6.5.2 Grab sampling provides detailed information (sediment; fauna) as data points which must be interpretated alongside other relevant datasets. Existing surveys, which included grab samples, have been conducted in the wider area, and show good validation against the regional data (Figure 6.5). The seabed morphology and sediments in the area are well studied and surveyed. As such, the available evidence base is considered sufficiently robust to underpin the assessment presented here, and an overall high confidence is placed in the baseline characterisation.

6.6.5.3 There is some uncertainty associated with the sediment plume assessment, and accompanying bed level changes due to the Proposed Development's activities and analogous developments. In addition, there are a number of factors which determine the exact sediment volume that is entrained into the water column, including the:

- type of drilling/ cable installation equipment used;
- variability of the forcing conditions at the installation time (i.e. the waves and tidal conditions); and
- mechanical properties of the geological units.

6.6.5.4 In the absence of this detailed information, a series of potential release scenarios have been considered in the assessments undertaken for this EIAR. Together, these scenarios capture the greatest impacts in terms of the highest concentration and persistent suspended sediment plumes, the maximum and greatest spatial extent of changes in bed level elevation.

6.6.5.5 Where a modelled activity occurs within the resolution of one model cell, the behaviour of the sediment plume can be considered to occur at a sub-grid scale. Therefore, it is not appropriate to draw conclusions for the size or concentration of the plume within the cell in which the activity occurs. Therefore, this has been supplemented with information based on expert judgement and analogous projects to allow meaningful interpretation.

6.6.5.6 The availability of robust data, as detailed in Section 6.5.1, relevant for the characterisation and assessment of Coastal Processes is such that it is considered that a thorough and meaningful characterisation for the purposes of EIA can be undertaken. As such, the available evidence base is sufficiently robust to underpin the assessment presented here, and an overall high confidence is placed on the assessment and its findings.

6.7 Impact assessment methodology

6.7.1 Key parameters for assessment

6.7.1.1 The assessment of significance of effects has been carried out on both of the two discrete Project Design Options detailed in Volume II, Chapter 4, Description of Development. This approach has allowed for a robust and full assessment of the Proposed Development.

6.7.1.2 The two Project Design Options and parameters relevant to each potential impact are detailed in Table 6.10 and Table 6.11.

Table 6.10: Proposed Development design parameters and impacts assessed - Project Design Option 1

Potential impact	Phase			Project Design Option 1
	C	O	D	
Impact 1: Increased suspended sediment concentrations and associated deposition	✓	✓	✓	**Construction phase** Confirmatory Surveys A suite of site (Array Area, Cable Corridor and Working Area) investigations will be undertaken to confirm on the seabed and geological conditions prior to the installation of the infrastructure. Complete details of the full suite of surveys proposed are provided in Volume II, Chapter 4: Description of Development. Those which are relevant to Impact 1 are: Geotechnical survey: boreholes (131); Cone Penetration Test (CPT) (431); vibrocore/ gravity core (300); and grab samples (240); Metocean survey: Floating LiDAR (includes seabed anchor points); Acoustic Doppler Current Profiler (ADCP) (deployed on a seabed frame and includes mooring structure); and Wave buoy (includes seabed mooring); Sediment dynamics survey: Benthic flume; Benthic lander (ballasted structure which requires no mooring/ anchor) Site preparation: Site preparation activities prior to inter-array, interconnector and offshore export cable installation to include boulder clearance and sandwave clearance: For the foundations, seabed preparation will be required: within an area of 100 m in diameter; with 5 m depth of material being relocated; and for, approximately, 20% of the WTG locations.

Potential impact	Phase			Project Design Option 1
	C	O	D	
				For the offshore export, inter-array and interconnector cabling, boulder clearance will firstly be undertaken by plough along all of the routes: along a corridor of 15 m in width; and to a depth of 0.5 m. Following a period of circa, more than 14 days, sandwave clearance will then occur: along a corridor of 70 m in width (for each cable); with 10 m depth of material being relocated; and for up to 30% of the cable length. <u>Foundation installation:</u> WTGs and OSPs installed on monopile foundations: Drilled installation of: WTGs: Number of structures: 25; Diameter: 11 m (range 7 m to 11 m); Drill depth: 37 m; Drilling duration (per pile): 88 hours; Drill arisings (per pile): 5,280 m^3 Number of concurrent drilling events: 1. OSPs: Number of structures: 2; Diameter: 14 m (range 7 m to 14 m); Drill depth: 45 m; Drilling duration (per pile): 88 hours; Drill arisings (per pile): 13,860 m^3 Number of concurrent drilling events: 1. <u>Cable installation:</u>

Potential impact	Phase			Project Design Option 1
	C	O	D	
				Cable installation techniques include: Jetting; Ploughing; Mechanical cutting; Simultaneous lay and burial; Controlled Flow Excavator (CFE). Interconnector cables: Length between 25 km and 28 km; Burial depth between 0 m and 2.5 m; Seabed disturbance width 15 m. Inter-array cables: Length between 110 km and 122 km; Burial depth between 0 m and 1.5 m; Seabed disturbance width 15 m. Export cables: Length between 35 m and 40 km; Burial depth between 0 m and 2.5 m; Seabed disturbance width 15 m. Landfall works: HDD drilling fluid release. Rate of release: 20 tonnes (per 24 hours)); and Period of release: 4.5 days (initial punch out followed by reaming phase).

Potential impact	Phase			Project Design Option 1
	C	O	D	
				Operational and maintenance phase Cable repair/ reburial activities: Methods include: Rock protection Concrete mattressing Re-burial Interconnector cables: Length requiring protection: 14 km; Repair and replacement: 1 every 3 years; Target burial depth: 10 m; Seabed disturbance width (maximum); 15 m. Inter-array cables: Length requiring repair/ reburial: between 110 km and 122 km; Repair and replacement: 1 every 3 years; Target burial depth (maximum): 1.5 m; Seabed disturbance width (maximum): 15 m. Export cables: Length requiring repair/ reburial: between 35 m and 40 km; Repair and replacement: 1 every 5 years; Target burial depth (maximum): 2.5 m; Seabed disturbance width (maximum): 15 m. Operational dredging: Cable length requiring dredging: 12.5 km; Seabed disturbance width: 10 m; Target depth (maximum): 2 m; Repeatability: 1 every 5 years.

Potential impact	Phase			Project Design Option 1
	C	O	D	
				Decommissioning phase All structures above the seabed would be removed with all foundations removed to 2 m below the seabed surface. Scour protection, cables and cable protection would be left in situ; and Decommissioning would be undertaken in the reverse of construction using similar plant and techniques.
Presence of infrastructure may lead to changes to tidal currents, wave climate, sediment transport and seabed morphology	×·	✓·	×·	**Operational and maintenance phase** <u>Installed infrastructure:</u> WTGs: Number of structures: 56 Monopile foundations; Pile diameter: 11 m (range 7 to 11 m); Seabed footprint per structure: 38 to 96 m^2 OSPs: Number of structures: 2 Monopile foundations; Pile diameter: 14 m (range 7 to 14 m); Seabed footprint per structure: 38 to 154 m^2 <u>Installed cable protection:</u> Inter-connector cables: Length of protection: 14 km Height of protection: 1.8 m Width of protection: 10 m Proportion of total length: 50%. Inter-array cables: Length of protection: 18 km Height of protection: 1.5 m Width of protection: 8 m

Potential impact	Phase			Project Design Option 1
	C	O	D	
				Proportion of total length: 15%. Export cables: Length of protection: 8 km Height of protection: 1.5 m Width of protection: 8 m Proportion of total length: 20%. <u>Temporary jack-up presence:</u> Number of occurrences: 14 per annum Spud can area: 1,200 m^2 Annual area: 16,800 m^2

Table 6.11: Proposed Development design parameters and impacts assessed - Project Design Option 2

Potential impact	Phase			Project Design Option 2
	C	O	D	
Impact 1: Increased suspended sediment concentrations and associated deposition	✓·	✓·	✓·	**Construction phase** Confirmatory Surveys A suite of site (Array Area, Cable Corridor and Working Area) investigations will be undertaken to confirm on the seabed and geological conditions prior to the installation of the infrastructure. Complete details of the full suite of surveys proposed are provided in Volume II, Chapter 4: Description of Development. Those which are relevant to Impact 1 are: Geotechnical survey: Boreholes (131); CPT (431); vibrocore/ gravity core (300); and grab samples (240); Metocean survey: Floating LiDAR (includes seabed anchor points); Acoustic Doppler Current Profiler (ADCP) (deployed on a seabed frame and includes mooring structure); and Wave buoy (includes seabed mooring); Sediment dynamics survey: Benthic flume; Benthic lander (ballasted structure which requires no mooring/ anchor) Site preparation: Site preparation activities prior to inter-array, interconnector and offshore export cable installation to include boulder and sandwave clearance: For the foundations, seabed preparation will be required: within an area of 100 m in diameter; with 5 m depth of material being relocated; and for, approximately, 20% of the WTG locations.

Potential impact	Phase			Project Design Option 2
	C	O	D	
				For the offshore export, inter-array and interconnector cabling, boulder clearance will firstly be undertaken by plough along all of the routes: along a corridor of 15 m in width; and to a depth of 0.5 m. Following a period of circa, more than 14 days, sandwave clearance will then occur: along a corridor of 70 m in width (for each cable); with 10 m depth of material being relocated; and for up to 30% of the cable length. <u>Foundation installation:</u> WTGs and OSPs installed on monopile foundations: Drilled installation of: WTGs: Number of structures: 25; Diameter: 11 m (range 7 m to 11 m); Drill depth: 37 m; Drilling duration (per pile): 88 hours; Drill arisings (per pile): 7,040 m^3 Number of concurrent drilling events: 1. OSPs: Number of structures: 2; Diameter: 14 m (range 7 m to 14 m); Drill depth: 45 m; Drilling duration (per pile): 88 hours; Drill arisings (per pile): 13,860 m^3 Number of concurrent drilling events: 1.

Potential impact	Phase			Project Design Option 2
	C	O	D	
				<u>Cable installation:</u> Cable installation techniques include: Jetting; Ploughing; Mechanical cutting; Simultaneous lay and burial; Controlled Flow Excavator (CFE). Interconnector cables: Length between 25 km and 28 km; Burial depth between 0 m and 2.5 m; Seabed disturbance width 15 m. Inter-array cables: Length between 110 km and 122 km; Burial depth between 0 m and1.5 m; Seabed disturbance width 15 m. Export cables: Length between 35 m and 40 km; Burial depth between 0 m and 2.5 m; Seabed disturbance width 15 m. <u>Landfall works:</u> HDD drilling fluid release. Rate of release: 20 tonnes (per 24 hours bentonite); and Period of release: 4.5 days (initial punch out followed by reaming phase). **Operational and maintenance phase**

Potential impact	Phase			Project Design Option 2
	C	O	D	
				Cable repair/ reburial activities: Methods include: Rock protection Concrete mattressing Re-burial Interconnector cables: Length requiring protection 14 km; Repair and replacement: 1 every 3 years; Burial depth between 0 m and 10 m; Seabed disturbance width (maximum) 15 m. Inter-array cables: Length between 110 km and 122 km; Repair and replacement: 1 every 3 years; Burial depth between 0 m and 1.5 m; Seabed disturbance width (maximum) 15 m. Export cables: Length between 35 m and 40 km; Repair and replacement: 1 every 5 years; Burial depth between 0 m and 2.5 m; Seabed disturbance width (maximum) 15 m. Operational dredging: Seabed disturbance width: 10 m Target depth (maximum): 2 m Repeatability: 1 every 5 years **Decommissioning phase**

Potential impact	Phase C	Phase O	Phase D	Project Design Option 2
				All structures above the seabed would be removed, foundations will be removed to 2 m below the seabed level, scour protection, cables and cable protection would be left in situ; and Decommissioning would be undertaken in the reverse of construction using similar plant and techniques.
Presence of infrastructure may lead to changes to tidal currents, wave climate, sediment transport and seabed morphology	✗	✓	✗	**Operational and maintenance phase** Installed infrastructure: WTGs: Number of structures: 47 Monopile foundations; Pile diameter: 11 m (range 7 to 11 m); Seabed footprint per structure: 38 to 154 m^2 OSPs: Number of structures: 2 Monopile foundations; Pile diameter: 14 m (range 7 to 14 m); Seabed footprint per structure: 38 to 154 m^2 Installed cable protection: Inter-connector cables: Length of protection: 14 km Height of protection: 1.8 m Width of protection: 10 m Proportion of total length: 50%. Inter-array cables: Length of protection: 18 km Height of protection: 1.5 m Width of protection: 8 m Proportion of total length: 15%. Export cables:

Potential impact	Phase			Project Design Option 2
	C	O	D	
				Length of protection: 8 km Height of protection: 1.5 m Width of protection: 8 m Proportion of total length: 20%. <u>Temporary jack-up presence:</u> Number of occurrences: 14 per annum Spud can area: 1,200 m^2 Annual area: 16,800 m^2

6.7.2 Impacts scoped out of the assessment

6.7.2.1 On the basis of the baseline environment and the description of development outlined in Volume II, Chapter 4: Description of Development, it is proposed to scope out seabed scour. Further detail, including a justification for scoping the impact out, is provided in Table 6.12.

Table 6.12: Impacts scoped out of the assessment for Coastal Processes

Potential impact	Justification
Scour of seabed sediments	The potential for scour of seabed sediments around the WTG and OSP foundations has been designed out through adopted engineering methods developed through detailed site characterisation and lessons learnt from AWP1; specifically a filter layer of scour protection will be laid within the dredged footprint prior to the WTG being installed. Further detail is provided in Volume II, Chapter 4: Description of Development. As such, this impact has been scoped out of the assessment.

6.8 Methodology for assigning the significance of effect

6.8.1 Overview

6.8.1.1 The Coastal Processes impact assessment has followed the methodology set out in Volume II, Chapter 5: EIA Methodology. The 'source-pathway-receptor' approach has been applied which allows a Coastal Processes Study Area to be identified which includes all the marine locations of the Proposed Developments' activities which may create potential sources of effects, in addition to all the pathways which create a linkage between the source and environmental receptors.

6.8.1.2 The baseline and assessment works have been undertaken using an evidence-based approach, supported by the Proposed Developments' specific surveys and numerical modelling, as appropriate.

6.8.1.3 For the most part, Coastal Processes are not in themselves receptors but are instead 'pathways'. However, changes to Coastal Processes have the potential to indirectly impact other environmental receptors (Lambkin *et al.*, 2009). An example is the creation of sediment plumes which may result in material settling onto benthic habitats. The potential significance of this particular change is assessed in Volume II, Chapter 9: Benthic Subtidal and Intertidal Ecology with Volume II Chapter 25: Interactions considering the environmental interactions between topics.

6.8.2 Impact assessment criteria

Sensitivity

6.8.2.1 This section describes the criteria applied in this chapter to assign values to the sensitivity of the receptors. The terms used to define sensitivity are based on those which are described in further detail in Volume II, Chapter 5: EIA Methodology of the EIAR.

6.8.2.2 The definition of magnitude specific to Coastal Processes is provided in Table 6.13. Where a range of sensitivity criteria are met, the final assessment for each receptor is based upon expert judgement.

Table 6.13: Coastal Processes definitions of sensitivity of the receptor

Receptor sensitivity	Definition
High	Adaptability: The receptor cannot avoid or adapt to an impact. Tolerance: The environment has no capacity to accommodate the proposed form of change. Recoverability: The effect on the receptor is anticipated to be long-term (i.e. over the Proposed Developments' lifetime). Value: The receptor is designated for international importance and/or very high socio-economic value.
Medium	Adaptability: The receptor has some capacity to avoid or adapt to an impact. Tolerance: The environment has limited capacity to accommodate the proposed form of change. Recoverability: The effect on the receptor is anticipated to be medium-term (i.e. over the Proposed Developments' operational and maintenance period). Value: The receptor is designated for regional importance and/or moderate socio-economic value.
Low	Adaptability: The receptor has capacity to avoid or adapt to an impact. Tolerance: The environment has moderate to low capacity to accommodate the proposed form of change. Recoverability: The effect on the receptor is anticipated to be short- to medium-term (i.e. over the Proposed Developments' construction period). Value: The receptor is not designated but of county level importance and/or low socio-economic value.
Negligible	Adaptability: The receptor can fully avoid or adapt to an impact. Tolerance: The environment has high capacity to accommodate the proposed form of change. Recoverability: The effect on the receptor is anticipated to be short- term (i.e. duration of the Proposed Developments' individual construction activities). Value: The receptor is not designated but of local level importance.

Magnitude

6.8.2.3 This section describes the criteria applied in this chapter to assign values to the magnitude of potential impacts. The terms used to define magnitude and sensitivity are based on those which are described in further detail in Volume II, Chapter 5: EIA Methodology of the EIAR.

6.8.2.4 The definition of magnitude specific to Coastal Processes is provided in Table 6.14. Where a range of magnitude criteria are met, the final assessment for each impact is based upon expert judgement.

Table 6.14: Coastal Processes definition of terms relating to the magnitude of an impact

Magnitude	Definition
High	Extent: Impact beyond the ZoI. Duration: The impact is anticipated to be long-term (i.e. over the Proposed Developments' lifetime). Frequency: The impact will occur constantly throughout the relevant project phase. Probability: The impact can reasonably be expected to occur. Consequences: Permanent changes to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Medium	Extent: Impact within the ZoI. Duration: The impact is anticipated to be medium-term (i.e. over the Proposed Developments' operational and maintenance period). Frequency: The impact will occur constantly throughout the relevant project phase.

Magnitude	Definition
	Probability: The impact can reasonably be expected to occur. Consequences: Noticeable, but temporary, changes to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Low	Extent: Impact within the Array Area or Cable Corridor and Working Area. Duration: The impact is anticipated to be short- to medium-term (i.e. over the Proposed Developments' construction period). Frequency: The impact will occur intermittently throughout the relevant project phase. Probability: The impact can reasonably be expected to occur. Consequences: Noticeable, but temporary, changes or barely discernible to key characteristics or features of the particular environmental aspect's character or distinctiveness.
Negligible	Extent: Localised impacts within the Array Area or Cable Corridor and Working Area. Duration: The impact is anticipated to be short- term (i.e. duration of the Proposed Developments' individual construction activities). Frequency: The impact will occur intermittently throughout the relevant project phase. Probability: The impact can reasonably be expected to occur. Consequences: Changes which are not discernible out with background variations of key characteristics or features of the particular environmental aspect's character or distinctiveness.

Significance of effect

6.8.2.5 The significance of the effect upon Coastal Processes is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 6.15. Where a range of significance of effect is presented in Table 6.15, the final assessment for each effect is based upon expert judgement.

Table 6.15: Significance of effect matrix

			Baseline Environment - Sensitivity			
			High	Medium	Low	Negligible
Description of Impact - Magnitude	Adverse Impact	High	Profound or Very Significant (significant)	Significant	Moderate*	Imperceptible
		Medium	Significant	Moderate*	Slight	Imperceptible
		Low	Moderate*	Slight	Slight	Imperceptible
	Neutral Impact	Negligible	Not Significant	Not Significant	Not Significant	Imperceptible
	Positive Impact	Low	Moderate*	Slight	Slight	Imperceptible
		Medium	Significant	Moderate*	Slight	Imperceptible

		High	Profound or Very Significant (significant)	Significant	Moderate*	Imperceptible

*Moderate levels of effect have the potential, subject to the assessor's professional judgement to be significant or not significant. Moderate will be considered as significant or not significant in EIA terms, depending on the sensitivity and magnitude of change factors evaluated. These evaluations are explained as part of the assessment, where they occur.

6.8.3 Factored in measures

6.8.3.1 The Project Design Options set out in Volume II, Chapter 4: Description of Development include a number of designed-in measures and management measures (or controls) which have been factored into the Proposed Development and are committed to be delivered by the Developer as part of the Proposed Development.

6.8.3.2 These factored-in measures are standard measures applied to offshore wind development, including lighting and marking of the Proposed Development, use of 'soft-starts' for piling operations etc, to reduce the potential for impacts. Factored-in measures relevant to the assessment on Coastal Processes are presented in Table 6.16. These measures are integrated into the description of development and have therefore been considered in the impact assessment (i.e. the determination of magnitude and therefore significance assumes implementation of these measures). These measures are considered standard industry practice for this type of development. This approach is in line with EPA guidance which states that '*in an EIAR it may be useful to describe avoidance measures that have been integrated into the proposed proposal*' (EPA, 2022).

Table 6.16: Factored in measures

Factored in measures	Justification
Scour protection	In the absence of scour protection, there is potential for scour pits to develop around foundations. This may result in the release of sediment into the water column and a change to seabed habitat in the vicinity of the foundation. Scour protection will be installed as described in Volume II, Chapter 4: Description of Development.
Definition and implementation of construction methods, Volume II, Chapter 4: Description of Development and Rehabilitation Schedule.	Volume II, Chapter 4: Description of Development provides cable laying plan, including refined cable laying techniques and refined cable burial depths (based on the parameters assessed in the EIAR). Operational and Maintenance activities are set out in Volume II, Chapter 4: Description of Development, in addition to a procedure for setting out the refined parameters of any cable repair or reburial activities. The Rehabilitation Schedule presented in Volume III, Appendix 4.1 outlines the measures for the decommissioning of the Proposed Development.
Preparation and implementation of environmental monitoring	Commitments to environmental monitoring. Operational and Maintenance asset monitoring commitments include survey of seabed and assets every six months for the first two years and annually thereafter (Volume II: Chapter 4: Description of Development).This will include monitoring to determine scour development and cable burial.
Cables will be buried where possible and protected where not possible.	The location of areas of cable protection (if cable protection is required) will be communicated to the fishing industry. Cable burial will have direct impacts on receptors through morphology changes and suspended sediments.

Factored in measures	Justification
Undertaking of post-installation cable burial surveys and periodic monitoring of cables.	This will monitor the impacts of cable burial/protection with respect to seabed features, including sandwave fields, sandbanks and scour development around cable protection.
The Developer confirms and commits that it will not carry out any works in respect of the Proposed Development under the planning permission (if granted) at the same time as any activities the subject of the Foreshore Licence for Site Investigations (FS007339).	The Developer was granted a Foreshore Licence (FS007339) for Site Investigations (associated with the Proposed Development) from the Minister for Housing, Local Government and Heritage in May 2022. The Developer confirms and commits that it will not carry out any works in respect of the Proposed Development under the planning permission (if granted) at the same time as any activities the subject of the Foreshore Licence for Site Investigations (FS007339) being carried out. As such there is no temporal overlap between the activities consented in this Foreshore Licence and the Proposed Development and there will be no potential for cumulative effects.
The Developer confirms and commits that it will not carry out any works in respect of the Proposed Development under the planning permission (if granted) at the same time as any activities the subject of the Foreshore Licence Application for Site Surveys FS007555 (should a licence be granted) are being carried out.	The Developer submitted a Foreshore Licence Application for Site Surveys to the Minister for Housing, Local Government and Heritage in April 2023 (FS007555) and this application is pending determination. The Developer confirms and commits that it will not carry out any works in respect of the Proposed Development under the planning permission (if granted) at the same time as any activities the subject of the Foreshore Licence Application for Site Surveys FS007555 (should a licence be granted) are being carried out. As such there is no temporal overlap between the activities proposed in the Foreshore Licence Application and the Proposed Development.

6.9 Assessment of the significance of effects

6.9.1.1 The impacts of the construction, operational and maintenance and decommissioning phases of both Project Design Options, as presented in Volume II, Chapter 4: Description of Development forming the Proposed Development have been assessed on Coastal Processes. The potential impacts arising from the construction, operational and maintenance and decommissioning phases of the Proposed Development are listed in Table 6.10and Table 6.11, along with the project parameters against which each impact has been assessed.

6.9.1.2 A description of the potential effect on Coastal Processes caused by each identified impact is provided in Section 6.10 and Section 6.11.

6.10 Assessment of Project Design Option 1

6.10.1 Impact 1 – Increased suspended sediment concentrations and associated deposition

6.10.1.1 As stated in paragraph 6.8.1.3, for the most part physical processes, such as the creation of sediment plumes and the associated consequential deposition, are not in themselves receptors but are instead ‘pathways’. Therefore, when considering Impact 1, the assessments of potential change to pathways are not at this stage accompanied by a conclusion regarding the significance of effect.

SENSITIVITY OF THE RECEPTOR

6.10.1.2 All the identified Coastal Processes receptors (Section 6.5) will be insensitive to localised changes in SSC and bed levels associated with the sediment disturbance activities described in this section. However, the potential for these changes to impact other EIAR receptor groups are considered elsewhere in the EIAR, in particular:

- Volume II, Chapter 7: Marine Sediment and Water Quality;
- Volume II, Chapter 9: Benthic Subtidal and Intertidal Ecology;
- Volume II, Chapter 10: Fish, Shellfish and Sea Turtle Ecology;
- Volume II, Chapter 11: Marine Mammals; and
- Volume II, Chapter 14: Commercial Fisheries.

Construction phase

6.10.1.3 Proposed Development activities will result in the disturbance of sediments and the consequential release into the water column. In turn, this will give rise to suspended sediment plumes and localised changes in bed levels as the material settles out of suspension. Those construction activities that will result in the greatest seabed sediment disturbance, due to the associated temporal scale, spatial scale and sediment volumes are presented in Table 6.10. These activities are:

- Pre-lay cable trenching using jetting tools at the seabed;
- Seabed preparation as:
  - boulder clearance for cable installation within the Array Area and along the Cable Corridor and Working Area;
  - sandwave clearance for WTG foundations and along the Cable Corridor and Working Area including spoil disposal via a TSHD;
- Foundation installation using drilling techniques; and
- Drilling fluid release during HDD, or other trenchless technique, operations.

6.10.1.4 The evidence base has been used to assess the potential impacts of these activities upon Coastal Processes using, where available, monitoring results from comparable activities in similar environmental conditions. This has been supplemented by a suite of project specific numerical modelling simulations (Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling). The release events simulated within the numerical model, as described in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling have been specifically designed to capture the full range of realistic precautionary outcomes in terms of:

- Sediment plume concentrations;
- Sediment plume extent;
- Vertical deposition depth (bed level change); and
- Horizontal extent of deposition (spatial extent (area) of bed level change).

6.10.1.5 The methodology applied to assess the characteristics of sediment plumes and associated changes in bed level arising from settling of material is set out in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling. The findings are presented in the following sections.

CONCEPTUAL UNDERSTANDING OF CHANGE

6.10.1.6 The actual magnitude and extent of change in SSC and bed levels will depend, in practice, on a range of factors, for which there will be a wide range of possible combinations such that it is not possible to predict the specific dimensions with complete certainty. The key factors include the:

- actual total volumes of sediment disturbed;
- rates of sediment disturbance;
- local water depth;
- current speed at the time of the activity;
- local sediment type;
- grain size distribution;
- local seabed morphology;
- local seabed slopes; and
- local sediment mobility.

6.10.1.7 To provide a robust assessment, a range of realistic combinations have been considered, based on conservatively representative locations (environmental) and design information specific to the Proposed Development, including a range of water depths, heights of sediment ejection/ initial resuspension, and sediment types.

6.10.1.8 The maximum distance, and as such the overall spatial extent that any resultant plume might be reasonably experienced, can be estimated as the spring tidal excursion distance. Any location beyond the tidal excursion distance[13] is unlikely to experience any measurable change in SSC from a sediment plume. Given the temporary nature of the sediment disturbance, any impacts are also anticipated to be short-lived, with any deposited material likely to be re-worked on subsequent tides. Further discussion on the predicted impacts from each of the seabed disturbance activities is provided in following sections.

6.10.1.9 The tidal excursion distance will vary in relation to the peak current speed on a given tide. Therefore, this distance may be smaller than shown during the smaller than average spring, intermediate and neap conditions, and only very occasionally may be larger than shown during larger than average spring conditions. The high spring and low neap model scenarios provided represent the top and bottom 0.5% of current speeds which are exceeded, approximately, three times per annum.

6.10.1.10 The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by the higher SSC and more localised plume, for more than one or two consecutive tides. Consequently, the associated deposition areas are also unlikely to be affected by deposition from suspended material over more than one or two tides.

6.10.1.11 During spring tidal conditions, any disturbed sediment will be transported away from the activity at a faster rate than during other, for example, neap tidal conditions. Consequently, the sediment mass will be dispersed over a larger area and water volume which therefore results in the plume SSC having a relatively lower concentration than on a comparable neap tide.

6.10.1.12 The plume's limited width/ footprint is such that specific locations will only be affected by an increased SSC for the limited duration it takes for the plume to be advected past by the tide. Discrete areas of larger depths of deposited sediments are considered to be over-predicted in the

[13] 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.

numerical model given the 75 m spatial resolution within the Array Area and Cable Corridor Working Area.

6.10.1.13 If multiple activities causing sediment disturbance (such as dredging, drilling or cable installation) are undertaken simultaneously at two or more locations that are aligned in relation to the ambient tidal streams, the areas affected (either by a change in SSC or sediment deposition) may potentially overlap. This change in SSC in areas of overlap will be additive only if the downstream activity occurs within the area of effect from upstream (i.e. sediment is disturbed within the sediment plume from the upstream location). The change in SSC will not be additive (i.e. the effects will be as described for single occurrences only) if the affected areas only meet or overlap downstream following the advection or dispersion of the effects. Effects on sediment deposition will be additive only if and where the footprints of the deposits overlap.

ARRAY AREA SEABED PREPARATION AND INSTALLATION ACTIVITIES

6.10.1.14 The following sections present the assessment for the following construction activities within the Array Area:

- Seabed preparation (boulder and sandwave clearance, including spoil disposal via a TSHD for the latter);
- Pre-lay cable trenching using jetting tools at the seabed; and
- Foundation installation using drilling techniques.

SEABED PREPARATION (SANDWAVE CLEARANCE INCLUDING SPOIL DISPOSAL VIA A TRAILER SUCTION HOPPER DREDGER)

6.10.1.15 Seabed preparation may be required prior to the installation of the Proposed Developments' infrastructure. This is likely to include seabed levelling to allow the foundations to be placed onto a flat seabed, as well as for areas of scour protection (where required). The parameters for these activities are presented in Table 6.10.

6.10.1.16 The sediment volume likely to be removed for seabed levelling within the Array Area (excluding export cables) is up to 2,639,200 m^3 and is to be excavated using a TSHD with an assumed hopper volume of 20,000 m^3 over the entire construction period. Whilst the hopper is being filled, overspill is likely to develop a near-surface sediment plume composed primarily of fine sediments. Once each hopper is filled, dredged material (spoil) will be returned to the seabed at a specified disposal site (as per Dumping at Sea permit), to the south of, and within the boundary of, the Array Area, as a relatively sudden release from under the vessel.

6.10.1.17 Numerical modelling (as presented in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling) has simulated the filling of a TSHD hopper load, in addition to overspill, followed by discharged at a spoil disposal site. The dredger is simulated remaining stationary at a single WTG for 60 minutes, before transiting to the disposal site in the southeastern corner of the Array Area, approximately 24 km away. Whilst the hopper is being filled, overspill is likely to develop a near-surface sediment plume composed primarily of fine sediments. The overspill phase from the TSHD lasts 60 minutes at the WTG location. There is then a 50-minute break in discharge during the demobilisation and transit to the disposal site, where a sudden discharge under the vessel occurs over a 10-minute period. For the overspill phase, the sediment is released at the water surface and for the disposal phase the material is released 9.8 m below the surface.

6.10.1.18 Once the dredger moves to discharge a full hopper load, the majority of the finer sediments are expected to have already been lost to overspill, although this will vary based on the sediment type and filling rate. During spoil disposal, sediments will be discharged as a highly turbid dynamic plume, with the coarser sediment fraction falling quickly to the seabed (on timescales of minutes to tens of minutes) with limited opportunity to be advected away by tidal currents, leading to a correspondingly greater localised depth of accumulation on the seabed. Finer sediments, which form a small proportion of the surficial sediment layer (Section 6.6.1), in the spoil will remain in suspension for longer (up to around a day), forming a passive plume which will then be advected by tidal currents. Should any wave energy be present during the operations, then any plume will be dispersed more quickly than under tidal currents alone.

6.10.1.19 The evidence base with respect to dredging activities is extensive and based on a range of monitoring and numerical modelling studies undertaken within the aggregate industry, as provided within the UK Marine SAC project (http://ukmpa.marinebiodiversity.org) which states:

- *"Dredging activities often generate no more increased suspended sediments than commercial shipping operations, bottom fishing or generated during severe storms (Parr et al., 1998);*
- *Natural events such as storms, floods and large tides can increase suspended sediments over much larger areas, for longer periods than dredging operations (Environment Canada, 1994).*
- *It is often very difficult to distinguish the environmental effects of dredging from those resulting from natural processes or normal navigation activities (Pennekamp et al.,1996)".*

6.10.1.20 As shown in Figure 6.10 and Figure 6.11, the numerical modelling simulations undertaken show the following:

- Suspended Sediment Concentrations:
  - Within the first hour of sandwave clearance[14], a plume of fine sediment is observed within 6 km of the seabed works. The maximum SSC within this thin (less than 0.2 km wide) plume is circa 2,000 mg/l and occurs immediately adjacent to the TSHD location. As this plume is advected by the tidal currents along the tidal axis, it is also dispersed such that the SSC levels reduce. After four hours, the discrete plume (circa 2 km by 1 km) is less than 5 mg/l, and by five hours the plume has further reduced such that it is discernible from background concentrations (less than 2.5 mg/l).
  - Disposal of the TSHD load to the south of the Array Area initially results in the formation of a plume with maximum concentrations of the order of 2,000 mg/l. Rapid dispersion is such that the discrete plume (circa 2 km by 1 km) is less than 5 mg/l, and by five hours the plume has further reduced such that it will be discernible from background concentrations (less than 2.5 mg/l). Elevated SSC above background concentrations is not predicted after 10 hours following the initial sandwave clearance.
  - Under all tidal flow simulations (speeds and direction), elevated SSC (above background concentration) are not shown to disperse beyond 8 km from the Cable Corridor and Working Area that surrounds the Array Area.
- Deposited Sediment:
  - Sediment deposition is shown to have the following general characteristics:
    - under higher current speeds[15], the resultant deposition is shown to have a greater spatial extent and lower thickness *than* under lower current speeds. Under lower speeds, the resultant deposition is shown to have a lesser areal extent and relative greater thickness.
    - the deposition location aligns with the axis of tidal flow, which are relatively linear to the north and south of the Array Area (Figure 6.1).

[14] For a release during high current speeds. During lower current speeds, the plumes' SSC remain of similar orders of magnitude, but its extent is reduced as would be expected due to the reduced dispersive energy of the tidal regime.

[15] Noting that the peak current speed occurs during the final ten minutes of the overspill phase.

- Sediment deposition is greatest in the vicinity of the installation works, with thicknesses between 100 mm and 500 mm occurring within 1 km. Beyond this, the thickness of deposited sediment rapidly reduces such that at 10 km from the active disturbance, the deposited thickness is of the order of 2.5 mm. Beyond this, the thickness of deposited sediment becomes immeasurable.

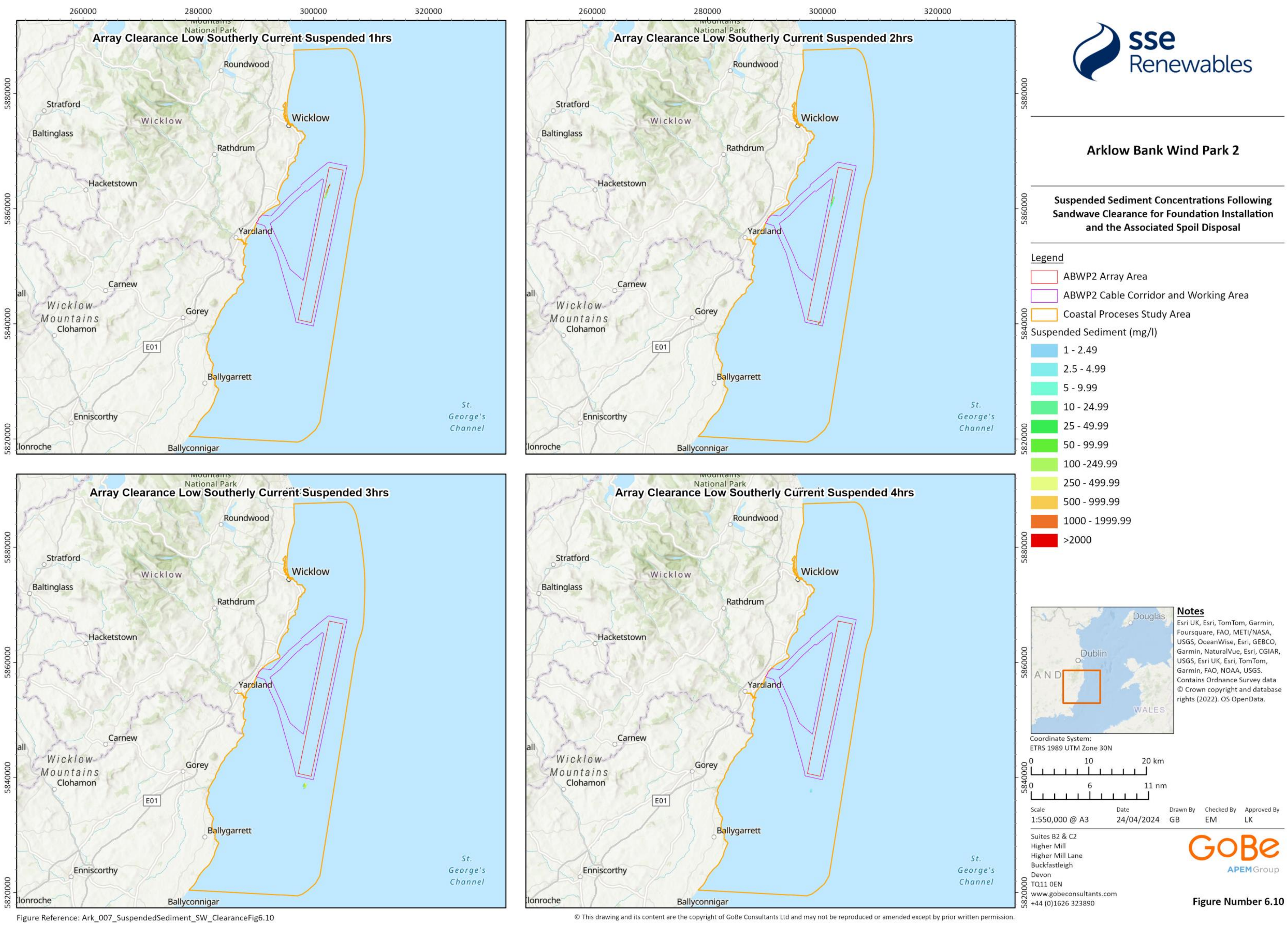

Figure 6.10: Suspended sediment concentrations following sandwave clearance for foundation installation and the associated spoil disposal. Shown for an ebb (southerly) high current regime

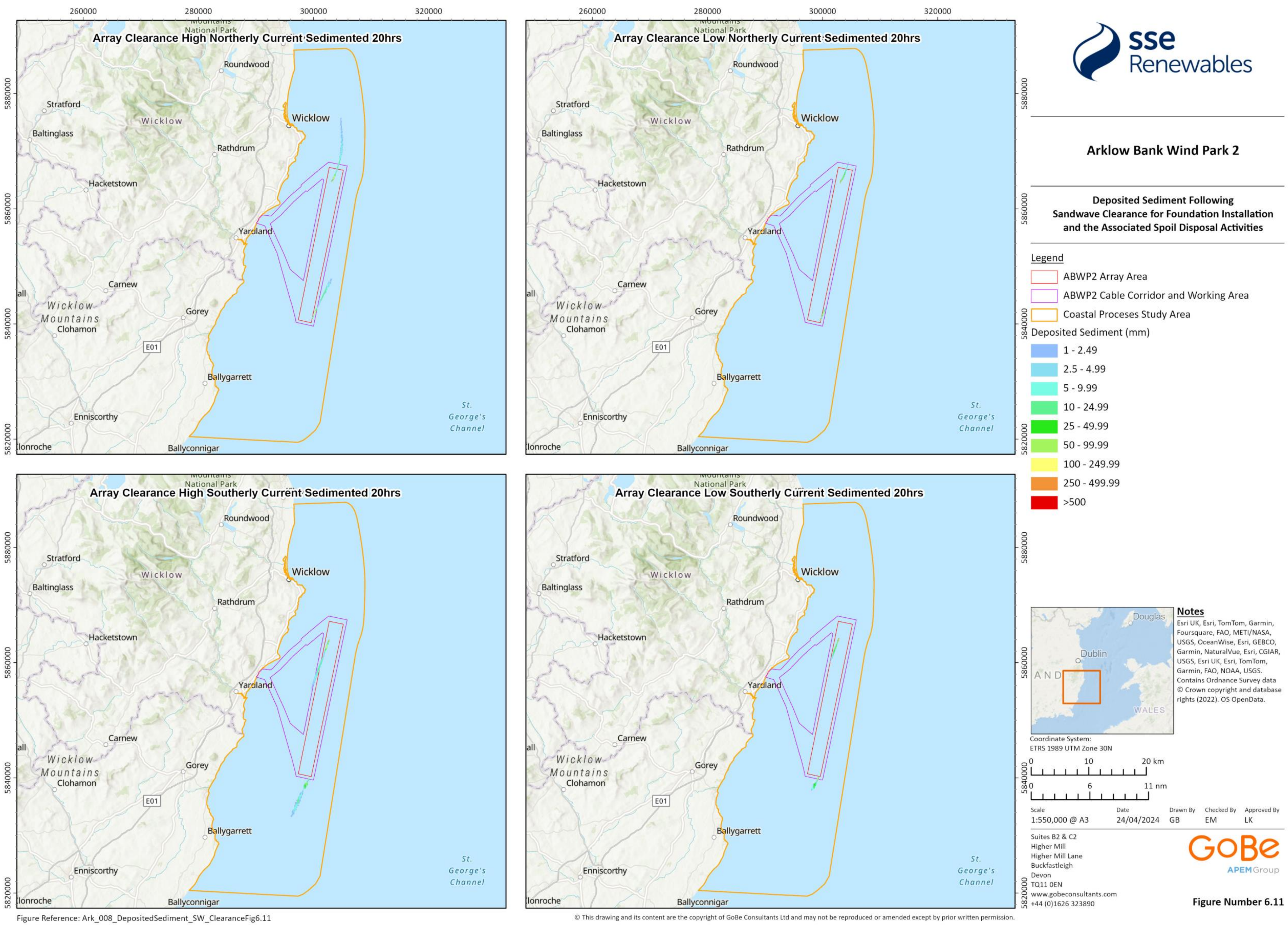

Figure 6.11: Deposited sediment following sandwave clearance for foundation installation and the associated spoil disposal activities. Shown for a high and low current regime on a flood (northwards) and ebb (southwards) tide

6.10.1.21 As presented in Partrac (2022), the sedimentary processes over Arklow Bank are highly dynamic and as such it is expected that the bedforms will recover/ reform, providing that there is an adequate sediment supply available within the system. A conceptual understanding of the sediment transport regime is provided in Figure 6.7. Using the sediment transport model of Creane *et al*., (2023) (paragraph 6.6.1.24 *et seq.*), the northern head and eastern flank represents the greatest sediment source to Arklow Bank. The rate of bedform recovery will vary in relation to the rate of sediment transport processes, faster infill and recovery rates will be associated with higher local flow speeds and more frequent wave influence, the latter of which occurs in the shallower water depths and during low-frequency, high-energy events. The shape of the bedform following recovery might recover to its original form (e.g. rebuilding a single crest feature likely in the direction of the northerly transport) or it might change (e.g. a single crest feature might bifurcate or merge with another nearby bedform). Given the highly dynamic nature of the sedimentary processes within the Array Area (Partrac, 2022), it is anticipated that any sediment deposited onto the seabed as a result of construction activities (Figure 6.11) will be quickly incorporated within the existing regime and thus contribute to the bedform recovery/ regeneration process. All such possible outcomes are consistent with the natural processes and bedform configurations that are already present in the Coastal Processes Study Area and will not adversely affect the onward form and function of the individual bedform features, nor the form and function of Arklow Bank.

6.10.1.22 Monitoring data from generally similar hydrodynamic and sedimentary environments provides evidence for this recovery process. Pre-levelling, levelling, and post-levelling bathymetry data for 19 locations (over 12 monitoring sites) within the Race Bank wind farm[16], provided observations of post-levelling sandwave response and recovery (approximately one to five months following levelling) across a range of similar but subtly different sandwave bedforms and sedimentary environments (DONG Energy, 2014). At Race Bank OWF, the surficial sediments are predominately sandy and water depths are similar to Arklow Bank. Whilst current speeds are slightly lower than at Arklow Bank (peak current speeds are between 1.0 m/s and 1.2 m/s (Centrica Energy, 2009), there is active sediment transport and seabed mobility at both locations. Evidence from Race Bank is therefore considered as an appropriate analogue for processes occurring at the Proposed Development.

6.10.1.23 The Race Bank monitoring data (DONG Energy, 2014) indicates that locally levelled sandwaves continue to evolve in a manner that is consistent with recovery towards a new natural equilibrium state over a period of months to years' post-levelling. At ten of the twelve monitoring sites within five months of levelling, there was evidence of partial to complete sandwave recovery consistent with the site being an active and dynamic sedimentary environment conducive to the development, maintenance and migration of sandwave bedforms.

6.10.1.24 Evidence from Larsen *et al*. (2019) further supports this conclusion which compares multiple high-resolution bathymetry datasets to investigate the response of sandwaves within the Race Bank wind farm to the dredging of two 16 m bottom width trenches. For both areas surveyed, the sandwave height is observed to have regenerated to, approximately, 65% after 300 days, with a prediction of full recovery (98%) after three years.

6.10.1.25 Further evidence supporting sandwave regeneration following clearance activities is provided from the analysis of bathymetric survey data from the Greater Changhua 1&2a OWF. This analysis demonstrated the ability of sandwaves to regenerate to pre-construction (2016) dimensions following dredging activities for installation activities in 2021/ 2022 (Roulund *et al*., 2023).

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[16] east coast of the UK

6.10.1.26 An assessment of the morphodynamics of Arklow Bank has shown that the sandwaves are under the control of the wave and tidal regime (Partrac, 2022). These processes function at scales larger than the proposed construction (and operation and maintenance) activities and as the installation and operational dredging works will not interrupt the wave and tidal regimes, it is unlikely that the bedforms, in turn, will be affected (ABPmer, 2018).

6.10.1.27 Evidence available from other windfarms and literature, as above, would support the hypothesis that local perturbations to existing sandwaves that do not change the fundamental conditions of the setting (i.e. the tidal and wave regime and the volume of mobile sediment available for sediment transport) will not prevent the continued evolution of the features through the same naturally occurring processes. As such, it is expected that the sandwave features will recover towards a new equilibrium state over time.

MAGNITUDE OF THE IMPACT

6.10.1.28 The magnitude of impacts (SSC; sediment deposition) that result from sandwave clearance for foundation installation and the associated spoil disposal activities are shown in Table 6.17 and Table 6.18. These magnitudes align with the justifications provided in Table 6.14 and are in accordance with EPA (2022).

Table 6.17: Determination of magnitude for changes to suspended sediment concentrations due to sandwave clearance for foundation installation and associated spoil disposal

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI. The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by the higher SSC and more localised plume, for more than one or two consecutive tides.
Duration	The predicted changes will occur during construction activities within the Array Area and are considered short-term, with measurable effects in the order of hours.
Frequency	The predicted changes will only occur during active sandwave clearance and spoil disposal and can be considered intermittent during construction. This is due to the transit time required from filling the THSD to the hopper discharge at the spoil site.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Elevated suspended sediment concentrations immediately adjacent to the activity for the duration of works. Plume transported by tidal flow away from Array Area and expected to be rapidly dispersed by energetic wave events. Noticeable, but temporary, changes to key characteristics or features of the particular environmental aspect's character or distinctiveness
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

Table 6.18: Determination of magnitude for changes to deposited sediment due to sandwave clearance for foundation installation and associated spoil disposal

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI.

Descriptor	Justification
	The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by deposition from suspended material over more than one or two tides.
Duration	The predicted changes will occur during construction activities within the Array Area and are considered short-term, with measurable effects in the order of hours.
Frequency	Suspended sediment will be deposited as it moves with the tidal flow away from the activity's location. The impact will occur intermittently throughout the construction phase given the temporary cessation in activity to allow for the TSHD to transit to the spoil disposal site.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Deposited sediment is greatest immediately adjacent to the construction activities for the duration of the activity, decreasing with distance from the activity. Any sediment deposited on the seabed will be rapidly incorporated into the active sediment transport regime.
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

PRE-LAY INTER-ARRAY CABLE TRENCHING AT THE SEABED

6.10.1.29 Boulder clearance along the interconnector and array cable routes within the Array Area will result in the total disturbance of 51,000 m^3. The use of a plough is such that the sediment is displaced from the seabed within a width of 15 m and from a depth of 0.5 m. Fluidisation of sediments will only occur using techniques such as jetting or flow excavators. Only the finer sediments are likely to be suspended following the seabed disturbance. The Proposed Development expects that the time periods between boulder clearance and other seabed works would be of the order of two weeks. This period would allow any suspended sediments to be dispersed/ deposited such that there are no additive effects anticipated from seabed works at the same location.

6.10.1.30 Of the different pre-lay cable trenching techniques considered by the Proposed Development, for which more information is presented in Volume II, Chapter 4: Description of Development, the use of CFE tools has been numerically assessed here as it provides the potential for seabed sediment to be disturbed the greatest extent into the water column.

6.10.1.31 As outlined in Table 6.10, this process would be used to excavate a trench with a width of 15 m and a depth of 1.5 m and has been calculated to result in a total seabed sediment disturbance of 1,830,000 m^2. The installation process is such that trenching will take place between two foundations whereupon the works will cease to allow for (i) the cable to be terminated at the hang-off, (ii) vessel re-positioning, (iii) inserting the cable into the J-tube and securing/ clamping and then (iv) laying across the scour layer. Should weather windows allow, it is considered that this cessation in activities will take circa 24 hours.

6.10.1.32 The temporary (24 hours) break in the trenching activity provides the opportunity for suspended material to be dispersed/ deposited in the absence of seabed disturbance activities (Figure 6.10). The trenched sediment volume is forced into suspension to a height of around 3 m above the seabed with the finer material settling within several meters of the trench. Displaced material will not be removed from the sedimentary system, and these small-scale changes in bed levels are likely to be quickly redistributed by the energetic hydrodynamic processes present within the Array Area (Section 6.6.1).

6.10.1.33 As shown in Figure 6.12 and Figure 6.13, the numerical modelling simulations undertaken show the following:

- Suspended Sediment Concentrations: maximum concentrations occur in the immediate locality of, and during the active phase of, the seabed CFE works. Here, SSC exceeding 2,000 mg/l occur within 1 km of the activity. Given the rectilinear tidal flows within the Array Area, elevated SSC typically occur in a narrow plume extending from the point of disturbance. The plume length is dependent upon the tidal direction and current speeds, such that a northerly flow with greater speeds results in the most elongated plume (elevated SSC within the natural variability of the system, circa less than 2.5 mg/l, are observed up to 17 km north and 9 km south of the seabed activities under a high northerly and high southerly current, respectively).
- Deposited sediment: sediment is deposited within the SSC's plume extent, with patterns of deposition comparable to the direction, extents and magnitudes of the suspended sediment. Maximum deposition occurs in the immediate proximity of the seabed activities, up to 100 mm. Sediment can be deposited within an area extending up to 18 km and 10 km, under the high northerly and high southerly currents, respectively. At these distances deposition is no greater than 2.5 mm, which is comparable to a 'very coarse' grain of sand. Continual re-working of the deposited sediment will occur through subsequent tidal cycles as re-suspension and dispersal. The wave regime will also act to re-suspend and disperse deposited sediment. Of note is that the maximum deposition occurs under the slower current speed scenarios when the sediment is not transported as far, falling out of suspension quicker than under the faster current speeds.

6.10.1.34 Cable installation may require sandwave clearance to take place beforehand to ensure effective cable burial depths and as assessed in paragraph 6.10.1.15 *et seq*. These features are expected to recover towards a new equilibrium state over time through the naturally-occurring hydrodynamic conditions of the site.

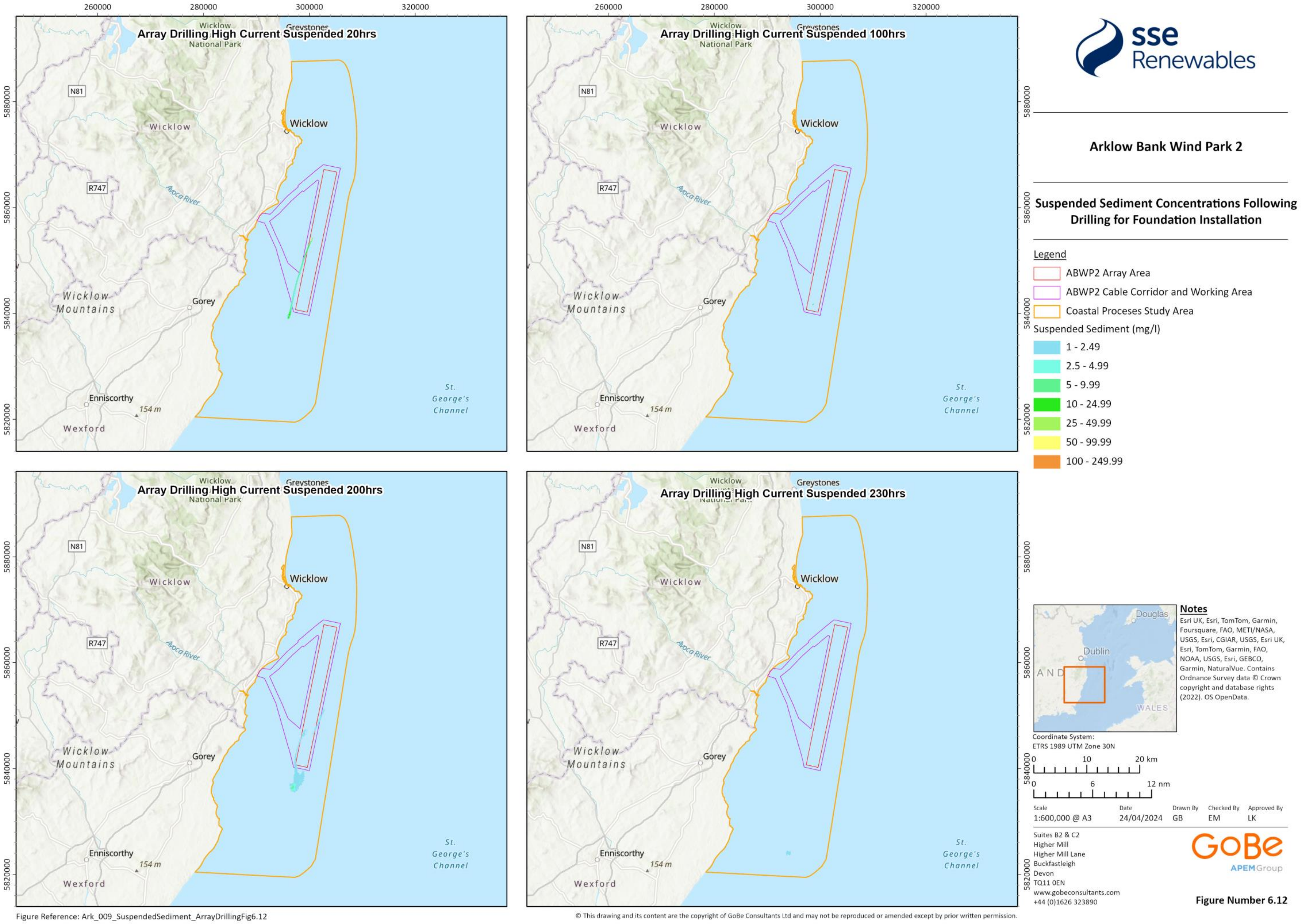

Figure 6.12: Maximum[17] suspended sediment following inter-array cable installation. Shown for a high and low current regime on a flood (northwards) and ebb (southwards) tide

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[17] Where the values shown are the maximum SSC that occur within the model domain at any time during the numerical simulation. As such, the results shown on this figure may be from different timesteps.

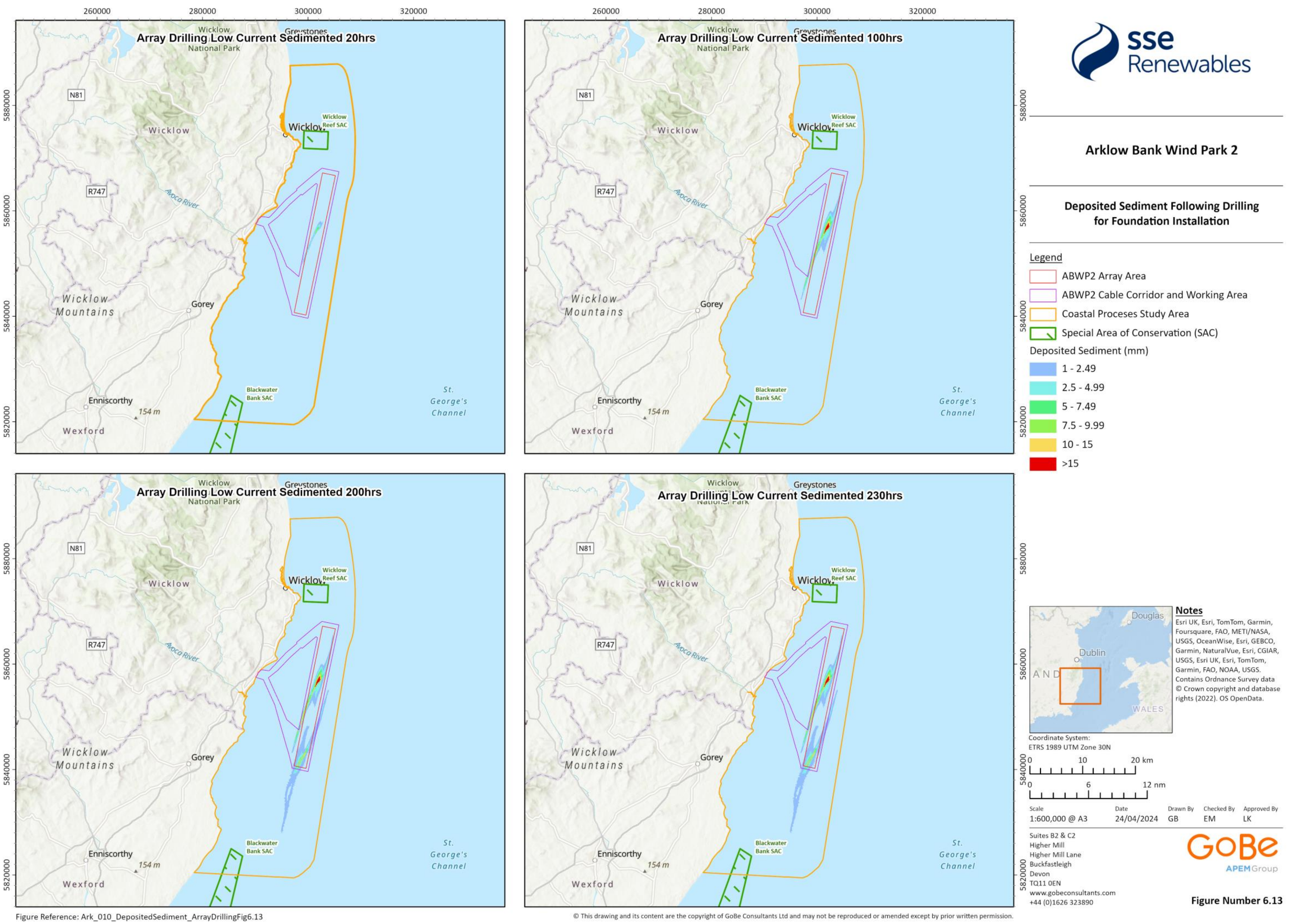

Figure 6.13: Maximum[18] deposited sediment following inter-array cable installation. Shown for a high and low current regime on a flood (northwards) and ebb (southwards) tide

[18] Where the values shown are the maximum depoistion that occur within the model domain at any time during the numerical simulation. As such, the results shown on this figure may be from different timesteps.

6.10.1.35 Cable burial operations have been reported to result in a localised and temporary re-suspension and subsequent settling of sediments (BERR, 2008). The exact nature of this disturbance will be determined by the soil conditions, the length of installed cable, the burial depth, burial method and environmental conditions at the time of installation works. Evidence collected from a number of wind farms, including Race Bank, in addition to aggregate extraction sites, has shown that for predominately sandy substrates, the seabed has shown to recover well following cable installation, especially in those environments (such as the Array Area) with active sediment transport (RPS, 2019).

MAGNITUDE OF THE IMPACT

6.10.1.36 The magnitude of impacts (SSC; sediment deposition) that result from pre-lay cable trenching within the Array Area are shown in Table 6.19 and Table 6.20. These magnitudes align with the justifications provided in Table 6.14 and are in accordance with EPA (2022).

Table 6.19: Determination of magnitude for changes to suspended sediment concentrations due to pre-lay cable trenching within the Array Area

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI. The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by the higher SSC and more localised plume, for more than one or two consecutive tides.
Duration	The predicted changes will occur during construction activities within the Array Area and are considered short-term.
Frequency	The predicted changes will only occur during active pre-lay cable trenching and can be considered intermittent during construction; pre-lay cable trenching within the Array Area will undergo a, circa, 24-hour pause at the monopile location to allow for vessel re-positioning, the insertion of the cable into J-tube, placement of scour layer and re-starting of installation activities.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Elevated suspended sediment concentrations adjacent to the activity for the duration of works. Plume transported by tidal flow away from Array Area and expected to be rapidly dispersed by energetic wave events. Noticeable, but temporary, changes to key characteristics or features of the particular environmental aspect's character or distinctiveness
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

Table 6.20: Determination of magnitude for changes to deposited sediment due to pre-lay cable trenching within the Array Area

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI. The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by deposition from suspended material over more than one or two tides.
Duration	The predicted changes will occur during construction activities within the Array Area and are considered short-term.

Descriptor	Justification
Frequency	Suspended sediment will be deposited as it moves with the tidal flow away from the activity's location. Suspended sediment will be available for deposition on an intermittent basis during construction (Table 6.19).
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Deposited sediment is greatest immediately adjacent to the trenching activities for the duration of the activity, decreasing with distance from the activity. Any sediment deposited on the seabed will be rapidly incorporated into the active sediment transport regime.
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low.**

FOUNDATION INSTALLATION USING DRILLING TECHNIQUES;

6.10.1.37 Monopile foundations will be installed into the seabed using standard piling techniques. In some locations, the particular geology may present an obstacle to piling in which case, some or all of the seabed material might be drilled within the pile footprint to assist in the piling process. Should it be impossible to install a monopile, which may occur at a maximum of five locations, jetting may be used to remove the structure prior to moving it no more than 50 m from its original position. This activity will result in the disturbance of up to 4,473 m^3 per monopile which is circa 64% less than the volume disturbed through drilling and represents a temporary seabed disturbance. A maximum of 45% to 53% (Project Design Option 1 and 2, respectively) of locations within the Array Area have been estimated to require drilling.

6.10.1.38 The impact of drilling operations mainly relates to the release of drilling spoil at or above the water surface which will put sediment into suspension and the subsequent redeposition of that material to the seabed. The nature of the disturbance will be determined by the:

- Drilling rate;
- Total volume of material to be drilled;
- Seabed and sub-bottom material type; and
- Drilling method (affecting the texture and grain size distribution of the drill spoil).

6.10.1.39 Disposal mounds may result from foundation drilling activities whereby the persistence and evolution of these seabed deposits will be dependent upon on range of factors, principally:

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

6.10.1.40 Geological information, based on historic data and project specific boreholes (paragraph 6.6.1.13 *et seq.)* indicates that gravels and sands predominate under the Holocene layer. A thin clay layer was observed in one of the boreholes. In those areas where disposal mounds comprise clays and gravels, it can reasonably be assumed that these mounds will become semi-permanent seabed features. The 'live bed' regime identified on Arklow Bank is such that the sand-sized sediment is mobilised on each tidal cycle (Partrac, 2022). Thus, over time, it can be expected that finer grained material will be further disaggregated and winnowed away, lowering the profile of the mound. As such, it can be reasonably expected that wave events will act, particularly under extreme, storm events and in the shallower water depths, to mobilise and disperse the larger grained material with time.

6.10.1.41 Numerical modelling (Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling) has simulated drilling at two locations; at a WTG location on the western side of Arklow Bank and the southern OSP. The release of drill arisings is simulated to persist for 88 hours (at the WTG), followed by a 12 hour pause, followed by another 88-hour period of drilling (at the southern OSP). The location of the two releases is such that, due to the orientation of the tidal axis and the absence of wave influence, there is opportunity for the disturbed sediment to be additive. The results can be summarised as follows:

- Suspended sediment concentrations (Figure 6.14):
  - Elevations in SSC progressively increase in both concentration and spatial extent as the drilling operations continue. The distance of increased SSC from the installation activity is predicted to be greater under higher current speeds; of note is that the plume remains within the ZoI. As would be expected, the greatest SSC concentration is predicted to occur towards the end of the drilling period, at each location (WTG; OSP). The maximum concentration occurs closer to the OSP and is a direct consequence of a greater volume of drill arisings which results from a wider pile dimension (5,280 m^3 (Project Design Option 1); 7,040 m^3 (Project Design Option 2) vs 13,860 m^3 (OSP)). (OSP)).
  - Under high, ebb (southerly), current conditions, once the WTG drilling has been completed (88 hours following commencement of works) the greatest SSC is predicted to occur in the plume centre (circa 25 mg/l), this rapidly dissipates such that prior to drilling at the OSP, there are no noticeable increases in SSC within the ZoI.
  - Under the high current conditions, drilling at the OSP elevates SSC by over 100 mg/l at the point of activity only. Beyond the drilling location, SSC rapidly reduces to less than 25 mg/l. Movement along the tidal axis, to the (approximately) north and south is such that concentrations less than 25 mg/l are predicted 18 km to the north of the release in a narrow, 1 km, plume and 6 km to the south.
  - 12 hours following the completion of the OSP drilling, elevated SSC of up to 2.5 mg/l are predicted 7 km to the south of the array, with a maximum elevation of 10 mg/l within an area of hundreds of metres from the location of the works. Nearly two days following completion, elevated SSC will be undiscernible from background concentrations (circa 2.5 mg/l; Section 6.6.1.17; Figure 6.6).
  - Patterns of elevated SSC under low tidal currents are similar both in magnitude and elevation, though it is observed that dispersion is lower and is such that there is a greater areal extent of the 2.5 mg/l elevations. Of note is that these remain within the ZoI.
- Deposited sediment (Figure 6.15):
  - The depth and areal extent of sediment deposited during and following foundation (WTG; OSP) installation works progressively increases with time. The suspended sediment (Figure 6.14) will be both dispersed by the tidal currents and settle out from suspension when the tidal current speeds are insufficient to transport it. Deposited sediment remains within the ZoI and its location is under the control of the tidal axis, in addition to the current speeds. Of note is that any deposited sediment has the potential to be re-worked by the tidal, and wave, regime. In an energetic environment such as Arklow Bank, this will be a rapid process and any deposited sediment is expected to quickly re-enter the sediment system. As is expected, sediment deposition is greater under lower (flood; northerly) tidal current flows, as such the following discussion is focussed on the results presented from these numerical simulations.
  - The depth and areal extent of the deposited sediment increases throughout the period of active works, such that, 12 hours following completion of the WTG installation, over 15 mm of sediment has settled onto the seabed immediately adjacent to the foundation. A narrow, <0.25 km, strip of sediment is deposited along the tidal axis, up to 12 km from the installation work.

– Once drilling commences for the OSP foundations, a second area of deposition occurs, again with the greatest deposition occurring in close proximity to the activity. Following completion of the OSP foundation drilling, the maximum deposition depth is, approximately, 15 mm in the vicinity of the project works.

MAGNITUDE OF THE IMPACT

6.10.1.42 The magnitude of impacts (SSC; sediment deposition) that result from pre-lay cable trenching within the Array Area are shown in Table 6.21 and Table 6.22. These magnitudes align with the justifications provided in Table 6.14 and are in accordance with EPA (2022).

Table 6.21: Determination of magnitude for changes to suspended sediment concentrations due to foundation drilling activities

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI. The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by the higher SSC and more localised plume, for more than one or two consecutive tides.
Duration	The predicted changes will occur during construction activities within the Array Area and are considered short-term.
Frequency	The predicted changes will only occur during active foundation drilling and can be considered intermittent during the construction period.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Elevated suspended sediment concentrations immediately adjacent to the activity for the duration of works. Plume transported by tidal flow away from Array Area and expected to be rapidly dispersed by energetic wave events. Noticeable, but temporary, changes to key characteristics or features of the particular environmental aspect's character or distinctiveness
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

Table 6.22: Determination of magnitude for changes to deposited sediment due to foundation drilling activities

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI. The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by deposition from suspended material over more than one or two tides.
Duration	The predicted changes will occur during construction activities within the Array Area and are considered short-term.
Frequency	The predicted changes will only occur during active foundation drilling and can be considered intermittent during the construction period.
Probability	The predicted changes can be reasonably expected to occur.

Descriptor	Justification
Consequence	Deposited sediment is greatest immediately adjacent to the foundation drilling activities for the duration of the activity, decreasing with distance from the activity. Any sediment deposited on the seabed occurs aligned with the direction of the tidal flow and is expected to be rapidly incorporated into the active sediment transport regime.
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

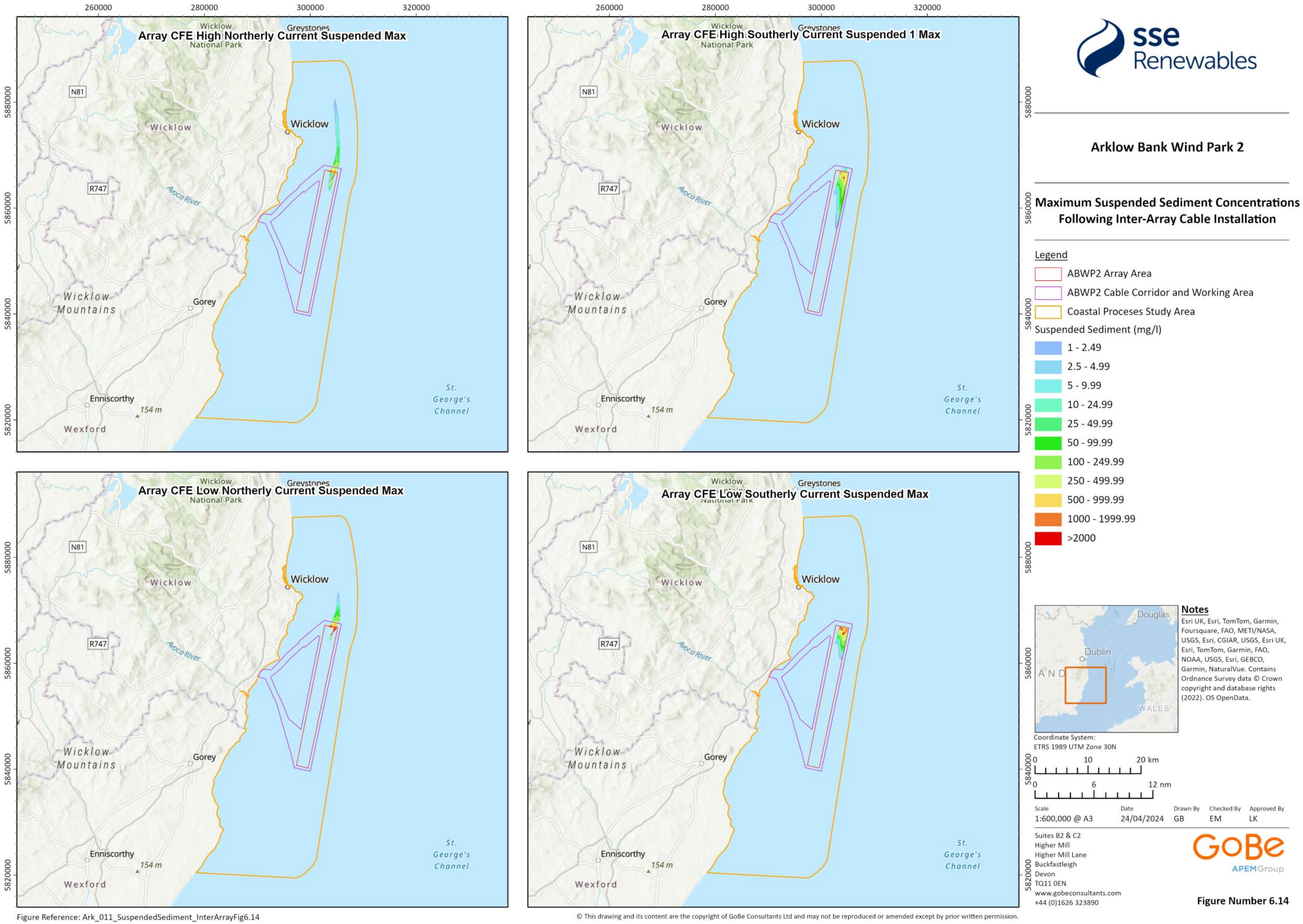

Figure 6.14: Suspended sediment concentrations following drilling for foundation installation. Shown for an ebb (southerly) high current regime

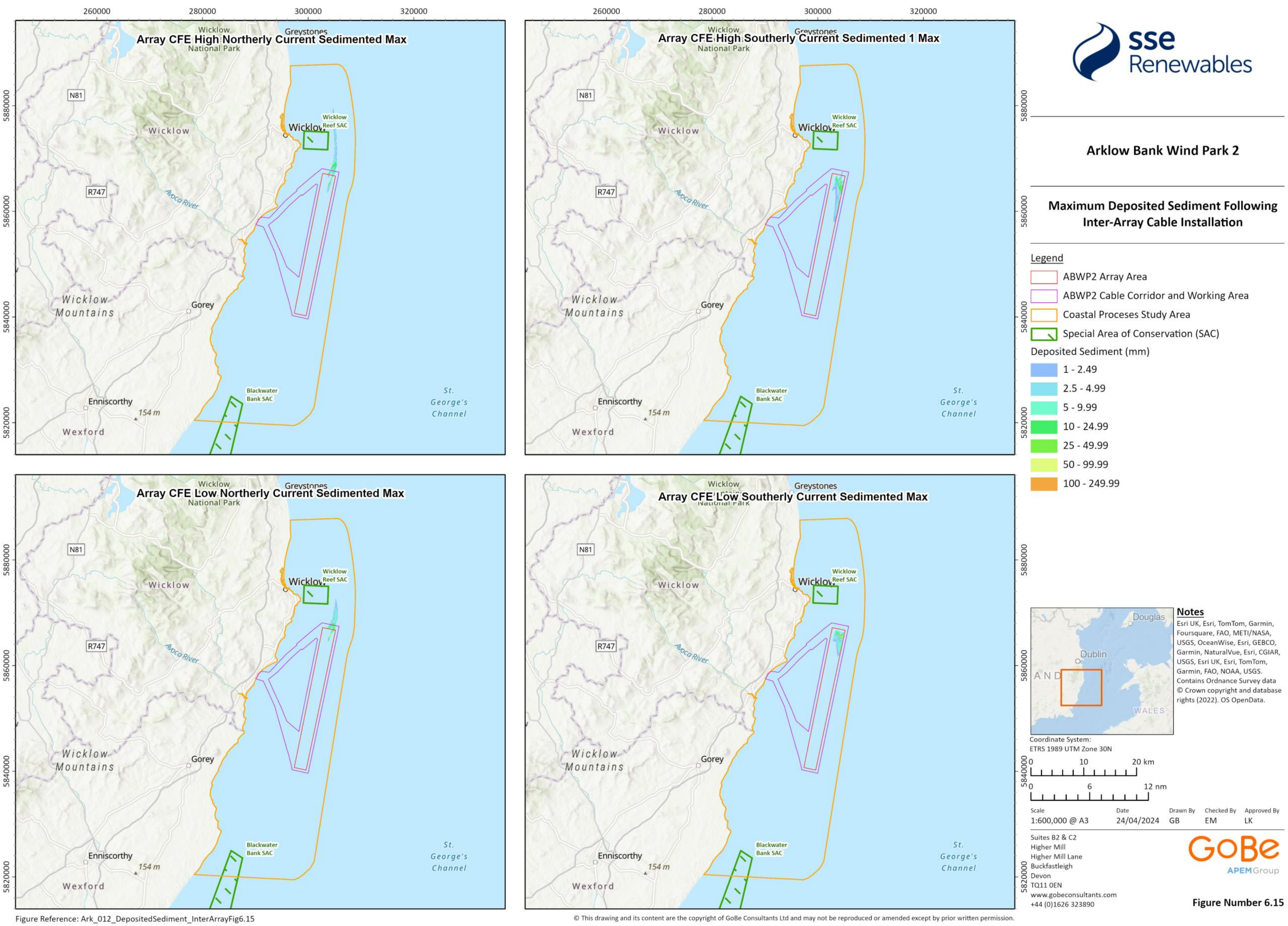

Figure 6.15: Deposited sediment following drilling for foundation installation. Shown for a low current regime on a flood (northwards) tide

EXPORT CABLE SEABED PREPARATION AND INSTALLATION ACTIVITIES

6.10.1.43 The following sections present the assessment for those construction activities within the Cable Corridor and Working Area.

SEABED PREPARATION (SANDWAVE CLEARANCE FOR CABLES) INCLUDING SPOIL DISPOSAL VIA A TRAILER SUCTION HOPPER DREDGER;

6.10.1.44 Seabed preparation may be required prior to the installation of the Proposed Developments' infrastructure. This is likely to include sandwave clearance (the removal of sections of mobile bedforms) for cable installation activities in order to ensure effective cable burial below the level of the stable bed. The parameters for these activities are presented in Table 6.10. Sandwaves may be cleared along a corridor of 70 m in width (for each cable) with 10 m depth of material being relocated. This may occur across 30% (12 km) of the total export cable length (maximum 40 km), resulting in, circa, 500,000 m^3 to be excavated using a TSHD with an assumed hopper volume of 20,000 m^3. The behaviour of the sediment upon collection and as spoil is presented in paragraph 6.9.1.15 *et seq*.

6.10.1.45 Numerical modelling has simulated the filling of a TSHD hopper load, in addition to overspill, followed by discharged at a spoil disposal site (as set out in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling). The dredger is simulated as moving along a 3.6 km line in the centre of the northern cable route for 60 minutes before transiting to the disposal site in the southeastern corner of the Array Area, approximately 26 km away. Whilst the hopper is being filled, overspill is likely to develop a near-surface sediment plume composed primarily of fine sediments. The overspill phase from the TSHD lasts 60 minutes after which there is then a 50 minute break in discharge during the demobilisation and transit to the disposal site, where a sudden discharge under the vessel occurs over a 10 minute period. For the overspill phase, the sediment is released at the water surface and for the disposal phase the material is released 9.8 m below the surface.

6.10.1.46 Once the dredger moves to discharge a full hopper load, the majority of the finer sediments are expected to have already been lost to overspill, although this will vary based on the sediment type and filling rate. During spoil disposal, sediments will be discharged as a highly turbid dynamic plume, with the coarser sediment fraction falling quickly to the seabed (on timescales of minutes to tens of minutes) with limited opportunity to be advected away by tidal currents, leading to a correspondingly greater localised depth of accumulation on the seabed. Finer sediments in the spoil will remain in suspension for longer (up to around a day), forming a passive plume which will then be advected by tidal currents. Should any wave energy be present during the operations, then any plume will be dispersed more quickly than under tidal currents alone.

6.10.1.47 The potential consequences of sandwave clearance upon the seabed regime have been considered elsewhere within this EIAR Chapter using both numerical assessments and monitoring results and it has been shown that:

- Race Bank OWF monitoring data provides evidence of sandwave regeneration after dredging, with the sandwave height observed to have regenerated to, approximately, 65% after 300 days and a prediction of full recovery (98%) after three years (Larsen *et al*., 2019);
- analysis of bathymetric survey data from the Greater Changhua 1&2a OWF demonstrates the ability of sandwaves to regenerate to the former magnitude following dredging activities (Roulund *et al*., 2023); and
- assessments undertaken for Norfolk Vanguard conclude that '*sandwave behaviour and responses are determined by the governing processes (tidal forcing, water depth and sediment supply) that occur at a much larger and regional scale than the proposed works. As these will not be disrupted by the proposed works, all available indicators point towards the form and function of the sandwaves and sandbanks being maintained'* (ABPmer, 2018)

6.10.1.48 As shown in Figure 6.16 and Figure 6.17, the numerical modelling simulations undertaken show the following:

- Suspended Sediment Concentrations (Figure 6.16):
  - Within the first hour of sandwave clearance[19], a plume of fine sediment is observed within 6 km of the seabed works. The maximum SSC within this thin (less than 0.2 km wide) plume is circa 2,000 mg/l and occurs immediately adjacent to the TSHD location. As this plume is advected by the tidal currents along the tidal axis, it is also dispersed such that the SSC levels reduce with increasing distance from the release location. After four hours, the plume has further reduced such that it is discernible from background concentrations (less than 2.5 mg/l).
  - Disposal of the TSHD load to the south of the Array Area, initially results in the formation of a plume with maximum concentrations of the order of 2,000 mg/l. Rapid dispersion is such that the discrete plume (circa 2 km by 0.5 km) is less than 250 mg/l after three hours, and by five hours the plume has further reduced such that it will only slightly be discernible from background concentrations (less than 5.0 mg/l). Elevated SSC above background concentrations is not predicted after 10 hours following the initial sandwave clearance.
  - Under all tidal flow simulations (speeds and direction), elevated suspended sediment concentrations (above background concentration) are not shown to disperse beyond 8 km from the Cable Corridor and Working Area.
- Deposited Sediment (Figure 6.17):
  - Sediment deposition is shown to have the following general characteristics:
    - under higher current speeds[20], the resultant deposition is shown to have a greater areal extent and lower thickness *than*;
    - under lower current speeds, the resultant deposition is shown to have a lesser areal extent and greater thickness.
    - the deposition location aligns with the axis of tidal flow, which are relatively linear to the north and south of Arklow Bank (Figure 6.1).
  - Sediment deposition is greatest in the vicinity of the disturbance activity, with thicknesses up to 250 mm occurring within 1 km. Beyond this, the thickness of deposited sediment rapidly reduces such that at 10 km from the active disturbance, the deposited thickness is of the order of 2.5 mm. Beyond this, the thickness of deposited sediment becomes immeasurable.
  - In reality, deposited sediment will become re-worked and entrained back into the sediment transport system under the action of both tides and waves.

[19] For a release during high current speeds. During lower current speeds, the plumes' SSC remain of similar orders of magnitude, but its extent is reduced as would be expected due to the reduced dispersive energy of the tidal regime.

[20] Noting that the peak current speed occurs during the final ten minutes of the overspill phase.

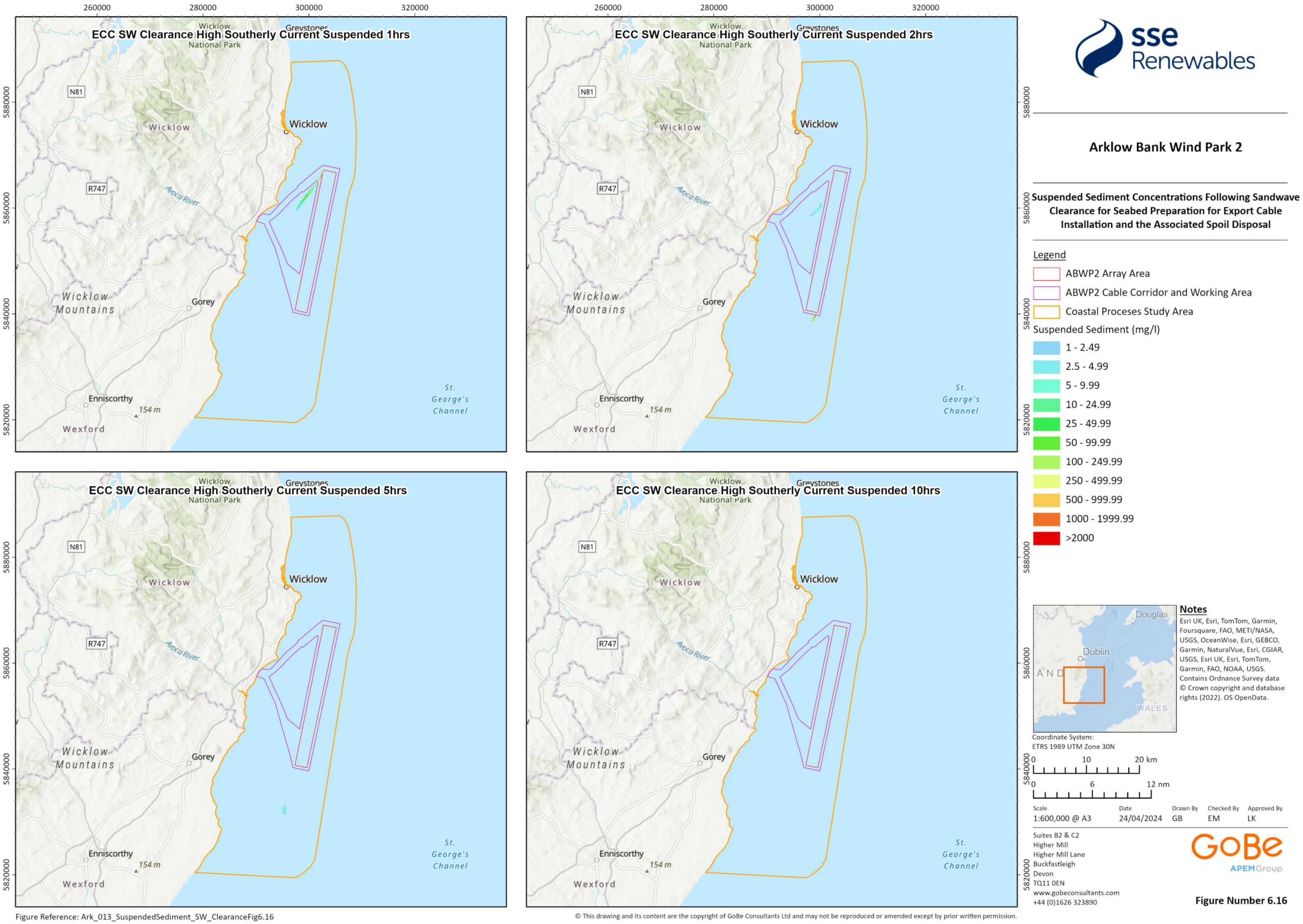

Figure 6.16: Suspended sediment concentrations following sandwave clearance for seabed preparation for export cable installation and the associated spoil disposal. Shown for a flood (northerly) high current regime

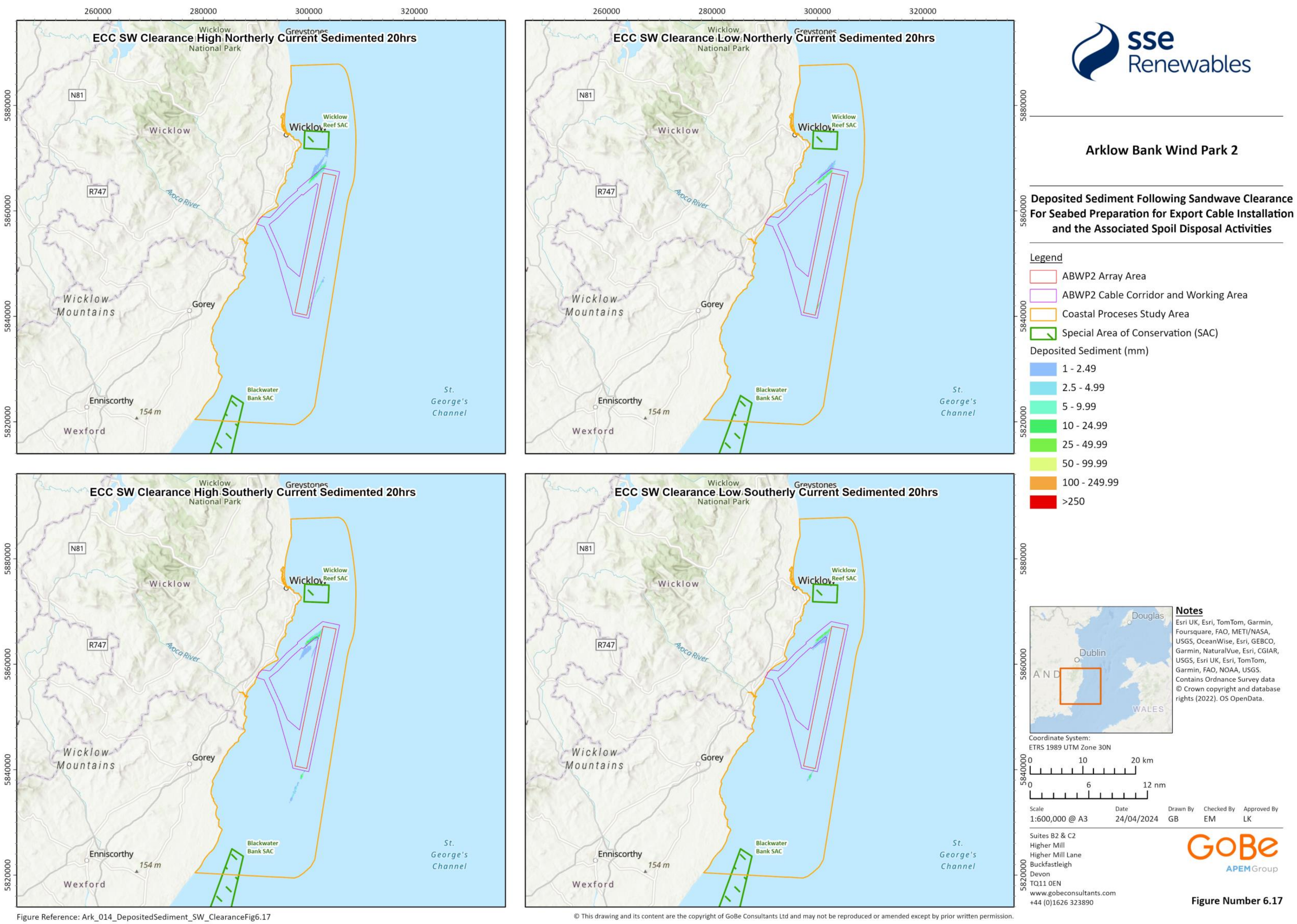

Figure 6.17: Deposited sediment following sandwave clearance for seabed preparation for export cable installation and the associated spoil disposal activities. Shown for a high and low current regime on a flood (northwards) and ebb (southwards) tide

MAGNITUDE OF THE IMPACT

6.10.1.49 The magnitude of impacts (SSC; sediment deposition) that result from sandwave clearance for export installation and the associated spoil disposal activities are shown in Table 6.23 and Table 6.24. These magnitudes align with the justifications provided in Table 6.14 and are in accordance with EPA (2022).

Table 6.23: Determination of magnitude for changes to suspended sediment concentrations due to sandwave clearance for export cable installation and associated spoil disposal

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI. The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by the higher SSC and more localised plume, for more than one or two consecutive tides.
Duration	The predicted changes will occur during construction activities within the Cable Corridor and Working Area and are considered short-term.
Frequency	The predicted changes will only occur during active sandwave clearance and spoil disposal and can be considered intermittent during construction. This is due to the transit time required from filling the THSD to the hopper discharge at the disposal site.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Elevated suspended sediment concentrations immediately adjacent to the activity for the duration of works. Plume transported by tidal flow away from Array Area and expected to be rapidly dispersed by energetic wave events. Noticeable, but temporary, changes to key characteristics or features of the particular environmental aspect's character or distinctiveness
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

Table 6.24: Determination of magnitude for changes to deposited sediment due to sandwave clearance for export cable installation and associated spoil disposal

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI. The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by deposition from suspended material over more than one or two tides.
Duration	The predicted changes will occur during construction activities within the Cable Corridor and Working Area and are considered short-term.
Frequency	Suspended sediment will be deposited as it moves with the tidal flow away from the activity's location. The impact will occur intermittently throughout the construction phase given the temporary cessation in activity to allow for the TSHD to transit to the spoil disposal site.
Probability	The predicted changes can be reasonably expected to occur.

Descriptor	Justification
Consequence	Deposited sediment is greatest immediately adjacent to the sandwave clearance activities along the Cable Corridor and Working Area, for the duration of the activity, decreasing with distance from the activity. Any sediment deposited on the seabed occurs aligned with the direction of the tidal flow and is expected to be rapidly incorporated into the active sediment transport regime.
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

PRE-LAY CABLE TRENCHING AT THE SEABED

SENSITIVITY OF RECEPTOR

6.10.1.50 The following receptors have been considered in the assessment of increased suspended sediment concentrations and associated deposition:

- Sites designated for physical features – Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs

SITES DESIGNATED FOR PHYSICAL FEATURES

6.10.1.51 Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs (Figure 6.2) are designated for the following qualifying features:

- Annual vegetation of drift lines;
- Embryonic shifting dunes;
- Shifting dunes along the shoreline with Ammophila arenaria (white dunes);
- Fixed coastal dunes with herbaceous vegetation (grey dunes);
- Atlantic decalcified fixed dunes;
- Dunes with Salix repens ssp. argentea; and
- Humid dune slacks.

6.10.1.52 Whilst these designated sites are located above the HWM, the two SAC have been included with this Coastal Processes assessment as a precautionary measure. The form and function of these designated sites is dependent upon a sufficient sediment supply, although it is noted in the associated conservation objectives that the sites are subject to natural varying cycles of accretion and erosion (NWPS, 2017a and 2017b). Justification of the sensitivity of the Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs, to increased suspended sediment concentrations and associated deposition, according to the definitions provided in Table 6.13, are presented in Table 6.25.

Table 6.25: Determination of sensitivity to Impact 1: Export cable seabed preparation and installation activities for the receptor: Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs

Descriptor	Justification
Adaptability	The receptor cannot avoid or adapt to an impact: the qualifying features of Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs undergo cycles of accretion and erosion.
Tolerance	The environment has high capacity to accommodate the proposed form of change: the qualifying features of the SAC are dependant upon a sufficient sediment supply, noting that the site is subject to naturally varying cycles of

Descriptor	Justification
	accretion and erosion. As such, it is considered that this feature has a high capacity to accommodate increases in SSC and associated deposition, should they occur as a result of landfall installation activities.
Recoverability	The effect on the receptor is anticipated to be short-term (i.e. over the Proposed Developments' individual construction activities): any effects arising from landfall installation activities will only occur for the duration of these works.
Value	The receptor is designated for international importance and/or very high socio-economic value: Magherabeg Dunes and Buckroney-Brittas Dunes and Fen are designated as SACs.
Overall Sensitivity	The potential sensitivity of the predicted changes is rated as **Low**.

6.10.1.53 Boulder clearance along the export cable route will result in the total disturbance of 300,000 m^3. The use of a plough is such that the sediment is displaced from the seabed from within a width of 15 m and to a depth of 0.5 m. Fluidisation of sediment only occurs using techniques such as jetting or flow excavators. Only the finer sediments are likely to be suspended following the seabed disturbance. The Proposed Development expects that the time periods between boulder clearance and other seabed works would be of the order of two weeks. This period would allow any suspended sediments to be dispersed/ deposited such that there are no additive effects anticipated from seabed works at the same location.

6.10.1.54 Of the different pre-lay cable trenching techniques considered by the Developer, for which more information is presented in Volume II, Chapter 4: Description of Development, the use of jetting tools has been numerically assessed along the export cable route. A description of the process which occurs is presented in Sections 6.10.1.31 and 6.10.1.35. As presented in Table 6.10, this process would be used to excavate a trench with a width at the seabed of 15 m and a depth of 2.5 m and represents a maximum total seabed area of disturbance of 600,000 m^2. For the purposes of the scenarios modelled for this assessment, the following parameters have been adopted:

- the tool is simulated to be moving along a 2 km section of the cable route, approximately 5.2 km offshore;
- the tool moves at a rate of 50 m per hour, such that trenching activities are continuous for 40 hours; and
- the material is released 2.5 m above the bed.

6.10.1.55 Full details of the assumptions and parameters used in the modelling scenarios are provided in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling.

6.10.1.56 As shown in Figure 6.18 and Figure 6.21, the numerical modelling simulations undertaken show the following:

- Suspended Sediment Concentrations (Figure 6.18):
  - The spatial distribution of elevated SSC is greater under higher[21] tidal currents with a greater magnitude under lower tidal current speeds in the plumes' centre;

[21] current speed peak events occur half way along the excavation route

  - The greatest increase in SSC is observed immediately adjacent to the active works (with levels circa 500 mg/l), whilst levels above background (2.5 mg/l) are observed up to 8 km from the point of disturbance;
  - Following completion of the active seabed disturbance, the elevated SSC rapidly reduces such that levels are comparative to background concentrations.
- Deposited Sediment (Figure 6.19):
  - Sediment deposition is shown to have the following general characteristics:
    - under higher current speeds[22], the resultant deposition is shown to have a greater areal extent and lower thickness than under lower current speeds when the resultant deposition is shown to have a lesser areal extent and relatively larger thickness.
    - the deposition location aligns with the axis of tidal flow, which are relatively linear to the north and south of Arklow Bank (Figure 6.1).
  - Sediment deposition is greatest in the vicinity of the disturbance activity, with thicknesses up to 25 mm occurring within 1 km. Beyond this, the thickness of deposited sediment rapidly reduces such that at 10 km from the active disturbance, the deposited thickness is less than 2.5 mm. Further still, the thickness of deposited sediment becomes immeasurable. In reality, deposited sediment will become re-worked and entrained back into the sediment transport system under the action of both tides and waves. Offshore export cable installation closer to the coastline may lead to a small amount of localised sedimentation on the foot of the dunes at the Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs. The sediment deposited will be native to the site and would be beneficial in the accretive behaviour of the dune systems.

[22] Noting that the peak current speed occurs during the final ten minutes of the overspill phase.

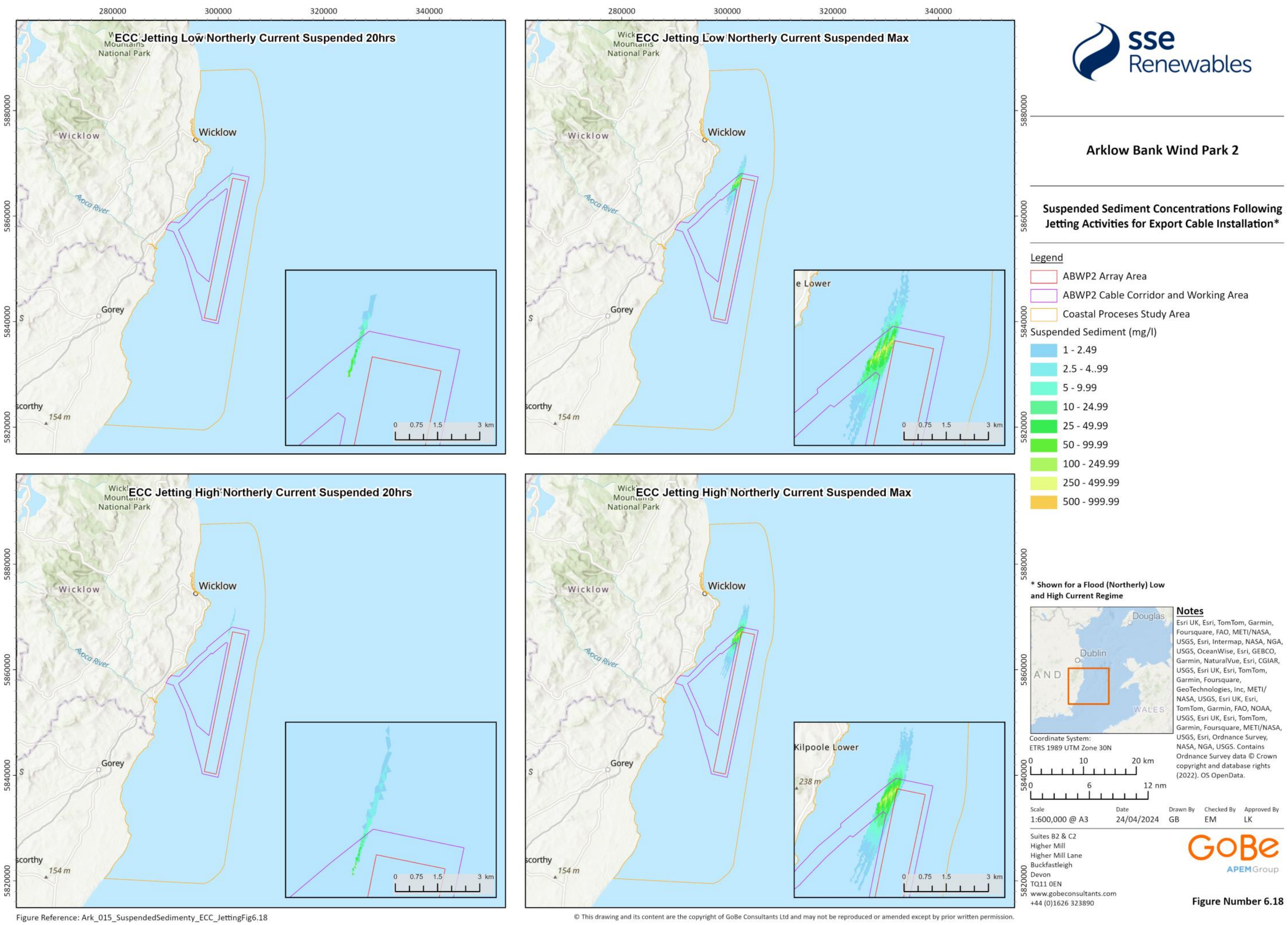

Figure 6.18: Suspended sediment concentrations following jetting activities within the Cable Corridor and Working Area. Shown for a flood (northerly) low and high current regime[23]

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[23] Where max refers to the maximum SSC value shown in any cell at anytime during the simulation.

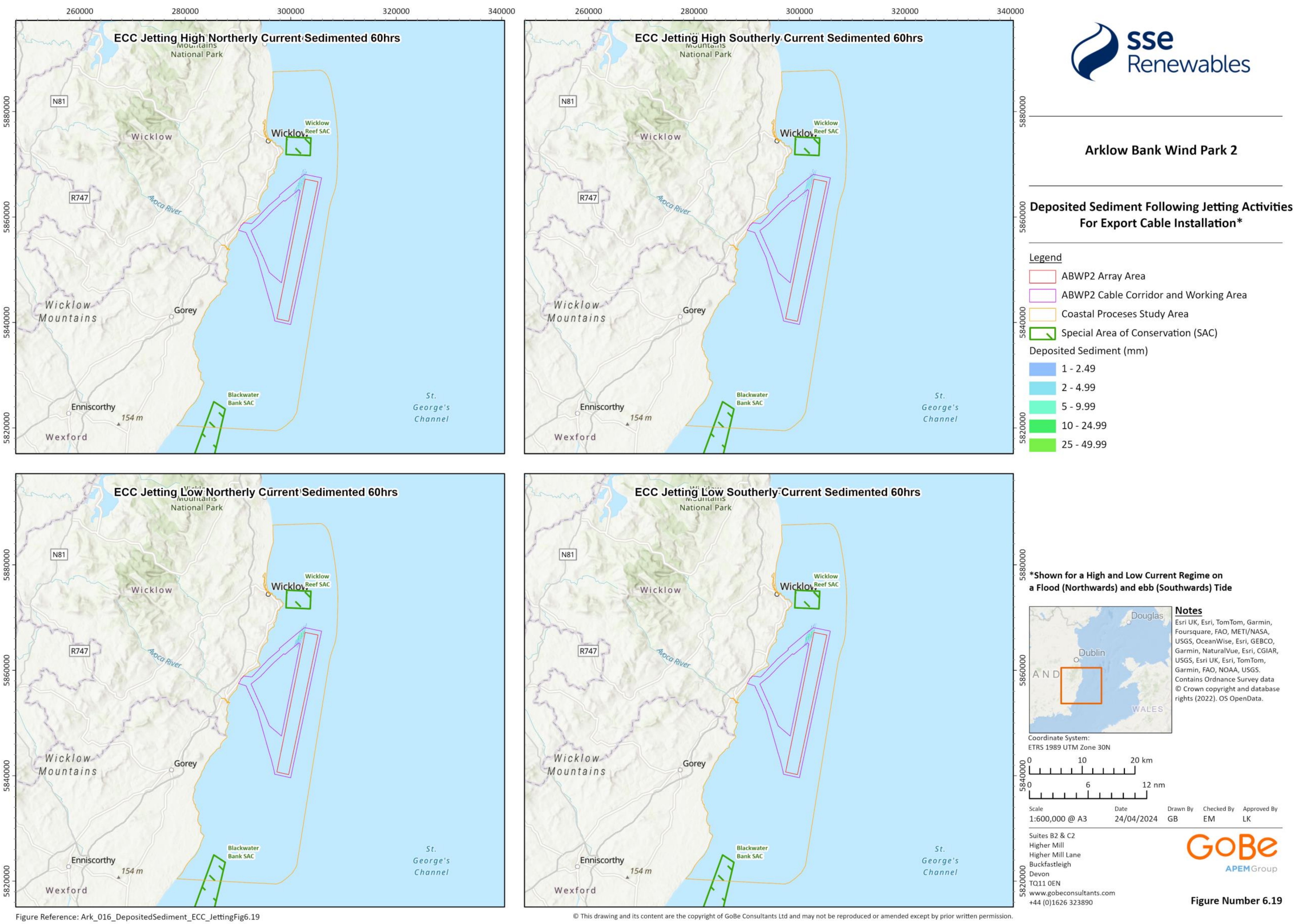

Figure 6.19: Deposited sediment following completion of jetting activities within the Cable Corridor and Working Area. Shown for a high and low current regime on a flood (northwards) and ebb (southwards) tide

MAGNITUDE OF THE IMPACT

6.10.1.57 The magnitude of impacts (SSC; sediment deposition) that result from sandwave clearance for export cable installation and the associated spoil disposal activities are shown in Table 6.26 and Table 6.27. These magnitudes align with the justifications provided in Table 6.14 and are in accordance with EPA (2022).

Table 6.26: Determination of magnitude for changes to suspended sediment concentrations due to sandwave clearance for export cable installation and associated spoil disposal

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by the higher SSC and more localised plume, for more than one or two consecutive tides.
Duration	The predicted changes will occur during construction activities within the Cable Corridor and Working Area and are considered short-term.
Frequency	The predicted changes will only occur during active sandwave clearance and spoil disposal and can be considered intermittent during construction. This is due to the transit time required from filling the THSD to the hopper discharge at the disposal site.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Elevated suspended sediment concentrations immediately adjacent to the activity for the duration of works. Plume transported by tidal flow away from the Cable Corridor and Working Area and expected to be rapidly dispersed by energetic wave events. Noticeable, but temporary, changes to key characteristics or features of the particular environmental aspect's character or distinctiveness
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

Table 6.27: Determination of magnitude for changes to deposited sediment due to sandwave clearance for export cable installation and associated spoil disposal

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI. The path followed by a tidal ellipse, whilst comparable, is not exactly the same on every tide. As such, it is unlikely that the same seabed area will be affected by deposition from suspended material over more than one or two tides.
Duration	The predicted changes will occur during construction activities within the Cable Corridor and Working Area and are considered short-term.
Frequency	Suspended sediment will be deposited as it moves with the tidal flow away from the activity's location. The impact will occur intermittently throughout the construction phase given the temporary cessation in activity to allow for the TSHD to transit to the spoil disposal site.

Descriptor	Justification
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Deposited sediment is greatest within the Cable Corridor and Working Area, for the duration of the activity, decreasing with distance from the activity. Any sediment deposited on the seabed occurs aligned with the direction of the tidal flow and is expected to be rapidly incorporated into the active sediment transport regime.
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

SIGNIFICANCE OF THE EFFECT

6.10.1.58 Those Coastal Processes receptors sensitive to the impact pathway are considered in the following section.

SITES DESIGNATED FOR PHYSICAL FEATURES

6.10.1.59 The sensitivity of Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs has been assessed as **Low**. The magnitude of Impact 1: Export cable seabed preparation and installation activities has been assessed as **Low**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance is concluded to be **Slight,** which is not significant in EIA terms**.**

PROPOSED MITIGATION

6.10.1.60 As there are no significant effects identified, it is considered that additional (non-embedded mitigation) measures are not required.

RESIDUAL EFFECT ASSESSMENT

6.10.1.61 There are no additional (non-embedded mitigation) measures proposed and as such a residual effect assessment has not been undertaken.

LANDFALL INSTALLATION ACTIVITIES

6.10.1.62 The following sections present the assessment for those construction activities at Landfall.

SENSITIVITY OF RECEPTOR

6.10.1.63 The following receptors have been considered in the assessment of increased suspended sediment concentrations and associated deposition:

- Sites designated for physical features – Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs

6.10.1.64 As the assessment of landfall installation activities considers the SSC and resultant sediment deposition, information pertaining to the sensitivity of these designated sites provided in paragraphs 6.10.1.50 *et seq.* and Table 6.25 remains relevant.

DRILLING FLUID RELEASE DURING HDD, OR OTHER TRENCHLESS TECHNIQUE, OPERATIONS.

6.10.1.65 The subsea export cable ducts will be installed underneath the beach using trenchless installation techniques, with HDD techniques as detailed in Chapter 4: Description of Development and as outlined in Table 6.10. The drilling activity utilises a viscous drilling fluid which consists of a mixture of water and bentonite, a non-toxic, naturally occurring clay mineral. The release of drilling fluid and drill cuttings from HDD operations will result in a plume of elevated SSC. The drilling fluid has an overall density and viscosity similar to seawater and so is expected to behave in a similar manner.

6.10.1.66 Numerical modelling has been used to simulate the release of bentonite over a 4.5 day[24] period during trenchless Landfall operations. Further detail is provided in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling.

6.10.1.67 The modelling results demonstrate that:

- Elevated SSC will be of localised extent and temporary duration, with maximum concentrations of 50 mg/l occurring only within at the location of the punch-out HDD exit pit and during the installation works. Rapid dispersion by tides and waves will result in the immediate dispersion and dilution of these concentrations. SSC is advected along the coast along the tidal axis to distances of up to 4 km, although concentrations at this distance are limited to below 25 mg/l. Of note is that dispersion to the south, following a release during a high spring southerly current is, approximately, 1 km less than under the equivalent northerly release (Figure 6.1). Away from the Landfall HDD activities and outside the Cable Corridor and Working Area, but within the ZoI, SSC levels are comparable/ less than background levels, shown to be no greater than 2.5 mg/l (Section 6.1.1); and
- Sediment deposition following cessation of HDD activities is shown in Figure 6.21. Deposition that is measurable in practice occurs within the immediate proximity of the Landfall works, remaining within the Cable Corridor and Working Area. Maximum deposition occurs during the activity as a result of the active release of the bentonite. Following cessation of the works, any deposited sediment will be re-worked by the tide and wave regimes, reducing its area and depth. Here, 6.5 days following the commencement of installation works, a maximum deposition of 7.5 mm is predicted within a coastal extent of 0.3 km within the Cable Corridor and Working Area (Figure 6.21). A similar pattern of deposition is predicted for releases during a northerly and southerly tidal flow. Deposition predicted for releases during high tidal flows, for both northerly and southerly flow, indicates a wider spread of deposition than during the low tidal flows. However, the directionality of the tidal flows is such that any deposited sediment is not transported, and ultimately deposited, in the offshore environment. This is to be expected due to the higher (faster) currents distributing sediment over a wider area.

6.10.1.68 In summary therefore, any measurable increases in SSC and deposition are small-scale, highly localised and is expected to be rapidly redistributed by wave action.

MAGNITUDE OF THE IMPACT

6.10.1.69 The magnitude of impacts (SSC; sediment deposition) that result from bentonite release from trenchless techniques, such as HDD, used at Landfall are shown in Table 6.28 and Table 6.29. These magnitudes align with the justifications provided in Table 6.14 and are in accordance with EPA (2022).

[24] initial punch-out followed by a reaming phase

Table 6.28: Determination of magnitude for changes to suspended sediment concentrations due to drilling fluid release during Horizontal Direction Drilling at the proposed Landfall.

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI and remain within the coastal zone.
Duration	The predicted changes will occur during construction activities at Landfall and as such can be classified as temporary.
Frequency	The predicted changes will only occur during the HDD works at Landfall and thus can be considered intermittent through the Proposed Developments' construction phase. The effects are reversible as the tide and waves disperse the suspended material.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Elevated suspended sediment concentrations occur immediately adjacent to the Landfall works for the duration of the activity. Increased concentrations occur within the coastal zone for up to 4 km, but within the range of natural levels, which are rapidly disperse due to wave and tidal action.
Overall Magnitude	The potential magnitude of the predicted changes is rated as Low.

Table 6.29: Determination of magnitude for changes to deposited sediment due to drilling fluid release during Horizontal Direction Drilling at the proposed Landfall

Descriptor	Justification
Extent	The predicted changes will be localised to within the ZoI and remain within the coastal zone.
Duration	The predicted changes will occur during construction activities at Landfall and as such can be classified as temporary.
Frequency	The predicted changes will only occur during the HDD works at Landfall and thus can be considered intermittent through the Proposed Developments' construction phase. The effects are reversible as the tide and waves redistribute the deposited material.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Deposited sediment is greatest immediately adjacent to the Landfall activities and remains within the Cable Corridor and Working Area. Any sediment deposited on the seabed occurs aligned with the direction of the tidal flow and is expected to be rapidly dispersed by any wave and tidal action.
Overall Magnitude	The potential magnitude of the predicted changes is rated as **Low**.

SIGNIFICANCE OF THE EFFECT

Those Coastal Processes receptors sensitive to the impact pathway are considered below.

SITES DESIGNATED FOR PHYSICAL FEATURES

6.10.1.70 The sensitivity of Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs has been assessed as **Low**. The magnitude of Impact 1: Landfall installation activities has been assessed as **Low**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance upon the SACs is concluded to be **Slight,** which is not significant in EIA terms**.**

PROPOSED MITIGATION

6.10.1.71 As there are no significant effects identified, it is considered that additional (non-embedded mitigation) measures are not required.

RESIDUAL EFFECT ASSESSMENT

6.10.1.72 There are no additional (non-embedded mitigation) measures proposed and as such a residual effect assessment has not been undertaken.

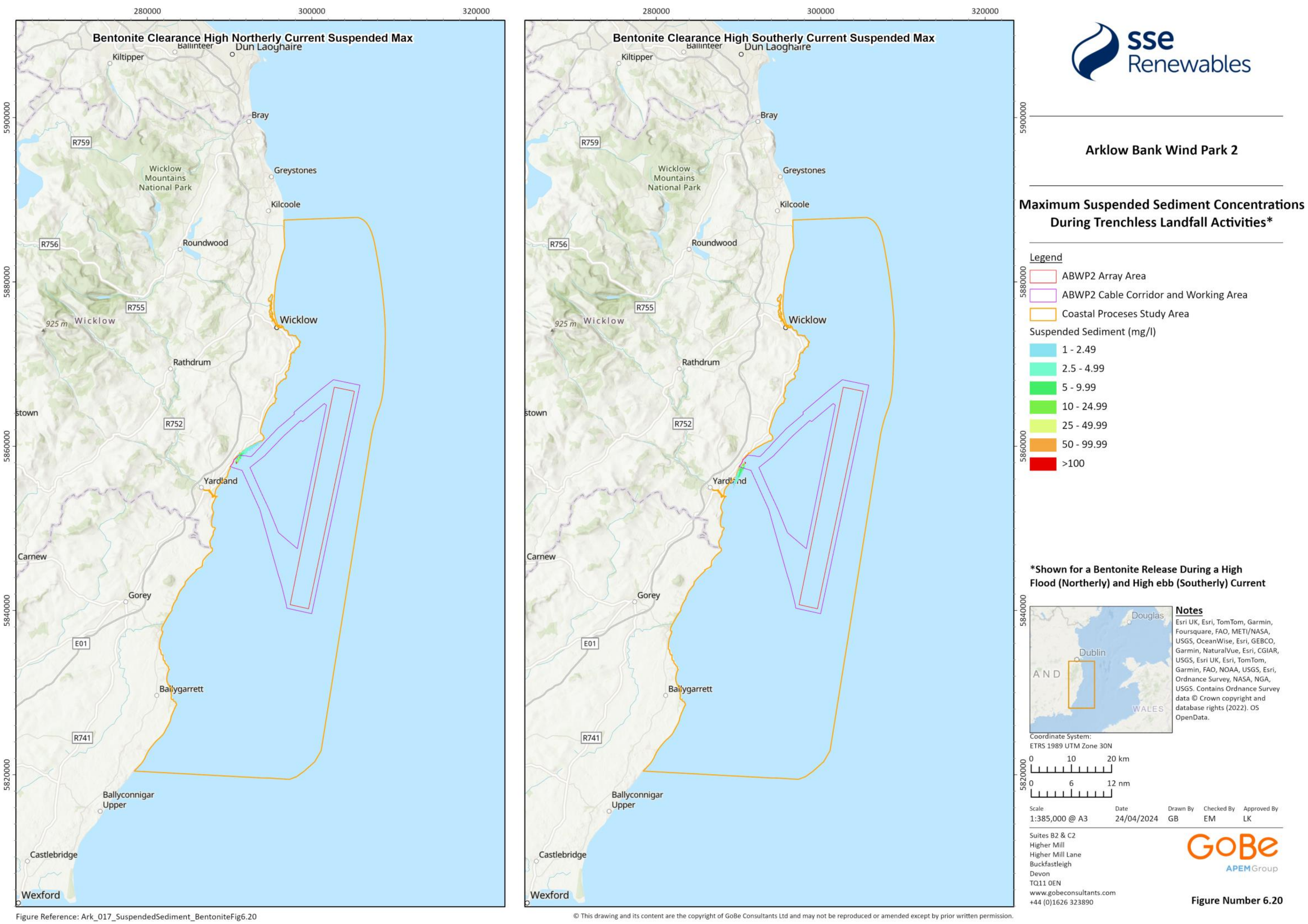

Figure 6.20: Maximum[25] suspended sediment concentrations during trenchless Landfall activities, shown for a bentonite release during a high flood (northerly) and high ebb (southerly) current

[25] Where the values shown are the maximum SSC that occur within the model domain at any time during the numerical simulation. As such, the results shown on this figure may be from different timesteps.

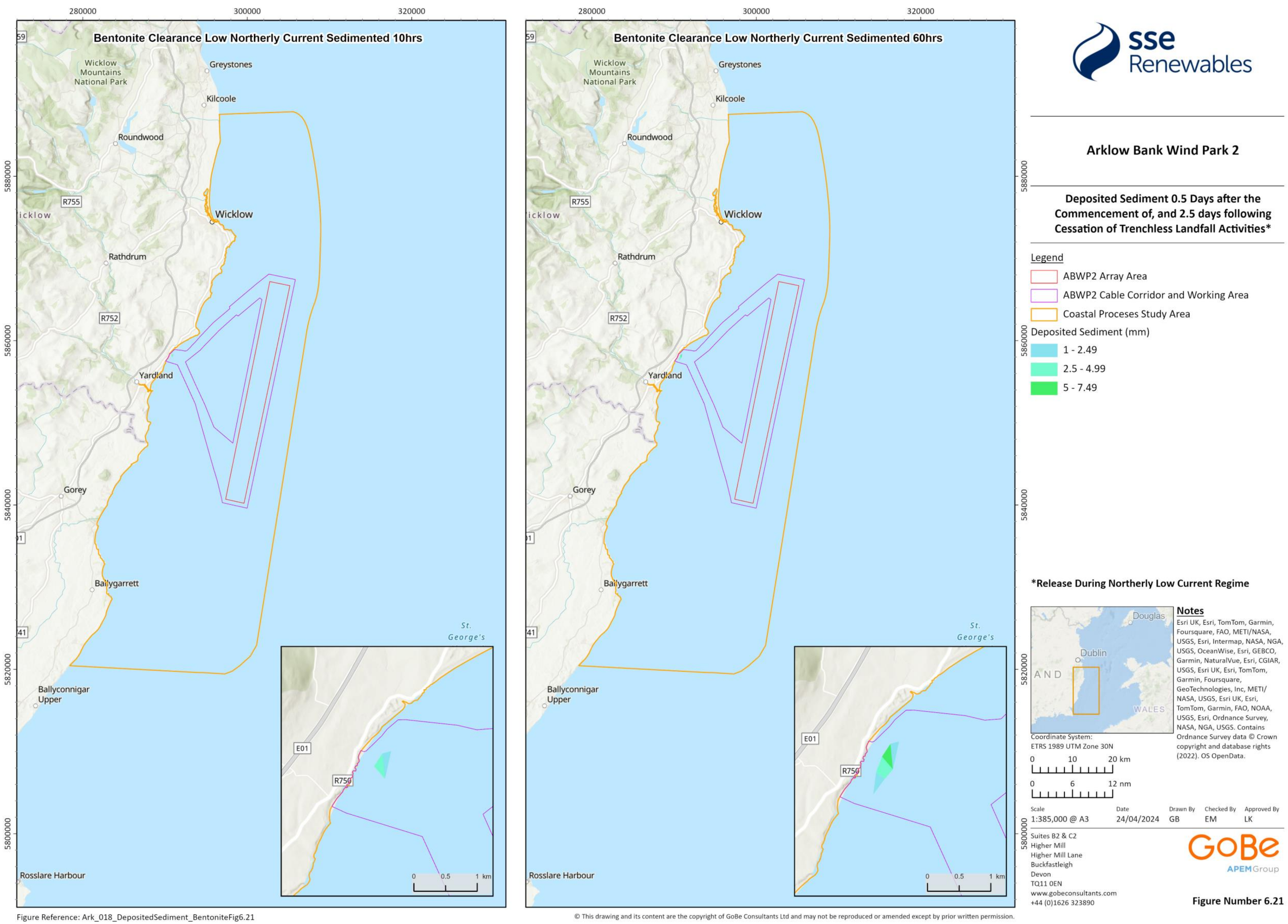

Figure 6.21: Deposited sediment 0.5 days after the commencement of, and 2.5 days following cessation of trenchless Landfall activities. Release during northerly low current regime

Operational and maintenance phase

6.10.1.73 Whilst activities associated with the Proposed Development during the operational and maintenance phase will result in seabed sediment disturbance into the water column, primarily through (i) cable protection and re-burial works; and (ii) operational maintenance dredging, if required, the volumes disturbed are much less than those disturbed during the construction phase. Both these activities can be considered intermittent throughout this phase of the Proposed Development's lifetime. The removal of any accumulated sediment along the cables route is not expected to impact the seabed morphology for the reasons discussed in paragraph 6.10.1.21 *et seq*. As the magnitude of effect during the construction phase for all activities has been assessed as **Low***,* the magnitude of effect arising as a result of 'increased suspended sediment concentrations and associated deposition' during the operation and maintenance phase are considered to be **Negligible.**

Decommissioning phase

6.10.1.74 Activities associated with the Proposed Development during the decommissioning phase will result in seabed sediment disturbance into the water column, the volumes of which are considered to be equal to, or less than, those disturbed during the construction phase. Given that the magnitude of effect during the construction phase has been assessed as **Low**, the magnitude of effect arising as a result of 'increased suspended sediment concentrations and associated deposition' during the decommissioning phase is also considered to be **Low.**

6.10.2 Impact 2 – Presence of infrastructure may lead to changes to tidal currents, wave climate, sediment transport and seabed morphology

6.10.2.1 The presence of offshore infrastructure will have the potential to result in a localised blockage of waves and tides, which could lead to changes to seabed and coastal morphology. This blockage will commence when offshore construction begins, increasing incrementally until the array is installed in its entirety), which is outlined in Table 6.10 and corresponds to an array for Design Option 1 which comprises 56 WTG foundations, 100% of which are monopiles (with a maximum pile diameter of 11 m) and two OSP structures, both of which are monopiles (with a maximum pile diameter of 14 m).

6.10.2.2 The evidence base has been used to assess the potential impacts of these activities upon Coastal Processes using, where available, monitoring results from comparable activities in similar environmental conditions (and as presented in the following assessment). This has been supplemented by a suite of project specific numerical modelling simulations (Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling). The hydrodynamic events simulated within the numerical model, as described in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling have been specifically designed to capture the full range of realistic forcing conditions in terms of:

- Wave conditions:
  - Wave height;
  - Wave period;
  - Wave direction; and
  - Return periods.
- Tidal conditions:
  - Current speed
  - Current direction; and
  - Surface elevation.

6.10.2.3 The methodology applied to assess the potential changes to the hydrodynamic regime is presented in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling. The findings are presented in the following sections.

SENSITIVITY OF THE RECEPTOR

6.10.2.4 The following receptors have been considered in the assessment of modifications to the wave and tidal regime and associated potential impacts on morphology:

- Offshore sandbanks – Arklow Bank and Seven Fathom Bank;
- Sites designated for physical features – Wicklow Reef SAC; and
- Coastal receptors below the HWM.

OFFSHORE SANDBANKS

6.10.2.5 Detail regarding the seabed sediments, bedforms, sediment transport and morphology of the Arklow and Seven Fathom Banks is provided in Section 6.6 of this EIAR Chapter.

6.10.2.6 Arklow Bank, an Open Shelf Linear Bank, is maintained'*in dynamic equilibrium by the perpetual tidal processes, episodic wave processes*[26]*, atmospheric (i.e. surge related) and Coriolis effects. These processes interact spatially (i.e. varying across the bank and with depth), and temporally (varying on timescales from a single tide through to decadal changes). The non-linear and complex processes that drives the evolution of such dynamic systems are typically characterized by multiple response pathways and subsequent system states'* (Partrac, 2022).

6.10.2.7 Seven Fathom Bank can be considered to be a satellite bank to Arklow Bank. Whilst there is limited information available, Partrac (2022) concluded that '*it is reasonable to postulate that due to its relative location, shape, profile and orientation, analogous processes to that which occur across Arklow Bank, occur across Seven Fathom Bank'.* The sheltering effect of Arklow Bank to Seven Fathom Bank would suggest that the wave regime has limited influence upon the latter feature.

6.10.2.8 Both the tide and wave regimes have been shown to impart control upon sediment transport over the sandbank, with the latter's influence rarely occurring in greater depths and during the high-frequency, low-energy events. Justification of the sensitivity of the offshore sandbanks, to changes in the tidal and wave regimes, according to the definitions provided in Table 6.13, are presented in Table 6.30.

Table 6.30: Determination of sensitivity to Impact 2 for the Coastal Processes receptor: sandbanks

Descriptor	Justification
Adaptability	The receptor cannot avoid or adapt to an impact: the sandbanks 'form and function' are dependant upon energetic tidal flows and episodic wave events (in addition to atmospheric and Coriolis effects).
Tolerance	The environment has moderate to low capacity to accommodate the proposed form of change: the tidal regime has been shown to be the dominant control upon the sandbanks 'form and function'. As such, it is considered that this feature has a higher capacity to accommodate changes in other forcing controls, such as the wave regime.
Recoverability	The effect on the receptor is anticipated to be medium-term (i.e. over the Proposed Developments' operational and maintenance period): impacts of the Proposed

[26] the influence of waves is limited to a short duration and only to the shallowest regions of Arklow Bank (Partrac, 2022)

Descriptor	Justification
	Development upon the tide and wave regimes are only anticipated whilst the array (WTG and OSP) is installed.
Value	The receptor is not designated but of local level importance: the sandbanks are a local seabed feature which contribute to the physical processes of the local area.
Overall Sensitivity	The potential sensitivity of the coastal process receptors is rated as **Medium**.

SITES DESIGNATED FOR PHYSICAL FEATURES

6.10.2.9 Wicklow Reef SAC (Figure 6.2) is designated for the marine Annex I qualifying interest of Reefs with the habitat: current-swept subtidal reef. For further information on the benthic habitats/ communities supported by Wicklow Reef SAC, please refer to Chapter 9: Benthic Subtidal and Intertidal Ecology. The form and function of this designated site is dependent upon high current flows and as such this feature has a high capacity to accommodate changes in the wave regime. Justification of the sensitivity of the offshore sandbanks, to changes in the tidal and wave regimes, according to the definitions provided in Table 6.13, are presented in Table 6.31

6.10.2.10 Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs (Figure 6.2) has been previously discussed in paragraphs 6.10.1.2 *et seq.*. A consideration of sensitivity to changes in the tidal and wave regimes, according to the definitions provided in Table 6.13, is presented in Table 6.32.

Table 6.31: Determination of sensitivity to Impact 2 for the Coastal Processes receptor: marine designated site: Wicklow Reef SAC

Descriptor	Justification
Adaptability	The receptor cannot avoid or adapt to an impact: the qualifying features of Wicklow Reef SAC are dependant upon energetic tidal flows
Tolerance	The environment has moderate to low capacity to accommodate the proposed form of change: the tidal regime has been shown to be the dominant control upon the qualifying features of Wicklow Reef SAC. As such, it is considered that this feature has a high capacity to accommodate changes in other forcing controls, such as the wave regime.
Recoverability	The effect on the receptor is anticipated to be medium-term (i.e. over the Proposed Developments' operational and maintenance period): impacts of the Proposed Development upon the tide and wave regimes are only anticipated whilst the array (WTG and OSP) is installed.
Value	The receptor is designated for international importance and/or very high socio-economic value: Wicklow Reef is designated as an Annex 1 habitat.
Overall Sensitivity	The potential sensitivity of the predicted changes is rated as **Medium**.

Table 6.32: Determination of sensitivity to Impact 2 for the Coastal Processes receptor: terrestrial designated sites: Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs

Descriptor	Justification
Adaptability	The receptor has capacity to avoid or adapt to an impact: the qualifying features of the SAC are dependant upon cycles of accretion and erosion.

Descriptor	Justification
Tolerance	The environment has moderate to low capacity to accommodate the proposed form of change: the tidal regime has been shown to flow parallel to the coast and thus any changes are unlikely to influence the immediate shoreline. The shingle beach has been shown to be under the influence of storm events and therefore any changes to these events which occur along the shoreline may impact the supply of this sediment to the SAC.
Recoverability	The effect on the receptor is anticipated to be medium-term (i.e. over the Proposed Developments' operational and maintenance period): impacts of the Proposed Development upon the tide and wave regimes are only anticipated whilst the array (WTG and OSP) is installed.
Value	The receptor is designated for international importance and/or very high socio-economic value: Magherabeg Dunes and Buckroney-Brittas Dunes and Fen are designated as an SAC.
Overall Sensitivity	The potential sensitivity of the predicted changes is rated as **Low**.

COASTAL RECEPTORS BELOW HWM

6.10.2.11 Coastal receptors (Section 6.1.1) are under the influence of waves and tides, and therefore may be impacted by changes to the wave and tidal regime. Justification of the sensitivity of the coast, to changes in the tidal and wave regimes, according to the definitions provided in Table 6.13, are presented in Table 6.33.

Table 6.33: Determination of sensitivity to Impact 2 for the Coastal Processes receptor: coastal receptors below the High Water Mark

Descriptor	Justification
Adaptability	The receptor has capacity to avoid or adapt to an impact: the presence of the installed monopiles will likely create a local blockage to wave energy moving through the array, with localised reduction and increases in the tidal flow around the monopiles. A reduction in wave energy at the coastline will reduce its erosive tendencies.
Tolerance	The environment has moderate to low capacity to accommodate the proposed form of change: the coast is currently experiencing erosion and any increase in wave energy which may reach the receptor has the potential to exacerbate this process.
Recoverability	The effect on the receptor is anticipated to be medium-term (i.e. over the Proposed Development operational and maintenance period): impacts of the Proposed Development upon the tide and wave regimes are only anticipated whilst the array is installed.
Value	The receptor is not designated, but of county level importance and low socio-economic value: the coast has residential and business value.
Overall Sensitivity	The potential magnitude of the predicted changes is rated as **Medium**.

ARRAY INFRASTRUCTURE: TIDE REGIME

6.10.2.12 The interaction between the tidal regime and the foundations of the windfarm infrastructure will result in a general reduction in current speed and an increase in levels of turbulence in a narrow, localised wake due to frictional drag effects. Incident flows will be decelerated immediately upstream and downstream of each foundation, with separation around the structure resulting in localised acceleration and the creation of vortices. Within the extent of the Array Area, the effect on tidal currents will be evident as a series of narrow and discrete wake features extending downstream along the tidal axis from each foundation. For smaller structures such as the windfarm foundations, the wake signature is expected to naturally dissipate within a distance in the order of ten to twenty obstacle diameters downstream (Li *et al*., 2014; Cazaneve *et al*., 2016; Rogan *et al*., 2016).

6.10.2.13 Numerical modelling has been undertaken to quantify change in hydrodynamic flows and water levels, with details of the model scenarios and method presented in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling. The tidal conditions modelled represent low frequency events and as such the changes presented represent the greatest change to be expected through an annual period. The conditions modelled are:

- Peak Spring flood tidal conditions – a flood current speed that would be exceeded approximately seven times per year (in the top 1% of flood current speeds);
- Peak Neap flood tidal conditions - a flood current speed that would be exceeded approximately seven times per year (in the bottom 1% of flood current speeds);
- Peak Spring ebb tidal conditions - an ebb current speed that would be exceeded approximately seven times per year (in the top 1% of ebb current speeds); and
- Peak Neap ebb tidal conditions - an ebb current speed that would be exceeded approximately seven times per year (in the bottom 1% of ebb current speeds).

6.10.2.14 Changes in the tidal flow characteristics are predicted to be small in absolute and relative terms, with <±1.0 m/s change in current speed, <±2 degrees change in current direction, and no visible change in surface elevation. The change in current speeds for all four scenario's modelled are shown in Figure 6.22, with, as expected, the larger changes shown for the faster tidal regime modelled. The largest changes in speed are predicted within the array boundary and immediately downstream of the foundations. Reductions less than 0.04 m/s form wakes up to 4 km outwith and downstream of the Array Area for the 'high northerly' conditions only. This is anticipated to be in response to the elevated current speeds which flow between Wicklow Trough and Arklow Bank. In several locations during high current speeds only and mainly along the sandbank's eastern flank (shown (paragraph 6.6.1.24 *et seq.*) to be a net sediment loss) the wakes are shown to overlap due to the highly rectilinear nature of the tides (Figure 6.3). The result is that these modifications to the tidal regime predominately occur parallel to and along the sandbank flanks.

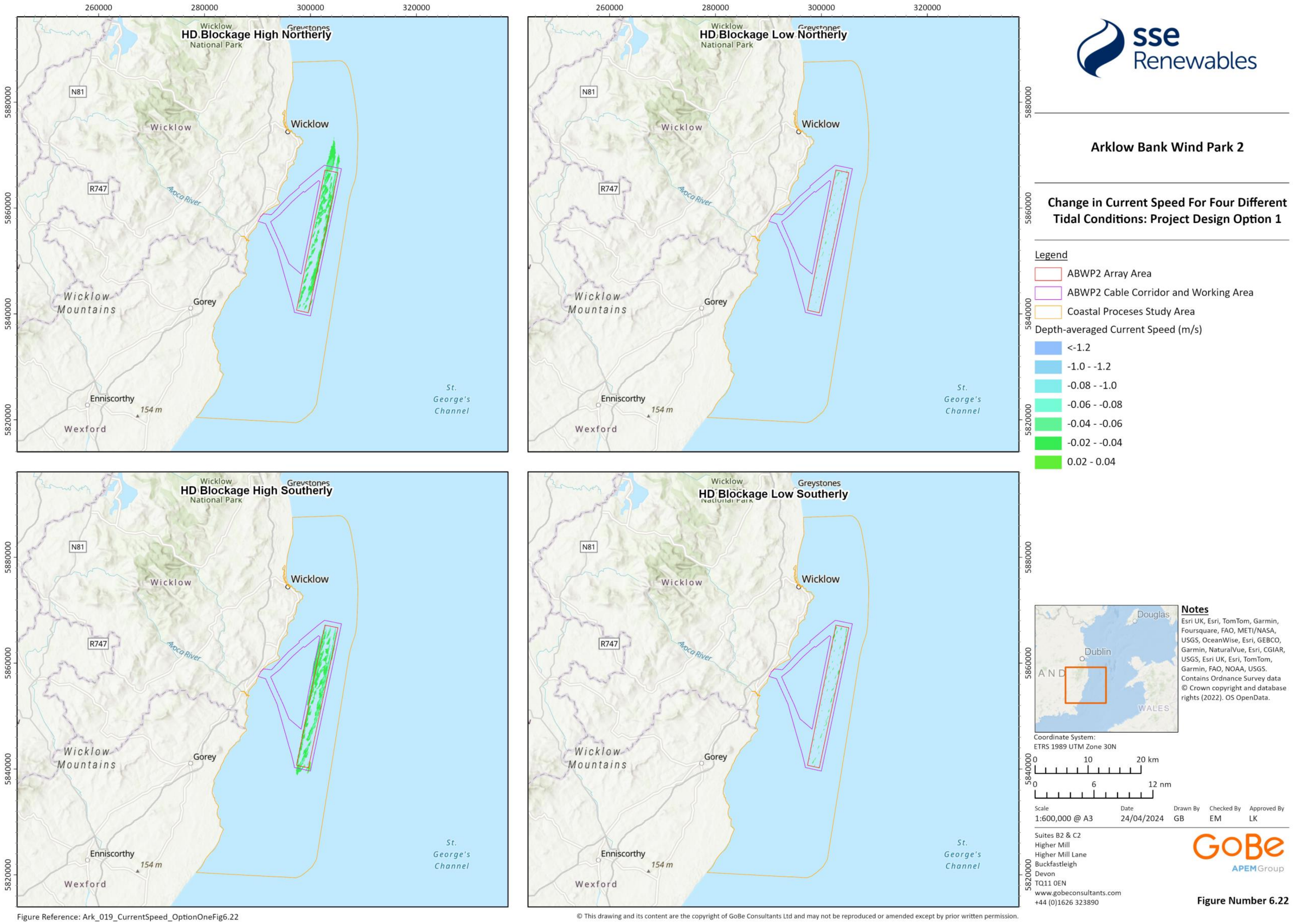

Figure 6.22: Change in current speed for four different tidal conditions: Project Design Option 1

ARRAY INFRASTRUCTURE: WAVE REGIME

6.10.2.15 The presence of the foundations in the sea also has the potential to modify the wave and wind wave regime passing through an OWF. The primary effects on waves (as identified by Christensen *et al*., 2013) are caused by:

- Drag forces against passing waves in contact with the foundation;
- Reflection (and scattering) of wave energy off the face of the foundation; and
- Diffraction of wave energy around the structure.

6.10.2.16 The interaction between waves and the wind farm infrastructure may result in a reduction in wave energy locally around foundations. Where the wave climate is important to local processes and is persistently modified, these changes may potentially alter the frequency of pattern of sediment transport, and therefore seabed morphology, in affected offshore areas. Further the rate and direction of littoral transport may be altered, potentially causing depositional/ accretional changes to coastal morphology on those coastlines reliant upon the sediment supply.

6.10.2.17 There is a strong evidence base which demonstrates that the changes to the wave regime due to the presence of foundation structures, even under a worst case of the largest surface area of structures in the water column, are both relatively small and relatively localised in spatial extent. Typically, the foundation type with the largest surface area in the water column are gravity base foundations which are not included with the project design of ABWP2 (Volume II, Chapter 4: Description of Development). This is supported by a review of modelling studies from circa 30 wind farms within the UK and European waters (Seagreen, 2012), existing guidance documents (ETSU 2000; ETSU 2002; COWRIE 2009), published research (Ohl *et al*., 2001) and post-installation monitoring (Cefas, 2006).

6.10.2.18 The degree to which an individual wave will interact with an obstacle of finite width depends on the ratio of the obstacle width and the wavelength. A wave that is long in comparison to the width of the obstacle will experience relatively little resistance other than some surface friction as the water within the wave moves against the foundation surface; in this case, energy loss is minimal and the wave will experience little to no change to its height, period or direction. A wave that is short in comparison to the width of the obstacle is more likely to result in the wave breaking or being reflected from the foundation, resulting in partial to total wave energy blockage within the cross-sectional width of the obstacle. However, such short waves are typically created continuously and by local winds consequentially any local energy loss will be quickly dispersed and replenished.

6.10.2.19 The wave modelling considered the following conditions:

- 1 in 1 Direction from 195°N, H_{m0} = 4.45 m, T_{m02} = 6.91 s;
- 1 in 50 Direction from 195°N, H_{m0} = 5.84 m, T_{m02} = 7.84 s;
- 1 in 50 Direction from 105°N, H_{m0} = 5.11 m, T_{m02} = 7.47 s; and
- 1 in 50 Direction from 15°N, H_{m0} = 4.36 m, T_{m02} = 7.01 s.

6.10.2.20 For waves originating from all directions, the results show that, each foundation presents an obstacle to the passage of waves locally, causing a small modification to the height (as reduction) and direction (as both reduction and increase) as they pass (Figure 6.23). This causes a wave shadow effect to be created by each foundation. Of note is that the wave blockage modelling includes AWBP1 as a precautionary measure in case of any delay in its decommissioning. As such, the removal of AWBP1 will act to reduce any blockage effects.

6.10.2.21 The results indicate a slight reduction in wave conditions, up to 0.5 m in significant wave height (H_{m0}) immediately adjacent to the individual structures. The greatest spatial extent of change (up to, approximately, 6 km from the Array Area) is observed under the 1 in 50 direction from 105°N scenario only. For all other directions, any change in the wave characteristics remains immediately adjacent or within the Array Area. Changes to significant wave heights which extend away from the individual structures occur up to -0.09 m. Directional changes are typically less than ±6 deg, with the greatest change observed immediately adjacent to the structures. Smaller changes of up to +4 deg extend to outside the Array Area, but do not reach the coast.

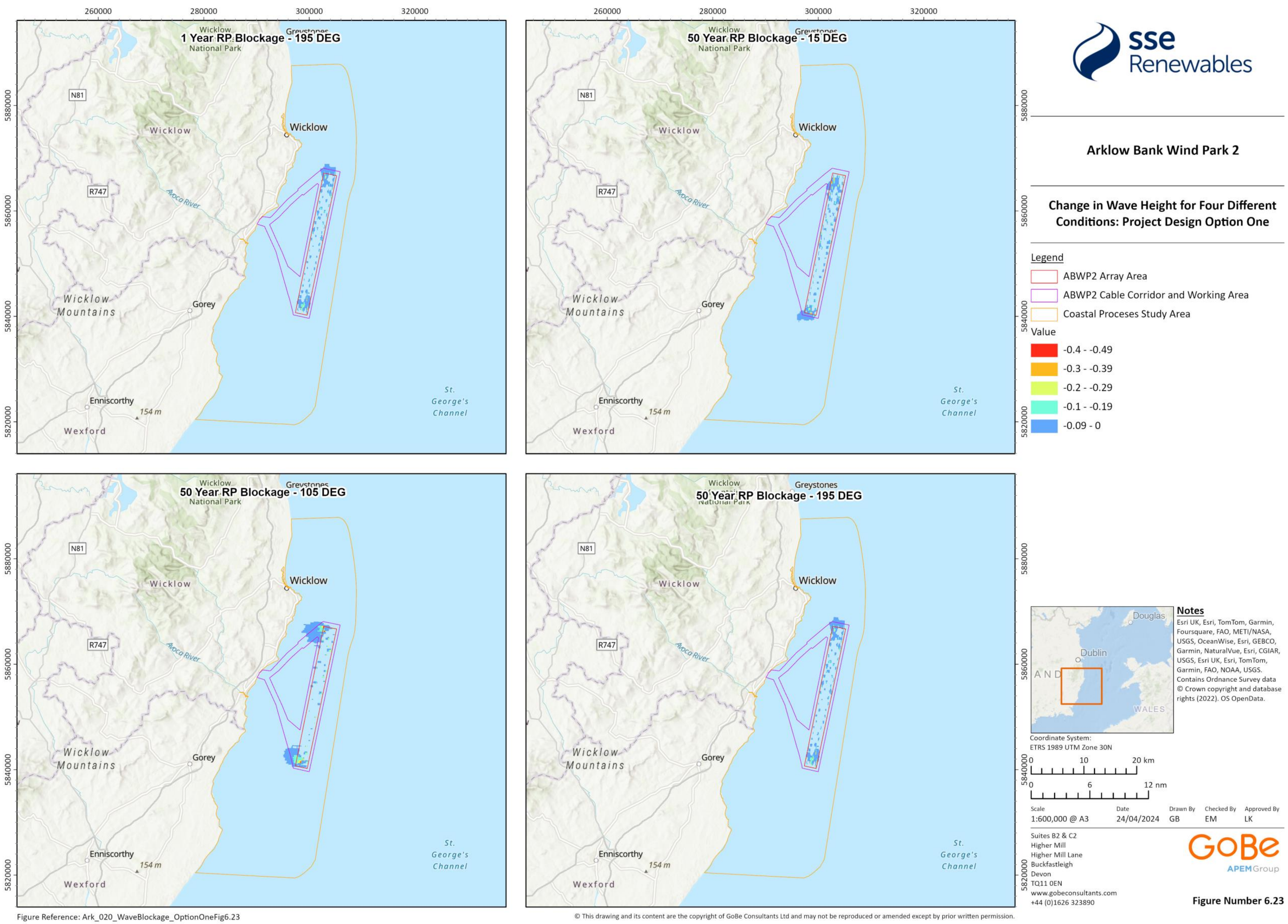

Figure 6.23: Change in wave height for four different conditions: Project Design Option 1

CABLE PROTECTION MEASURES

6.10.2.22 All offshore cables will be buried as far as is practicable. However, where it is not possible to bury cables to an adequate depth it will be necessary to install cable protection to prevent scour and minimise the risk of cable exposure. Details of the proposed cable protection for the inter-connector, inter-array and export cables are provided in Table 6.10 and Table 6.11.

6.10.2.23 The implementation of rock berms (which is considered to represent the greatest seabed alteration from the Project Design Options)) will result in a change in the seabed profile of up to 1.5 m for the inter-array and export cables, and 1.8 m for the inter-connector cables. There is also likely to be a change in substrate type, dependent upon the protection method implemented, with potential effects that could last over the operational period. The presence of cable protection measures may also have the potential to cause a direct (albeit highly localised) blockage of bedload sediment transport processes. Based on the seabed environment outlined in Section 6.6, the installation of rock berms in mobile, sandy sediments is considered to represent the most precautionary impact upon Coastal Processes.

6.10.2.24 In areas of sand, active sediment transport processes are indicated by the presence of mobile bedforms such as sandwaves and megaripples, as shown in Figure 6.8. Here, the installation of rock berms will result in a change to the sediment substrate. However, following installation an initial period of sediment accumulation would be expected to occur, creating a smooth slope against the cable protection. Once any void spaces have been infilled, saltation is expected to be largely unaffected by the presence of the cable protection such that existing transport process (including bedform migration) will remain unaffected.

PRESENCE OF MAINTENANCE VESSELS

6.10.2.25 The presence of jack-up vessels and associated anchors during the operational phase may result in changes to seabed morphology due to depressions left by jack-up vessels and associated anchors.

6.10.2.26 As the jack-up leg (of an area of 300 m^2 per leg) is inserted (between 0 m and 20 m depending on the soil's geotechnical properties at the exact point of penetration), seabed sediments would primarily be compressed vertically downwards and displaced laterally which may result in the seabed around the inserted leg to be raised in a series of concentric pressure ridges. Whilst the leg will have a maximum penetration depth, in reality it is unlikely that this depth will be reached. As the leg is retracted, some sediment would return to the hole via mass slumping under gravity until a stable slope angle is achieved. Over longer timescales, the hole is likely to become shallower and less distinct due to infilling from mobile seabed sediments, although the seabed response is dependent on the actual leg dimensions and the local soils' geotechnical properties. Post-construction monitoring from the Moray East Offshore Wind Farm, which is located in a more benign hydrodynamic and thus lesser mobile sediment environment with a smaller potential for sediment infilling, indicates that whilst the deepest leg penetration was 13 m, the depression remaining after natural backfill was 5.4 m (Royal HaskoningDHV, 2020).

6.10.2.27 A maximum of 14 jack-up vessels per annum will be onsite; it is noted that the maximum number of vessels on site at any one time will less than this and likely to be less than two.

6.10.2.28 Depressions in clay-type soils are likely to persist for longer periods than mobile sands (the latter being present at ABWP2), in the order of months to years, as evidenced by post-construction scour monitoring undertaken at several Round 1 and Round 2 windfarm sites (TKOWFL, 2015). Monitoring at the Barrow OWF showed spud-can depressions were almost entirely infilled, approximately, one year after construction (BOWind, 2008). Indentations with depths between 0.5 m and 2.0 m were identified at the Kentish Flats OWF, which is characterised by variable thicknesses of coarse sand underlain by soft to firm clays. After approximately three years, these depressions had infilled by an average of 0.6 m (ABPmer *et al*., 2010).

6.10.2.29 Whilst jack-up footprint depressions would likely persist after jack-up operations have been completed, it is likely that these would infill over time through natural seabed mobility particularly given the highly active regime upon Arklow Bank (Partrac, 2022).

6.10.2.30 Once depressions have been infilled, sediment transport will continue unimpeded. Vessel footprints (300 m^2) will be of a much smaller scale than the processes governing the overall evolution of the sediment transport system (hydrodynamic regime, water depth and sediment availability (array-scale to regional-scale; months to years)) and they are therefore expected to recover through natural processes. Therefore, it is not anticipated that jack-up vessel footprints will have implications for the morphological or sediment regimes.

MAGNITUDE OF THE IMPACT

6.10.2.31 Changes in the tidal regime may indirectly impact seabed morphology in a number of ways. In particular, there is a close relationship between flow speed and bedform type (Belderson *et al.*, 1982) and therefore any changes to flows have the potential to alter seabed morphology over the lifetime of the Proposed Development. In the immediate near-field, within approximately 200 m of individual turbines, there may be localised reductions in current speed of up to 0.1 m/s during high current conditions, leading to localised reductions in seabed mobility. However, although this change is noticeable, it is restricted in both spatial and temporal extent, with localised variation throughout the tidal cycle. On this basis, the magnitude of impact to the tidal regime, from the presence of the proposed infrastructure, is assessed in Table 6.34. These magnitudes align with the justifications provided in Table 6.14 and are in accordance with EPA (2022).

6.10.2.32 Evidence from the Scroby Sands OWF, also installed on a sandbank, demonstrates that the overall sandbank form has not changed since the construction of the offshore wind farm, and that natural change dominates. Detailed survey results show no change in overall elevation or morphology across the bank, with no evidence for direct interaction between the installed monopile foundations and sandwave features (Cefas, 2006). This outcome is considered to be indicative of similar sandbank locations with high sediment mobility, such as on Arklow Bank (DECC, 2008). Furthermore, surveys suggest that no major change to the form of Arklow Bank can be identified since the installation of ABWP1 (Partrac, 2022). This evidence demonstrates that potential reductions in flow speed, although they may have localised effects on sediment mobility, are not of sufficient scale to impact on the wider hydrodynamic and sedimentary processes governing the structure of Arklow Bank.

6.10.2.33 Similarly, any changes in the wave regime may contribute to changes in seabed morphology due to alteration of sediment transport patterns. Within the Coastal Processes Study Area, sediment transport is dominated by the action of tidal currents, with wave-driven sediment transport only becoming important to shallow coastal waters, distant to the Array Area (Partrac, 2022). As shown in Figure 6.22 to Figure 6.25, any change to the wave climate dissipates far from the coast, and therefore there is no pathway of effect on the nearshore wave climate. This also limits any potential for impact on coastal erosion or processes. Any impacts on the wave regime will not result in any discernible change to morphology. On this basis, the magnitude of impact to the wave regime, from the presence of the proposed infrastructure, is assessed in Table 6.35. These magnitudes align with the justifications provided in Table 6.14and are in accordance with EPA (2022).

Table 6.34: Determination of magnitude for changes to tidal currents due to the presence of the infrastructure

Descriptor	Justification
Extent	The predicted changes will be localised to within the Array Area and adjacent to its boundary. No changes are anticipated to occur at the coast or designated sites. There is therefore no pathway of effect on designated sites or coastal receptors.
Duration	The predicted changes will occur throughout the project's operational phase and as such can be classified as long-lasting.
Frequency	The predicted changes will occur on every tide throughout the project's operational phase.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Changes which are not discernible outwith background variations of key characteristics or features of the particular environmental aspect's character or distinctiveness.
Overall Magnitude	The potential magnitude of the predicted changes to the tidal regime at the identified coastal process receptors is rated as: Offshore sandbanks: **Low** Sites designated for physical features: **Negligible** Coastal receptors below HWM: **Negligible**

Table 6.35: Determination of magnitude for changes to the wave regime due to the presence of the infrastructure

Descriptor	Justification
Extent	The predicted changes will be localised to within the Array Area and adjacent to its boundary. No changes are anticipated to occur at the coast or designated sites. There is therefore no pathway of effect on designated sites or coastal receptors.
Duration	The predicted changes will occur throughout the project's operational phase and as such can be classified as long-lasting.
Frequency	The predicted changes will occur on every tide throughout the project's operational phase.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Changes which are not discernible outwith background variations of key characteristics or features of the particular environmental aspect's character or distinctiveness.
Overall Magnitude	The potential magnitude of the predicted changes to the wave regime at the identified coastal process receptors is rated as: Offshore sandbanks: **Low** Sites designated for physical features: **Negligible** Coastal receptors below HWM: **Negligible**

SIGNIFICANCE OF THE EFFECT

6.10.2.34 A discussion of the significance of the effect upon the Coastal Processes receptors sensitive to the Impact 2 is provided in the following sub-sections.

OFFSHORE SANDBANKS

6.10.2.35 The sensitivity of Arklow Bank and Seven Fathom Bank has been assessed as **Medium**. The magnitude of Impact 2 has been assessed as **Low**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance of Impact 2 upon the offshore sandbanks is concluded to be **Slight.**

SITES DESIGNATED FOR PHYSICAL FEATURES

6.10.2.36 The sensitivity of Wicklow Reef SAC has been assessed as **Medium**. The magnitude of Impact 2 has been assessed as **Negligible**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance of Impact 2 upon the offshore sandbanks is concluded to be **Not Significant.**

6.10.2.37 The sensitivity of Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs has been assessed as **Low**. The magnitude of Impact 2 has been assessed as **Negligible**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance of Impact 2 upon the offshore sandbanks is concluded to be **Not Significant.**

COASTAL RECEPTORS BELOW MHW

6.10.2.38 The sensitivity of coastal receptors below MHW has been assessed as **Medium**. The magnitude of Impact 2 has been assessed as **Negligible**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance of Impact 2 upon the offshore sandbanks is concluded to be **Not Significant.**

PROPOSED MITIGATION

6.10.2.39 As there are no significant effects identified, it is considered that additional (non-embedded mitigation) measures are not required.

RESIDUAL EFFECT ASSESSMENT

6.10.2.40 There are no additional (non-embedded mitigation) measures proposed and as such a residual effect assessment has not been undertaken.

6.11 Assessment of Project Design Option 2

6.11.1 Impact 1 – Increased suspended sediment concentrations and associated deposition

6.11.1.1 The assessment of Project Design Option 1 is applicable for Project Design Option 2 for a consideration of Impact 1; the Project Design Envelope for installation (seabed preparation; cable installation) for the two Project Design Options are the same. Therefore, for a consideration of Impact 1 for Project Design Option 2, the reader is referred to Section 6.10.1.

6.11.2 Impact 2 – Presence of infrastructure may lead to changes to tidal currents, wave climate, sediment transport and seabed morphology

6.11.2.1 The presence of offshore infrastructure will have the potential to result in a localised blockage of waves and tides, which could lead to changes to seabed and coastal morphology. This blockage will commence when offshore construction begins, increasing incrementally up until all WTG and OSP are installed (Table 6.11) and corresponds to an array comprising 47 WTG foundations, 100% of which are monopiles (with a maximum pile diameter of 11 m) and two OSP structures, both of which are monopiles (with a maximum pile diameter of 14 m).

6.11.2.2 The evidence base has been used to assess the potential impacts of these activities upon Coastal Processes using, where available, monitoring results from comparable activities in similar environmental conditions. This has been supplemented by a suite of project specific numerical modelling simulations (Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling). The hydrodynamic events simulated within the numerical model, as described in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling have been specifically designed to capture the full range of realistic forcing conditions in terms of:

- Wave conditions:
  - Wave height;
  - Wave period;
  - Wave direction; and
  - Return periods.
- Tidal conditions:
  - Current speed
  - Current direction; and
  - Surface elevation.

6.11.2.3 The methodology applied to assess the potential changes to the hydrodynamic regime is presented in Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling. The findings are presented in the following sections.

SENSITIVITY OF THE RECEPTOR

6.11.2.4 The following receptors have been considered in the assessment of modifications to the wave and tidal regime and associated potential impacts on morphology:

- Offshore sandbanks – Arklow Bank and Seven Fathom Bank;
- Sites designated for physical features – Wicklow Reef SAC; Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs; and
- Coastal receptors below the HWM.

6.11.2.5 The sensitivity of these receptors remains as per Project Design Option 1 and can be found in paragraph 6.10.2.4 *et seq.*.

CONCEPTUAL UNDERSTANDING OF CHANGE

ARRAY INFRASTRUCTURE: TIDE REGIME

6.11.2.6 The conceptual understanding of change for the tidal regime remains as per Project Design Option 1 and can be found in paragraph 6.10.2.12 *et seq.*

6.11.2.7 Changes in the tidal flow characteristics are predicted to be small in absolute and relative terms, with <±1.0 m/s change in current speed, <±2 degrees change in current direction, and no visible change in surface elevation. The change in current speeds for all four scenario's modelled are shown in Figure 6.22, with, as expected, the larger changes shown for the faster tidal regime modelled. The largest changes in speed are predicted within the array boundary and immediately downstream of the foundations. Reductions less than 0.04 m/s form wakes up to 4 km downstream of the Array Area for the 'high northerly' conditions only. This is anticipated to be in response to the elevated current speeds which flow to between Wicklow Trough and Arklow Bank. In several locations, these wakes are shown to overlap due to the highly rectilinear nature of the tides (Figure 6.3), however this is largely mitigated by the separation distance between the WTGs.

ARRAY INFRASTRUCTURE: WAVE REGIME

6.11.2.8 The conceptual understanding of change for the wave regime remains as per Project Design Option 1 and can be found in paragraph 6.10.2.15 *et seq.*

6.11.2.9 The wave modelling considered the following conditions:

- 1 in 1 Direction from 195°N, H_{m0} = 4.45 m, T_{m02} = 6.91 s;
- 1 in 50 Direction from 195°N, H_{m0} = 5.84 m, T_{m02} = 7.84 s;
- 1 in 50 Direction from 105°N, H_{m0} = 5.11 m, T_{m02} = 7.47 s; and
- 1 in 50 Direction from 15°N, H_{m0} = 4.36 m, T_{m02} = 7.01 s.

6.11.2.10 For waves originating from all directions, the results show that, each foundation presents an obstacle to the passage of waves locally, causing a small modification to the height (as reduction) and direction (as both reduction and increase) as they pass (Figure 6.25). This causes a wave shadow effect to be created by each foundation, which interact to form an array-scale blockage.

6.11.2.11 The results indicate a slight reduction in wave conditions, up to 0.5 m in significant wave height (H_{m0}) immediately adjacent to the individual structures. The greatest spatial extent of change (up to, approximately, 6 km from the Array Area) is observed under the 1 in 50 direction from 105°N scenario only. For all other directions, any change in the wave characteristics remains immediately adjacent or within the Array Area. Changes to significant wave heights which extend away from the individual structures occur up to -0.09 m. Directional changes are typically less than ±6 deg, with the greatest change observed immediately adjacent to the structures. Smaller changes of up to +4 deg extend to outside the Array Area, but do not reach the coast.

CABLE PROTECTION MEASURES

6.11.2.12 The conceptual understanding of change and associated assessment for cable protection measures remains as per Project Design Option 1 and can be found in paragraph 6.10.2.22 *et seq.*

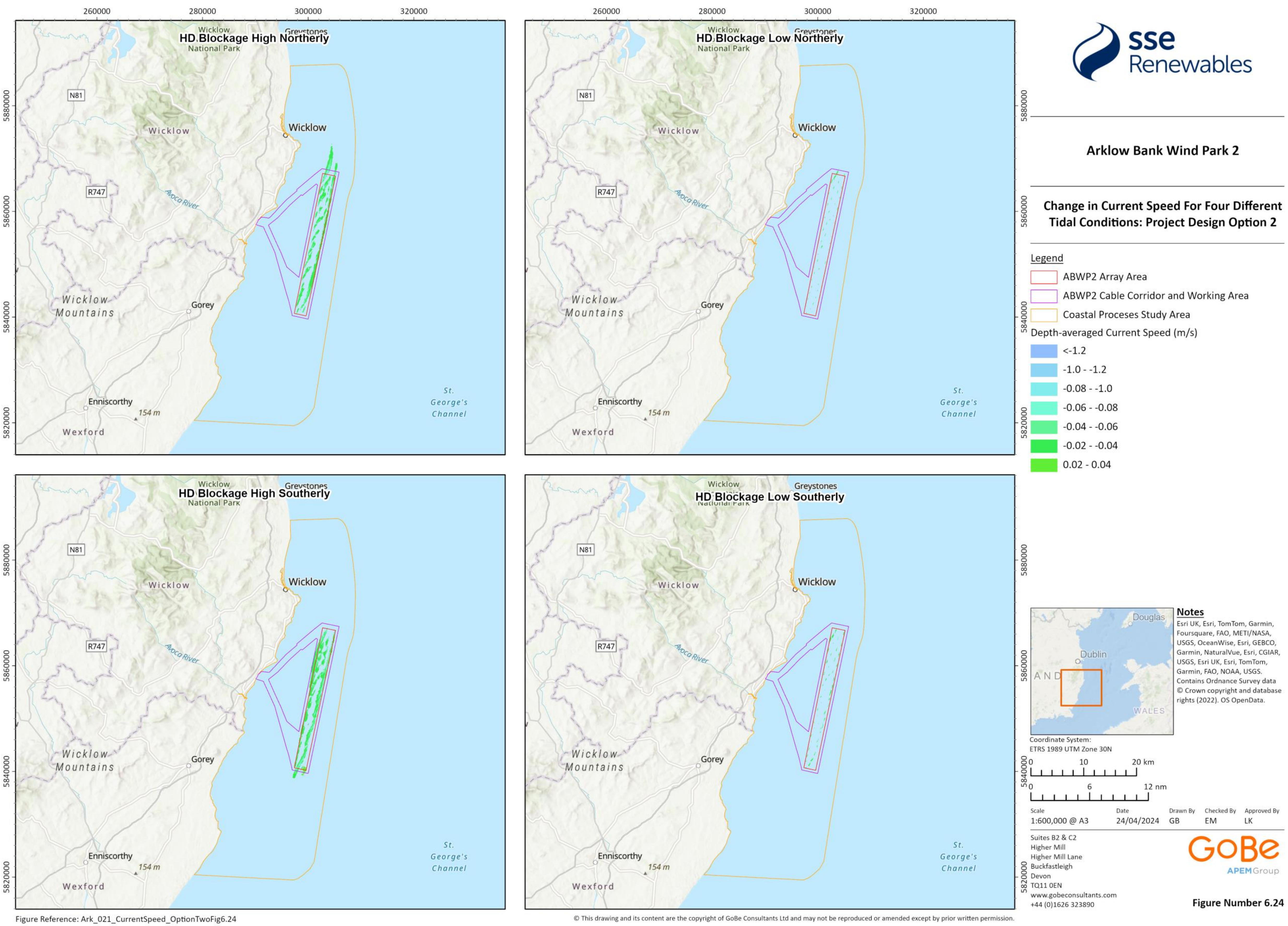

Figure 6.24: Change in current speed for four different tidal conditions: Project Design Option 2

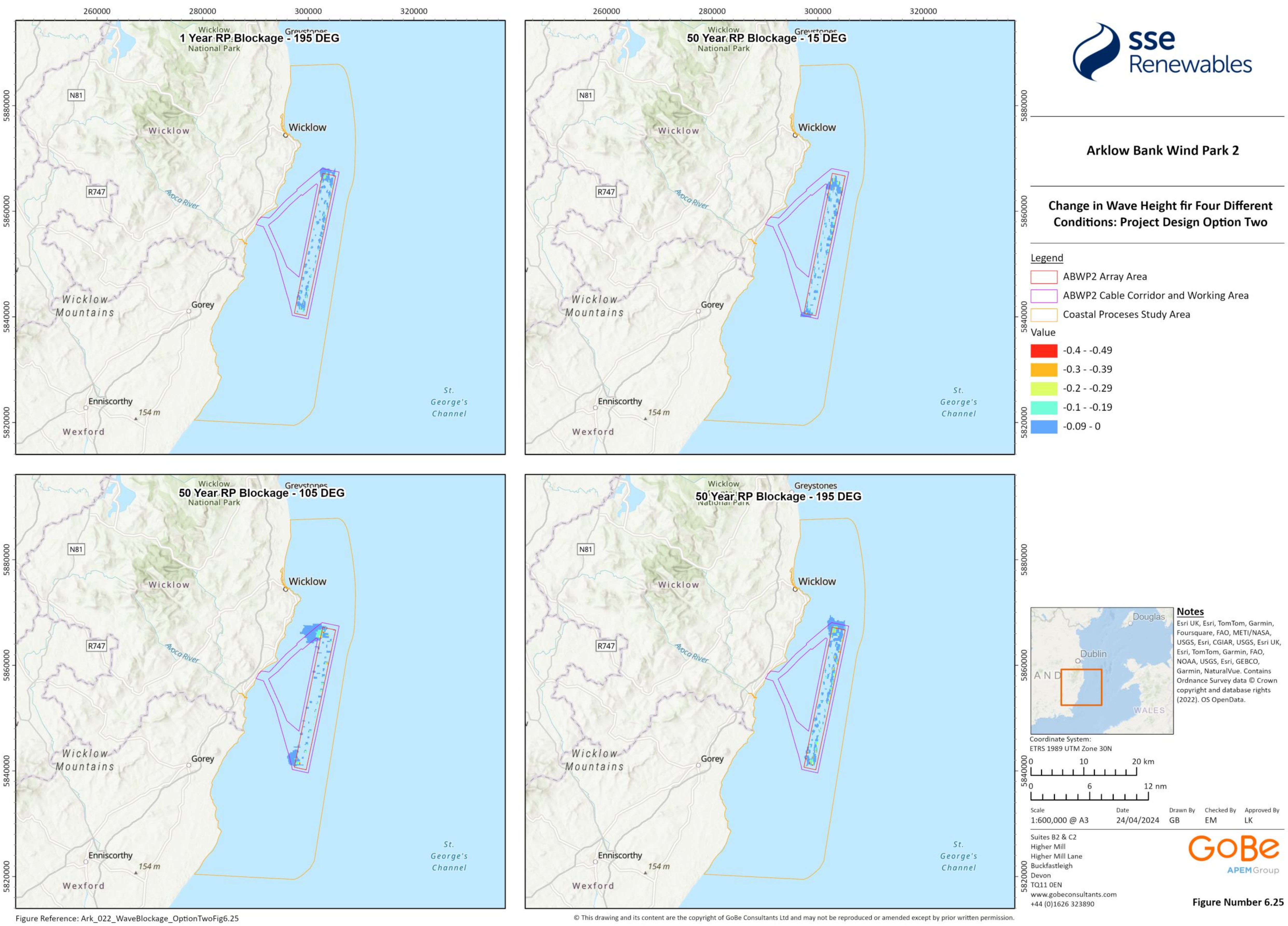

Figure 6.25: Change in wave height for four different conditions: Project Design Option 2

MAGNITUDE OF THE IMPACT

6.11.2.13 Changes in the tidal regime may indirectly impact seabed morphology in a number of ways. In particular, there is a close relationship between flow speed and bedform type (Belderson *et al.*, 1982) and therefore any changes to flows have the potential to alter seabed morphology over the lifetime of the Project. In the immediate near-field, within approximately 200m of individual turbines, there may be localised reductions in current speed of up to 0.1m/s during high current conditions, leading to localised reductions in seabed mobility. However, although this change is noticeable, it is restricted in both spatial and temporal extent, with localised variation throughout the tidal cycle. On this basis, the magnitude of impact to the tidal regime, from the presence of the proposed infrastructure, is assessed in Table 6.36. These magnitudes align with the justifications provided in Table 6.14and are in accordance with EPA (2022).

6.11.2.14 Similarly, any changes in the wave regime may contribute to changes in seabed morphology due to alteration of sediment transport patterns. Within the Coastal Processes Study Area, sediment transport is dominated by the action of tidal currents, with wave-driven sediment transport only becoming important to shallow coastal waters, distant to the Array Area (Partrac, 2022). As shown in Figure 6.25, any change to the wave climate dissipates far from the coast, and therefore there is no pathway of effect on the nearshore wave climate. This also limits any potential for impact on coastal erosion or processes. Any impacts on the wave regime will not result in any discernible change to morphology. On this basis, the magnitude of impact to the wave regime, from the presence of the proposed infrastructure, is assessed in Table 6.37 These magnitudes align with the justifications provided in Table 6.14and are in accordance with EPA (2022).

Table 6.36: Determination of magnitude for changes to tidal currents due to the presence of the infrastructure

Descriptor	Justification
Extent	The predicted changes will be localised to within the Array Area and adjacent to its boundary. No changes are anticipated to occur at the coast or designated site. There is therefore no pathway of effect on designated sites or coastal receptors.
Duration	The predicted changes will occur throughout the Proposed Development's operational phase and as such can be classified as long-lasting.
Frequency	The predicted changes will occur on every tide throughout the Proposed Development's operational phase.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Changes which are not discernible outwith background variations of key characteristics or features of the particular environmental aspect's character or distinctiveness.
Overall Magnitude	The potential magnitude of the predicted changes to the tidal regime at the identified coastal process receptors is rated as: Offshore sandbanks: **Low** Sites designated for physical features: **Negligible** Coastal receptors below HWM: **Negligible**

Table 6.37: Determination of magnitude for changes to the wave regime due to the presence of the infrastructure

Descriptor	Justification
Extent	The predicted changes will be localised to within the Array Area and adjacent to its boundary. No changes are anticipated to occur at the coast or designated site. There is therefore no pathway of effect on designated sites or coastal receptors.
Duration	The predicted changes will occur throughout the Proposed Development's operational phase and as such can be classified as long-lasting.
Frequency	The predicted changes will occur on every tide throughout the Proposed Development's operational phase.
Probability	The predicted changes can be reasonably expected to occur.
Consequence	Changes which are not discernible outwith background variations of key characteristics or features of the particular environmental aspect's character or distinctiveness.
Overall Magnitude	The potential magnitude of the predicted changes to the wave regime at the identified coastal process receptors is rated as: Offshore sandbanks: **Low** Sites designated for physical features: **Negligible** Coastal receptors below HWM: **Negligible**

SIGNIFICANCE OF THE EFFECT

6.11.2.15 A discussion of the significance of the effect upon the Coastal Processes receptors sensitive to the Impact 2 is provided in the following sub-sections.

OFFSHORE SANDBANKS

6.11.2.16 The sensitivity of Arklow Bank and Seven Fathom Bank has been assessed as **Medium**. The magnitude of Impact 2 has been assessed as **Low**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance of Impact 2 upon the offshore sandbanks is concluded to be **Slight.**

SITES DESIGNATED FOR PHYSICAL FEATURES

6.11.2.17 The sensitivity of Wicklow Reef SAC has been assessed as **Medium**. The magnitude of Impact 2 has been assessed as **Negligible**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance of Impact 2 upon the identified designated sites is concluded to be **Not Significant.**

6.11.2.18 The sensitivity of Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs has been assessed as **Low**. The magnitude of Impact 2 has been assessed as **Negligible**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance of Impact 2 upon the offshore sandbanks is concluded to be **Not Significant.**

COASTAL RECEPTORS BELOW MHW

6.11.2.19 The sensitivity of coastal receptors below the HWM has been assessed as **Medium**. The magnitude of Impact 2 has been assessed as **Negligible**. Consequently, and in accordance with the matrix provided in Table 6.15, the significance of Impact 2 upon coastal receptors below the HWM is concluded to be **Not Significant.**

PROPOSED MITIGATION

6.11.2.20 As there are no significant effects identified, it is considered that additional (non-embedded mitigation) measures are not required.

RESIDUAL EFFECT ASSESSMENT

6.11.2.21 There are no additional (non-embedded mitigation) measures proposed and as such a residual effect assessment has not been undertaken.

6.12 Cumulative impacts assessment methodology

6.12.1 Methodology

6.12.1.1 The Cumulative Impact Assessment (CIA) takes into account the impacts associated with the Proposed Development together with other proposed and reasonably foreseeable projects, plans and existing and permitted projects. The projects and plans selected as relevant to the CIA presented within this chapter are based upon the results of a screening exercise (see Volume III, Appendix 3.2: CIA Screening). Each project and plan has been considered on a case-by-case basis for screening in or out of this chapter's assessment based upon the source-impact-receptor model and the spatial/temporal scales involved.

6.12.1.2 A tiered approach is adopted to provide an assessment of the Proposed Development as a whole. The tiering methodology is provided in Volume III, Appendix 3.2: CIA Screening.

6.12.1.3 The specific projects scoped into this cumulative impact assessment, and the tiers into which they have been allocated are presented in Table 6.38. The operational projects included within the table are included due to their completion/ commission subsequent to the data collection process for the Proposed Development and as such not included within the baseline characterisation. Other elements of the overall project are also assessed in this section, namely the Onshore Grid Infrastructure (OGI), Operations and Maintenance Facility (OMF) and EirGrid Upgrade Works.

6.12.1.4 Due to the commitments made by the Developer in respect of the Foreshore Licence FS007339 and Foreshore Licence Application FS007555 (Table 6.16) FS007339 and FS007555 have been screened out of the cumulative impact assessment.

Table 6.38: List of other projects and plans considered within the cumulative impact assessment

Project/Plan	Status	Distance from Array Area (km)	Distance from Cable Corridor & Working Area (km)	Description of Project/Plan	Dates of Construction	Dates of Operation	Justification for screening in
Tier 1							
ABWP2 Onshore Grid Infrastructure (OGI)	Consented	10.2	0.0	Onshore grid infrastructure located onshore and required for the operation of the Proposed Development. Includes onshore grid infrastructure including 220kV export cable circuits and fibre optic cables, new 220kV GIS substation at Shelton Abbey and overhead line connection and all associated ancillary works	2026 - 2030	2030 - 2066	Potential temporal overlap with the Proposed Development construction, operation and maintenance phases.
ABWP1 (Arklow Offshore Array)	Operational	0	0.*5*	Constructed in 2003/04 consisting of seven wind turbines with a capacity of 25.2 MW. Included as part of the baseline environment with potential for ongoing impact to the Proposed Development.	Complete	2003/2004 - uncertain	Temporal overlap with Proposed Development construction, O&M and decommissioning phases
ABWP1 Power Cable	Operational	0	0	Export cable from ABWP1 Array Area to the Irish mainland.	Complete	2003/2004 - uncertain	Potential for temporal overlap of operation with Proposed Development construction and operation and

							maintenance phases.
Hibernia Atlantic Telecom Cable	Operational	15.4	14.8	Part of a transatlantic submarine cable system in the North Atlantic Ocean, connecting Canada, the United States, Ireland and the United Kingdom	Complete	2021 -	Potential for temporal overlap of operation with Proposed Development construction and operation and maintenance phases.
Tier 2 Other Plans and Projects							
Arklow Flood Relief Scheme	Conditionally approved	4.01	11.5	Wicklow County Council funded by the Office of Public Works (OPW), proposes to undertake engineering works along the Avoca River and surrounds to mitigate the risk of flooding in the Arklow town area in County Wicklow. Proposed works include dredging, installation of flood defence embankments/ walls and gravel/ debris traps.	2024 - 2028	2028 -	Potential for temporal overlap with Proposed Development construction phase.
Tier 3							
ABWP1 Decommissioning Assumptions		0	0	Constructed in 2003/04 consisting of seven wind turbines with a capacity of 25.2 MW. Included as part of the baseline environment.	Anticipated duration of four months during 2025-2027		

Phase 1 Projects							
Codling Wind Park (formerly known as Codling I and Codling II)	Proposed	10.3	9.4	Application expected to be made under the Maritime Area Planning (MAP) Act 2021.	Unknown	Unknown	Potential for temporal overlap with Proposed Development construction and operation and maintenance phases.

6.12.1.5 The potential impacts, development phase, and the list of projects/ plans with which the two Project Design Options have been cumulatively assessed are presented in Table 6.39.

Table 6.39: Cumulative assessment impacts, phases, scenarios, and projects to be considered cumulatively

Potential cumulative impact	Phase C	Phase O	Phase D	Projects considered cumulatively	Justification for projects considered cumulatively
Impact 1 – Increased suspended sediment concentrations and associated deposition	✓	✓	✓	Project parameters associated with Project Design Option 1 or 2 plus the following projects: **Tier 1** ABWP2 OGI; ABWP1 Power Cable; ABWP1 Offshore Array; Hibernia Atlantic Telecom; **Tier 2** Arklow Flood Relief Scheme **Tier 3** ABWP1 Decommissioning **Phase 1 Projects** Codling Wind Park.	If these intermittent activities overlap temporally with either the construction or O&M of the Proposed Development, there is potential for cumulative SSC and sediment deposition to occur within the modelled plume footprints.
Impact 2 – Presence of infrastructure may lead to changes to tidal currents, wave climate, sediment transport and seabed morphology	×	✓	×	Project parameters associated with Project Design Option 1 or 2 plus the following projects: **Tier 3** ABWP1 Decommissioning. Phase 1 Projects Codling Wind Park.	Potential for cumulative changes to hydrodynamics, waves and sediment transport.

6.13 Cumulative impact assessment

6.13.1.1 A description of the significance of cumulative effects upon Coastal Processes arising from each identified impact is given below.

6.13.2 Project Design Option 1 and 2 - Impact 1 - Increased suspended sediment concentrations and associated deposition

SENSITIVITY OF THE RECEPTOR

6.13.2.1 As stated in paragraph 6.10.1.2, all the identified Coastal Processes receptors will be insensitive to localised changes in SSC and bed levels associated with the sediment disturbance activities described in this section.

Construction phase

TIER 1

MAGNITUDE OF IMPACT

6.13.2.2 Due to the localised effects and short-term duration of the construction activities (sandwave clearance and TSHD disposal; foundation drilling; jetting) of the Proposed Development alone, the magnitude is considered to be Low for both Project Design Options.

6.13.2.3 Sediment plumes from operational and maintenance activities are generally short-lived, with major maintenance works infrequent. Any impacts from the subsea infrastructure in Table 6.39 are therefore likely to be short-lived and of localised extent, with limited opportunity to overlap with the Proposed Development's activities.

6.13.2.4 The assessment undertaken for the Proposed Development alone shows that in almost all cases, sediment plumes are rapidly indistinguishable from background levels. On this basis, although there is limited potential for sediment plumes from Proposed Development activities to interact with those from other activities resulting in seabed disturbance, any overlap is expected to be short-lived and affect the near-field only. Therefore, when assessed cumulatively with the Proposed Development, the magnitude is considered to be Low for both Project Design Options.

TIER 2

MAGNITUDE OF IMPACT

6.13.2.5 Due to the localised effects and short-term duration of the construction activities (sandwave clearance and TSHD disposal; foundation drilling; jetting) of the Proposed Development alone, the magnitude is considered to be Low for both Project Design Options.

6.13.2.6 Sediment plumes from operational and maintenance activities are generally short-lived, with major maintenance works infrequent. Any interaction between sediment plumes generated by Proposed Development’s construction activities and those from nearby seabed disturbance due to flood relief works within the River Avoca could theoretically occur in two ways:

- Where plumes generated from the two different activities meet and coalesce to form one larger plume; or
- Where seabed sediment disturbance occurs within the plume generated by Proposed Development’s construction activities (or vice versa).

6.13.2.7 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, in the case of plumes formed by dredging operating within the plume created by foundation installation or bed preparation activities (or vice versa), the two plumes would be additive, creating a plume with higher SSC. The assessment undertaken for the Proposed Development alone shows that in almost all cases, sediment plumes are rapidly indistinguishable from background levels. Further, the assessment also indicates that the sediment plumes disperse along the north-south orientated tidal axis which further limits the potential for sediment plumes from Proposed Development activities to interact with those from other activities resulting in seabed disturbance. Therefore, when assessed cumulatively with the Proposed Development, the magnitude is considered to be **Low** for both Project Design Options.

TIER 3

MAGNITUDE OF IMPACT

6.13.2.8 Due to the localised effects and short-term duration of the construction activities (sandwave clearance and TSHD disposal; foundation drilling; jetting) of the Proposed Development alone, the magnitude is considered to be Low for both Project Design Options.

6.13.2.9 Opportunity exists for overlap between impacts resulting from the Proposed Development's Array Area construction activities and the removal of ABWP1 array infrastructure, namely the removal of the seven monopiles to 2 m below the seabed. The current assumption is that this process will take four months over a two year period between 2025 and 2027. The construction period for the Proposed Development is for the period 2026 to 2030, thus providing a small overlap for the activities. Therefore, whilst there is some potential for sediment plumes from the Proposed Development activities to interact with those from the decommissioning of ABWP1, any overlap is expected to be short-lived and within the near-field only. Therefore, when assessed cumulatively with the Proposed Development, the magnitude is considered to be **Low** for both Project Design Options.

PHASE ONE PROJECTS

MAGNITUDE OF IMPACT

6.13.2.10 Due to the localised effects and short-term duration of the construction activities (sandwave clearance and TSHD disposal; foundation drilling; jetting) of the Proposed Development alone, the magnitude is considered to be Low for both Project Design Options.

6.13.2.11 Construction activities for Codling Wind Park will also result in temporary SSC increases and resultant sediment deposition. The Proposed Development and Codling Wind Park are not directly aligned according to the tidal flows, reducing the potential for any sediment plumes to overlap. Further, on a northerly tide any sediment plumes produced during construction works will travel in a northerly direction from both developments (and vica versa on a southerly tide) thus reducing further the potential for any cumulative impacts. Therefore, when assessed cumulatively with the Proposed Development, the magnitude is considered to be **Low** for both project design options.

TIER 1 + TIER 2 + TIER 3 + PHASE ONE PROJECTS

MAGNITUDE OF IMPACT

6.13.2.12 The spatial disparity of the projects considered within the cumulative assessment when considered against the direction of tidal flow and the location of the Proposed Development, is such that the magnitude of impact remains **Low** for both Project Design Option 1 and 2.

SIGNIFICANCE OF THE EFFECT

6.13.2.13 There are no Coastal Processes receptors sensitive to the impact pathway and as such, assessment of significance is not applicable.

Operational and maintenance phase

6.13.2.14 Whilst activities associated with the Proposed Development during the Operational and Maintenance phase will result in seabed sediment disturbance into the water column, primarily through cable protection and re-burial works, if required, the volumes disturbed are much less than those disturbed during the construction phase. Given that the magnitude of effect during the construction phase for all activities has been assessed as Low, impacts arising as a result of 'increased suspended sediment concentrations and associated deposition' during the Operational and Maintenance phase have been not considered further within this EIAR Chapter. Further, when considered cumulatively with the Proposed Development, the impact of the magnitude is considered to be Low for both Project Design Options (as presented in Table 6.10 and Table 6.11).

SIGNIFICANCE OF THE EFFECT

6.13.2.15 There are no Coastal Processes receptors sensitive to the impact pathway and as such, assessment of significance is not applicable.

Decommissioning phase

6.13.2.16 Activities associated with the Proposed Development during the decommissioning phase will result in seabed sediment disturbance into the water column, the volumes of which are considered to be equal to, or less than, those disturbed during the construction phase. Given that the magnitude of effect during the construction phase has been assessed as low, impacts arising as a result of 'increased suspended sediment concentrations and associated deposition' during the decommissioning phase are also considered to be Low. Further, when considered cumulatively with the Proposed Development, the impact of the magnitude is considered to be Low for both Project Design Options (as presented in Table 6.10 and Table 6.11).

SIGNIFICANCE OF THE EFFECT

6.13.2.17 There are no Coastal Processes receptors sensitive to the impact pathway and as such, assessment of significance is not applicable.

6.13.3 Project Design Option 1 and 2 - Impact 2 – Presence of infrastructure may lead to changes to tidal currents, wave climate, sediment transport and seabed morphology

SENSITIVITY OF THE RECEPTOR

6.13.3.1 As discussed in paragraph 6.10.2.4 *et seq.*, the following receptors have been considered in the assessment of modifications to the wave and tidal regime and associated potential impacts on morphology:

- Offshore sandbanks – Arklow Bank and Seven Fathom Bank – Medium sensitivity;
- Sites designated for physical features – Wicklow Reef SAC – Medium sensitivity; Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs Low sensitivity.; and
- Coastal receptors below the HWM – Medium sensitivity.

Operational and maintenance phase

TIER 3

MAGNITUDE OF IMPACT

6.13.3.2 The Tier 3 project that qualifies for inclusion within the Cumulative Impact Assessment is ABWP1 Decommissioning. The seven WTG structures that are currently installed are expected to be decommissioned over a four month period between 2025 and 2027. The construction period for the Proposed Development is for the period 2026 to 2030; however, the foundation installation process is not currently scheduled to occur until month seven to nine of 2027 (Volume II, Chapter 4: Description of Development).

6.13.3.3 As such it is expected that there is limited opportunity for the two projects to provide a cumulative impact with respect to blockage effects upon the tide and wave regimes. Therefore the impact of the magnitude is considered to be as per that as a result of the Proposed Development alone and as provided in Table 6.34, Table 6.35, Table 6.36 and Table 6.37.

PHASE ONE PROJECTS

MAGNITUDE OF IMPACT

6.13.3.4 Blockage effects from the presence of the Proposed Development's infrastructure has the potential to combine with those from other projects within the region. On the basis of hydrodynamic and wave blockage modelling presented in paragraph 6.10.2 *et seq.*, it is expected that only projects within 12 km of the Array Area have the potential to create overlapping blockage effects. This is based on the maximum array-scale wave blockage created by the Array Area over baseline conditions, as shown in Figure 6.23 and Figure 6.25. The Phase One Project that has the potential to create cumulative blockage effects therefore includes Codling Wind Park.

6.13.3.5 Numerical hydrodynamic modelling, as presented in paragraph 6.10.2 *et seq*, indicates that change to the tidal regime remains localised to the Array Area. Any interaction with Codling Wind Park is therefore not considered likely and hence hydrodynamic blockage effects have not been considered further.

6.13.3.6 The wave blockage modelling, as shown in Figure 6.22 and Figure 6.24 indicates that any changes to the wave regime are restricted to the immediate west and west north west of the array. This would indicate that there is limited to no potential for wave regime effects introduced by the presence of the Proposed Development to act cumulatively with that of Codling Wind Park.

6.13.3.7 Therefore the impact of the magnitude is considered to be as per that as a result of the Proposed Development alone and as provided in Table 6.34, Table 6.35, Table 6.36 and Table 6.37.

SIGNIFICANCE OF THE EFFECT

6.13.3.8 A discussion of the significance of the effect upon the Coastal Processes receptors sensitive to the Impact 2 is provided in the following sub-sections.

OFFSHORE SANDBANKS

6.13.3.9 The sensitivity of Arklow Bank and Seven Fathom Bank has been assessed as **Medium**. The magnitude of the Proposed Development alone has been assessed as **Low**. Given that any tide and wave interaction impacts with other project infrastructure is not considered likely the cumulative significance of Impact 2 for both Project Design Options upon the offshore sandbanks is concluded to be **Slight.**

SITES DESIGNATED FOR PHYSICAL FEATURES

6.13.3.10 The sensitivity of Wicklow Reef SAC has been assessed as **Medium**. The magnitude of the Proposed Development alone has been assessed as **Low**. Given that any tide and wave interaction impacts with other project infrastructure is not considered likely the cumulative significance of Impact 2 for both project design options upon sites designated for physical features is concluded to be **Not Significant.**

6.13.3.11 The sensitivity of Magherabeg Dunes and Buckroney-Brittas Dunes and Fen SACs has been assessed as **Low**. The magnitude of the Proposed Development alone has been assessed as **Low**. Given that any tide and wave interaction impacts with other project infrastructure is not considered likely the cumulative significance of Impact 2 for both Project Design Options upon sites designated for physical features is concluded to be **Not Significant.**

COASTAL RECEPTORS BELOW MHW

6.13.3.12 The sensitivity of coastal receptors below the HWM has been assessed as **Medium**. The magnitude of the Proposed Development alone has been assessed as **Low**. Given that any tide and wave interaction impacts with other project infrastructure is not considered likely the cumulative significance of Impact 2 for both Project Design Options upon coastal receptors below the HWM is concluded to be **Not Significant.**

6.14 Transboundary effects

6.14.1.1 A screening of transboundary impacts has been carried out and has identified that there was no potential for significant transboundary effects with regard to Coastal Processes from the Proposed Development upon the interests of other states.

6.15 Summary of effects

6.15.1.1 This chapter has investigated the potential effects on Coastal Process receptors arising from the Proposed Development. The range of potential impacts and associated effects has been informed by the Scoping Opinion and consultation responses from stakeholders, alongside reference to existing legislation and guidance.

6.15.1.2 The assessment has been undertaken in the three following stages:

- The identification of the project parameters for Project Design Option 1 and 2 from the Offshore Project Description (Volume II, Chapter 4: Description of Development);
- The determination of the baseline physical environment (including potential changes over the Proposed Development lifetime due to natural variation); and
- Assessment of changes to Coastal Processes arising from the project design options both for the Proposed Development on its own and in conjunction with other built and consented projects.

6.15.1.3 In order to assess the potential changes relative to the baseline (existing) coastal and marine environment, a combination of complementary approaches have been adopted for this Coastal Processes assessment. These include:

- Numerical modelling of hydrodynamic, wave and sediment transport processes;
- The 'evidence base' containing monitoring data collected during the construction and O&M of other OWF developments (especially in similar environmental settings); and
- Analytical assessments of project-specific data.

6.15.1.4 A wide range of potential changes to Coastal Processes have been considered, including short-term sediment disturbance due to construction activities and the potential for changes to the coast and sandbank systems, arising from the blockage of waves and tides.

6.15.1.5 Using a precautionary assessment approach, it has been found that for all receptor groups, the level of effect significance is either **Negligible** or **Low** for all phases of development (Table 6.40 and Table 6.41). Accordingly, all of the potential effects to Coastal Process receptors are therefore considered Not Significant in terms of the EIA Regulations.

Table 6.40: Summary of potential environmental impacts, mitigation and monitoring for Project Design Option 1

Description of impact	Phase C	Phase O	Phase D	Factored-in measures	Magnitude of impact	Sensitivity of Receptors	Significance of effect	Additional measures	Residual effect	Proposed monitoring
1. Increased suspended sediment concentrations and associated deposition	✓	✓	✓	The factored-in measures (Table 6.16) include: – Definition and implementation of construction methods, Volume II, Chapter 4: Description of Development and Rehabilitation Schedule. – Preparation and implementation of environmental monitoring – Cables will be buried where possible and protected where not possible. – Undertaking of post-installation cable burial surveys and periodic	C: Low O: Negligible D: Low	C: n/a (pathway) O: n/a (pathway) D: n/a (pathway)	C: n/a (pathway) O: n/a (pathway) D: n/a (pathway)	None	C: n/a (pathway) O: n/a (pathway) D: n/a (pathway)	n/a

Description of impact	Phase C	Phase O	Phase D	Factored-in measures	Magnitude of impact	Sensitivity of Receptors	Significance of effect	Additional measures	Residual effect	Proposed monitoring
				monitoring of cables.						
2. Presence of infrastructure may lead to changes to tidal currents, wave climate and sediment transport	✓	✓	✓	n/a	C: Negligible O: Low to Negligible D: Negligible	C: Medium O: Medium D: Medium	C: Not significant in EIA terms O: Slight adverse to not significant (not significant in EIA terms) D: Not significant in EIA terms	None	C: Not significant in EIA terms O: Slight adverse to not significant (not significant in EIA terms) D: Not significant in EIA terms	n/a

Table 6.41: Summary of potential environmental impacts, mitigation and monitoring for Project Design Option 2

Description of impact	Phase C	Phase O	Phase D	Factored-in measures	Magnitude of impact	Sensitivity of Receptors	Significance of effect	Additional measures	Residual effect	Proposed monitoring
1. Increased suspended sediment concentrations and associated deposition.	✓	✓	✓	The factored-in measures (Table 6.16) include: – Definition and implementation of construction methods, Volume II, Chapter 4: Description of Development and Rehabilitation Schedule. – Preparation and implementation of environmental monitoring – Cables will be buried where possible and protected where not possible. – Undertaking of post-installation cable burial surveys and periodic	C: Low O: Negligible D: Low	C: n/a (pathway) O: n/a (pathway) D: n/a (pathway)	C: n/a (pathway) O: n/a (pathway) D: n/a (pathway)	None	C: n/a (pathway) O: n/a (pathway) D: n/a (pathway)	n/a

Description of impact	Phase C	Phase O	Phase D	Factored-in measures	Magnitude of impact	Sensitivity of Receptors	Significance of effect	Additional measures	Residual effect	Proposed monitoring
				monitoring of cables						
2. Presence of infrastructure may lead to changes to tidal currents, wave climate and sediment transport.	✓	✓	✓	N/A	C: Negligible O: Low to Negligible D: Negligible	C: Medium O: Medium D: Medium	C: Not significant in EIA terms O: Slight adverse to not significant (not significant in EIA terms) D: Not significant in EIA terms	None	C: Not significant in EIA terms O: Slight adverse to not significant (not significant in EIA terms) D: Not significant in EIA terms	n/a

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