Dublin Array
Generation for generations

EIAR Volume 3: Offshore Infrastructure Assessment Chapters Chapter 1: Marine Geology, Oceanography and Physical Processes

Kish Offshore Wind Ltd.

RWE SLR GoBe APEM Group

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Dublin Array Offshore Wind Farm

Environmental Impact Assessment Report

Volume 3, Chapter 1: Marine Geology, Oceanography and Physical Processes

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Glossary

Term	Definition
Array area	The area within which the WTGs and OSP will be located.
Borehole	A borehole is a deep, narrow hole drilled into the ground or seabed to collect subsurface samples and conduct in-situ testing. In offshore projects, boreholes provide detailed information about sediment layers and geotechnical properties critical for foundation design and installation.
Geophysical survey	A geophysical survey is a method of collecting data about the physical properties of the subsurface, often using techniques such as sonar, seismic reflection, magnetometry, and ground-penetrating radar. In a marine context, it helps characterise seabed conditions and identify hazards.
Geotechnical survey	A geotechnical survey is an investigation of the physical and mechanical properties of the seabed and subsurface soils. This survey involves sampling and testing sediment layers to assess soil strength, composition, and stability.
Maximum Design Option (MDO)	The design option that is assessed for each impact and which will result in the greatest impact (e.g., largest footprint, longest exposure, or largest dimensions). Unless otherwise identified in the assessment it can be assumed that any other (lesser) scenario for that impact will result in no greater significance than that assessed and presented in the EIAR. The design information is based on the best available information and the parameters outlined in the project description chapters are realistic and considered estimations of future design parameters.
Offshore Infrastructure	Wind turbine generators, offshore substation platform, inter array cables offshore export cables and landfall works below MHWS.
Offshore Export cable corridor (ECC)	The Offshore Export Cable Corridor (north and south route) (one corridor and two routes)
Pile	A long, structural element driven or drilled into the ground to anchor structures to the seabed, ensuring stability and load-bearing capacity.
Sandwave	A sandwave is a dynamic, large-scale bedform composed of sand, commonly found on the seafloor in areas with strong tidal currents which can migrate over time due to currents.
Trailing Suction Hopper Dredger (TSHD)	A type of dredging vessel equipped with suction pipes that remove sediment from the seabed. The dredged material is stored in an onboard hopper and can be transported and deposited elsewhere
The Applicant	The Applicant for Dublin Array is defined as Kish Offshore Wind Limited on behalf of Kish Offshore Wind Limited and Bray Offshore Wind Limited.
Wind turbine generators (WTG)	All the components of a wind turbine, including the tower, nacelle and rotor.

Acronyms

Term	Definition
BERR	Department for Business, Enterprise and Regulatory Reform
BSF	Below Sea Floor
CD	Chart Datum
CBRA	Cable Burial Risk Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture
CIP	Cable Installation Plan
CHERISH	Climate, Heritage and Environment of Reefs, Islands, and Headlands
CGS	County Geological Sites
COWRIE	Collaborative Offshore Wind Research into the Environment
CREL	Centrica Renewable Energy Limited
DAPPMS	Dublin Array Physical Process Modelling System
DAS	Dumping at Sea
DECC	Department of Environment, Climate and Communications (formally DCCAE)
DCCAE	Department of Communications, Climate Action and Environment (now DECC)
DPSIR	Driver, pressure, states, impacts and responses
Dublin Array	Dublin Array Offshore Wind Farm
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EMODnet	European Marine Observation and Data Network
EPA	Environmental Protection Agency
FM	Flexible Mesh
GSI	Geological Survey Ireland
GWFlood	Groundwater Flooding
HDD	Horizontal Directional Drilling
HVDC	High Voltage Direct Current
HWM	High Water Mark
HWS	High Water Springs
IAC	Inter-array cables
ICES	International Council for the Exploration of the Sea
IPCC	Intergovernmental Panel on Climate Change

Term	Definition
INFOMAR	Integrated Mapping for the Sustainable Development of Ireland's Marine Resource
LAT	Lowest Astronomical Tide
LWS	Low Water Springs
MAC	Maritime Area Consent
MDO	Maximum Design Option
MFE	Mass Flow Excavator
MSL	Mean Sea Level
MW	Megawatt
MW&SQ	Marine Water and Sediment Quality
NHA	National Heritage Area
NIS	Natura Impact Statement
NPWS	National Parks and Wildlife Service
NTU	Nephelometric Turbidity Units
O&M	Operations and Maintenance
offshore ECC	Offshore Export Cable Corridor
OPW	Office of Public Works
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PINS	Planning Inspectorate
PSA	Particle Size Analysis
PSD	Particle Size Distribution
SPM	Suspended Particulate Matter
SSC	Suspended Sediment Concentrations
STFATE	Short-Term Fate of Dredged Material Model
SW	Spectral Wave
TSHD	Trailer Suction Hopper Dredger
UKHO	United Kingdom Hydrographic Office
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USACE	United States Army Corps of Engineers
WFD	Water Framework Directive
WTG	Wind Turbine Generator
ZoI	Zone of Influence

1 Marine Geology, Oceanography and Physical Processes

1.1 Introduction

1.1.1 This chapter presents the results of the Environmental Impact Assessment (EIA) for the potential impacts of the construction, operation and maintenance (O&M), and decommissioning phases in the array area and offshore export cable corridor (the latter referred to as the offshore ECC) on Marine Geology, Oceanography and Physical Processes (hereafter referred to as 'physical processes'). Specifically, this chapter considers potential impacts below the High Water Mark (HWM), defined as the natural boundary between the offshore and onshore water and terrestrial environments for EIA assessments.

1.1.2 In this document "physical processes" has been defined as the collective term for the following:

- Tides and tidal currents;
- Waves (and winds);
- Sediments and geology (including seabed sediment distribution and transport (including suspended sediments));
- Seabed geomorphology[1]; and
- Coastal geomorphology.

1.1.3 This EIAR chapter should be read in conjunction with the following documents:

- Volume 4, Appendix 4.3.1-1: Technical Baseline Report - Physical Processes (hereafter referred to as the Physical Processes Technical Baseline);
- Volume 4, Appendix 4.3.1-2: Physical Process Modelling for Dublin Array Offshore Wind Farm (hereafter referred to as the Physical Processes Modelling Report);
- Volume 4, Appendix 4.3.1-3: Hydrodynamic Calibration and Validation Report (hereafter referred to the Hydrodynamic Calibration and Validation Report);
- Volume 4, Appendix 4.3.1-4: Spectral Wave Model Calibration and Validation Report (hereafter referred to as the Spectral Wave Model Calibration and Validation Report); and
- Volume 4, Appendix 4.3.1-5: Physical Processes Modelling and Design Options Comparison Report (hereafter referred to as the Physical Processes Modelling and Design Options Comparison Report).

[1] Geomorphology is the study of landforms and the processes that shape them.

1.1.4 The Physical Processes Technical Baseline (referenced above) provides a detailed characterisation of the receiving environment. Information from the baseline report has been summarised within this chapter.

1.1.5 For the most part, physical processes are not in themselves receptors but are instead 'pathways'[2]. Changes to physical processes have the potential to indirectly impact other environmental receptors (Lambkin *et al*., 2009), notably those described within:

- Volume 3, Chapter 2: Marine Water and Sediment Quality (hereafter referred to as the MW&SQ Chapter);
- Volume 3, Chapter 3: Benthic and Intertidal Ecology (hereafter referred to as the Benthic Ecology Chapter);
- Volume 3, Chapter 4: Fish and Shellfish (hereafter referred to as the Fish and Shellfish Chapter);
- Volume 3, Chapter 5: Marine Mammal Ecology (hereafter referred to as the Marine Mammals Chapter);
- Volume 3, Chapter 6: Offshore and Intertidal Ornithology (hereafter referred to as the Ornithology Chapter);
- Volume 3, Chapter 13: Marine Archaeology (hereafter referred to as the Marine Archaeology Chapter); and
- Volume 3, Chapter 11: Infrastructure and Other Users (hereafter referred to as the Infrastructure and Other Users Chapter).

1.2 Regulatory background

1.2.1 The legislation, policy and guidance relevant to the whole Planning Application is set out in Consents, Legislation, Policy and Guidance (Volume 2, Chapter 2). The principal legislation, policy and guidance relevant to this chapter is set out in Annex A.

1.2.2 The assessment of potential impacts upon Marine Geology, Oceanography and Physical Processes has been made with specific reference to the relevant regulations, guidelines and guidance, which include:

- Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment: Best Practice Guidance (ABPmer and HR Wallingford, 2009); and
- Potential Effects of Offshore Wind Developments on Coastal Processes (ABPmer and Metoc Plc, 2002).

1.2.1 The relevance of specific policies or guidance and their key provisions with regards physical processes and how these have been addressed within this assessment are presented in Annex A.

[2] 'Pathways' refer to the link between the source and the receptor impacted by the effect, as considered within the source-pathway-receptor model described in Paragraph 1.4.8.

1.2.2 Consideration of designated European sites is required under Part XAB of the Planning Act and the implementing provisions in the Planning Regulations. Consideration of strictly protected species and habitats is required under the European Communities (Birds and Natural Habitats Regulations 2011 (S.I. No. 477 of 2011)), as amended, and of birds under the Wildlife Acts (see Policy Chapter). An assessment of the impact of the Dublin Array offshore infrastructure on European sites and their supporting species and habitat qualifying interests is presented in the Natura Impact Statement (NIS) (Part 4: Habitats Directive Assessments, Volume 4: NIS).

1.3 Consultation

1.3.1 As part of the EIA for Dublin Array, non-statutory consultation has been undertaken with various statutory and non-statutory bodies. A scoping report (RWE, 2020) was made publicly available and issued to statutory consultees on 9th October 2020. Table 1 provides a summary of the consultation undertaken for Marine Geology, Oceanography and Physical Processes to date for Dublin Array.

1.3.2 In accordance with recommendations outlined in the DCCAE guidance[3] "the Applicant sought to consult during the scoping stage with the Environmental Protection Agency (EPA), Geological Survey of Ireland and the Office of Public Works (OPW) for coastal processes, sedimentation processes and seabed geology/ morphology.

[3] Guidance on Environmental Impact Statement (EIS) and Natura Impact Statement (NIS) Preparation for Offshore Renewable Energy Projects (Environmental Working Group of the Offshore Renewable Energy Steering Group and the DCCAE, 2017)

Table 1 Summary of consultation relating to physical processes

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
November 2020	Geological Survey Ireland (GSI) Scoping Response	County Geological Sites (CGS), as adopted under the National Heritage Plan, include additional sites that may also be of national importance, but which were not selected as the very best examples for National Heritage Areas (NHA) designation. All geological heritage sites identified by GSI are categorised as CGS pending any further NHA designation by National Parks and Wildlife Service (NPWS).	National Heritage Areas and County Geological Sites are addressed specifically in Volume 3, Chapter 8: Nature Conservation (hereafter referred to as the Nature Conservation Chapter).
November 2020	GSI Scoping Response	With the current plan, there may be potential impacts on the integrity of current CGSs envisaged by the proposed development, should these sites not be assessed as constraints. Ideally, the sites should not be damaged or integrity impacted or reduced in any manner due to the proposed development. However, this is not always possible, and in this situation appropriate mitigation measures should be put in place to minimize or mitigate potential impacts. Where the integrity cannot be preserved we would ask that careful consideration be given in design to accommodating preservation of exposures and access to the site during construction to record the exposures to strengthen our knowledge and datasets. We would also ask that the design considers the use of information panels as appropriate to highlight the significance of the impacted CGS.	County Geological Sites are addressed specifically in the Nature Conservation Chapter. Impacts to coastal processes have been assessed within this document, where appropriate, with a consideration of coastal erosion provided within Section 1.6.
November 2020	GSI Scoping Response	GSI maintains online datasets of bedrock and subsoils geological mapping that is reliable, accessible and meets the requirements of all users including depth to bedrock and physiographic maps. These datasets include depth to bedrock data and subsoil classifications.	The Applicant has utilised offshore data derived from the EMODnet project map compiled by GSI from Petroleum Affairs Division and Integrated Mapping for the Sustainable Development of Ireland's Marine Resource (INFOMAR) mapping and other published sources. Further details

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
			are provided in Section 1.4 and the Physical Processes Technical Baseline.
November 2020	GSI Scoping Response	Geohazards can cause widespread damage to landscapes, wildlife, human property and human life. In Ireland, landslides are the most prevalent of these hazards. GSI has information available on past landslides for viewing as a layer on our Map Viewer. GSI Ireland also engages in national projects such as Landslide Susceptibility Mapping and Groundwater Flooding (GWFlood), and in international projects, such as the Tsunami Warning System, coordinated by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organisation (UNESCO). Historical records and geological evidence indicate that, while tsunamis are unlikely events around Ireland, the Irish coast is vulnerable to tsunamis from submarine landslides and distant earthquakes.	This is noted by the Applicant. The information regarding historic landslides in the area is considered in Section 1.6.
November 2020	GSI Scoping Response	Associated levels of coastal flooding are expected to be similar to those seen during storm surges, but with much more energetic inundation and a much shorter time to react. Ireland participates in an international tsunami detection and alerting system, coordinated by the Intergovernmental Oceanographic Commission of UNESCO. We recommend that geohazards and particularly flooding be taken into consideration, especially when developing areas where these risks are prevalent, and we encourage the use of our data when doing so. Coastal Vulnerability while seen as a potential geohazard, is discussed in more detail under our marine and coastal unit information below.	Coastal flooding is considered in Section 1.14 of this document. The vulnerability of the coastline is characterised in the Physical Processes Technical Baseline and assessed in Sections 1.14 to 1.16.
November 2020	GSI Scoping Response	GSI continues to populate and develop our national geotechnical database and viewer with site investigation	This is welcomed by the Applicant. Within the physical processes study area, the Applicant identified five

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
		data submitted voluntarily by industry. The current database holding is over 7500 reports with 134,000 boreholes; 31,000 of which are digitised which can be accessed through downloads from our Geotechnical Map Viewer. We would strongly recommend that this database be consulted as part of any baseline geological assessment of the proposed development as it can provide invaluable baseline data for the region or vicinity of the proposed development area. This information may be beneficial and cost saving for any site specific investigations that may be designed as part of the development.	reports which have been reviewed to verify the characterisation of the receiving environment.
November 2020	GSI Scoping Response	GSI is of the view that the sustainable development of our natural resources should be an integral part of all development plans from a national to regional to local level to ensure that the materials required for our society are available when required. GSI highlights the consideration of mineral resources and potential resources as a material asset which should be explicitly recognised within the environmental assessment process. GSI provides data, maps, interpretations and advice on matters related to minerals, their use and their development in our Minerals section of the website. The Active Quarries, Mineral Localities and the Aggregate Potential maps are available on our Map Viewer. We would recommend use of the Aggregate Potential Mapping viewer to identify areas of High to Very High source aggregate potential within the area. In keeping with a sustainable approach, we would recommend use of our data and mapping viewers to identify and ensure that natural resources used in the proposed development are sustainably sourced from properly recognised and licensed facilities.	The Applicant utilised the GSI Map Viewer and did not identify any Mineral Localities or Aggregate Potential areas within the study area of this assessment (i.e. below the High Water Mark (HWM)).

Date	Consultation type	Consultation and key issues raised	Section where provision is addressed
November 2020	GSI Scoping Response	We would therefore recommend use of our Marine and Coastal Unit datasets available on our website and Map Viewer. The Marine and Coastal Unit also participate in coastal change projects such as CHERISH (Climate, Heritage and Environments of Reefs, Islands, and Headlands) and are undertaking mapping in areas such as coastal vulnerability and coastal erosion.	This is welcomed by the Applicant. Information from the CHERISH project, including the Coastal Vulnerability Index as presented in Caloca-Casado, 2018 have been utilised to characterise the receiving environment. Further details are provided in the Physical Processes Technical Baseline.
November 2020	National Parks and Wildlife Service (NPWS) Meeting	NPWS advised the project to ensure the assessment was very explicit about extent of plumes associated with different sediment fractions.	The maximum extent of potential sediment plumes is presented explicitly in Sections 1.14 to 1.17.

1.4 Methodology

1.4.1 For a full description of the methodology as to how this EIAR was prepared, see Volume 2, Chapter 3: EIA Methodology (hereafter the EIA Methodology Chapter). The methodology that follows below is specific to this chapter.

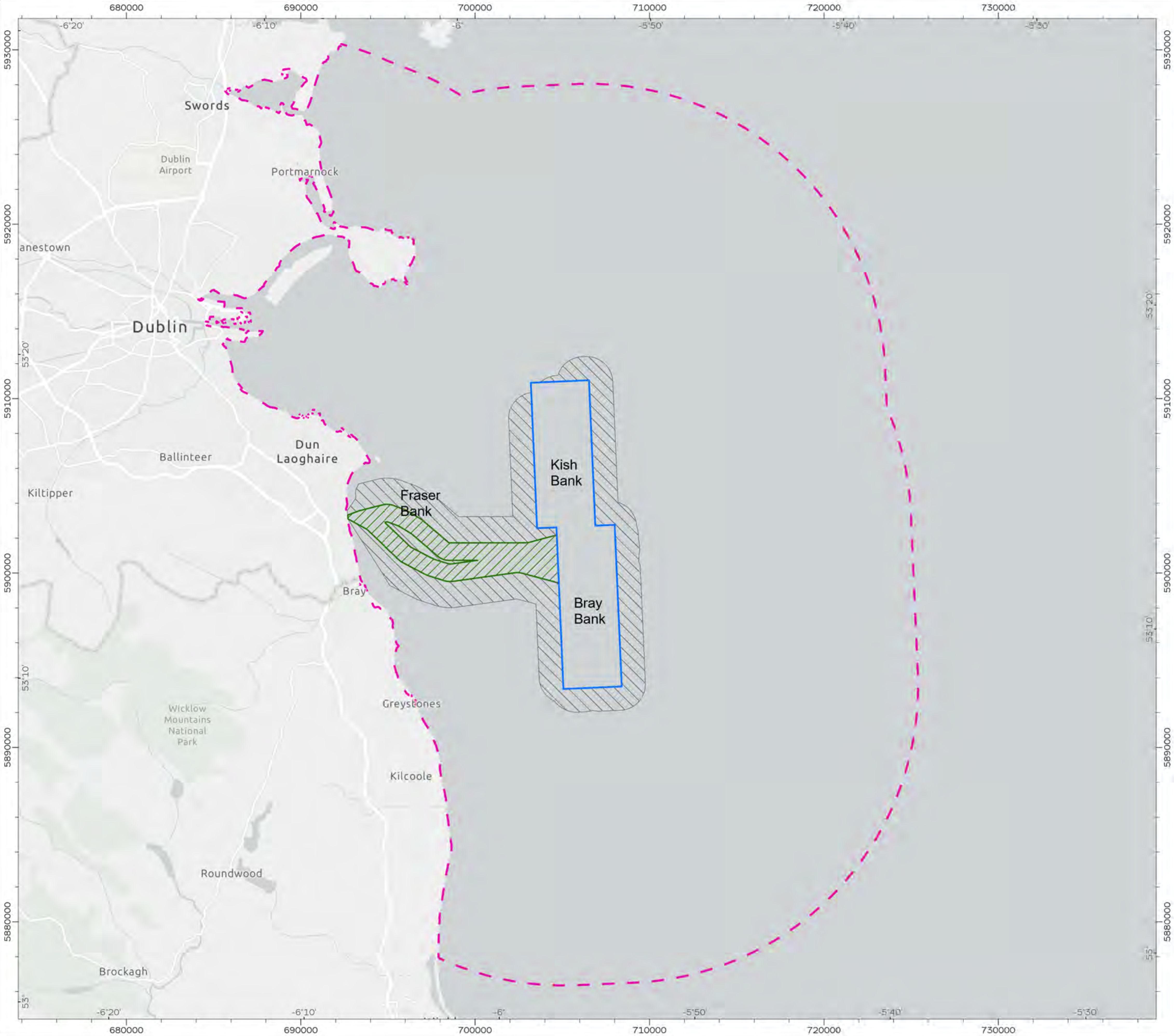
Study area

1.4.2 The DCCAE guidelines recommends that the Zone of Influence (ZoI) and study area for consideration in an EIA are established at the scoping stage. These ZoI are acknowledged by the guidance to differ depending upon the pressure or ecosystem component under consideration. Data and identification of features of interest within the zones that might be impacted by an offshore renewable energy project are required so that a source – pathway – receptor risk assessment can be carried out and the subsequent evaluation of effects can be undertaken for key features.

1.4.3 For the purposes of the EIAR for the physical marine environment, the study area for physical processes is determined by the ZoI of the offshore infrastructure. The ZoI for the physical marine environment has been defined by the maximum spring tidal excursion[4] within the proposed development (which is approximately 16 km based on the project specific modelling undertaken[5]). Therefore, a study area of a 17 km buffer[6] around the proposed development[7] is considered to be both precautionary and to encapsulate all significant effects that may occur on the physical marine environment as a result of the proposed offshore infrastructure. The boundaries of the offshore infrastructure and the modelled tidal ellipse buffer area effectively characterise the predicted zone of potential primary (direct) and secondary (indirect) impacts of the development on physical processes receptors respectively.

1.4.4 The study area is limited to the marine and coastal environment below the HWM, with the exception of the consideration of coastal erosion which may extend above the HWM. The HWM has been defined as a natural boundary between the offshore and onshore water and terrestrial environments for EIA assessments (Volume 6, Appendix 6.5.4-2: OES Flood Risk Assessment will assess onshore receptors above the HWM). The study area for the physical processes environment is presented in Figure 1.

[4] Tidal excursion length is the net horizontal distance travelled by a water particle from Low Water Springs (LWS) to High Water Springs (HWS) or vice versa. It can be used to describe the movement of pollutants in estuaries during a tidal cycle (Zhen-Gang, 2008).
[5] Based on the distance of sediment plume travelled which was released at low water until the flooding tide during a mean spring tide within the proposed array.
[6] All distances are straight line (geodesic) as calculated using GIS taken from the outer boundary of all offshore works, the buffer also incorporates the temporary occupation area and as such are inherently precautionary.
[7] Activities undertaken within the temporary occupation area, namely the use of jack-up vessels and anchors during the construction, O&M, and decommissioning phases have been screened out within the Physical Processes Chapter for suspended sediment and deposition with their use not resulting in notable changes in SSC and associated sediment deposition, however the use of a buffer ensures a precautionary approach is taken.



- Physical Processes Study Area (17km Buffer)
- Array Area
- Temporary Occupation Area
- Export Cable Corridor

DRAWING STATUS

FINAL

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PROJECT TITLE

Dublin Array

DRAWING TITLE

Geographical Overview of the Study Area for the Physical Marine Environment

DRAWING NUMBER: 1

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 2 4 6 8 km
0 1 2 3 4 nm

N GRID NORTH

SCALE	1:225,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

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Baseline data

1.4.5 The evidence used to characterise the baseline for this assessment is supported by a data and literature search relevant to both the wider region of the Irish Sea and the study area. This section details the key data sources identified through undertaking a review of data sources, including but not limited to:

- Integrated Mapping for the Sustainable Development of Ireland's Marine Resource (INFOMAR);
- European Marine Observation and Data Network (EMODnet);
- Dublin Array project specific modelling (provided in the Physical Processes Modelling Report);
- The Irish Marine Weather Buoy network;
- The Commissioners of Irish Lights buoy in Dublin Bay;
- Centre for Environment, Fisheries and Aquaculture Science (Cefas)[8;] and
- Dublin Port Company (turbidity monitoring buoys);
- Published and grey literature; and
- Data archives/ online repositories.

1.4.6 The available information listed above has been complimented by project specific surveys, including surficial seabed sampling, for both the coastal and offshore areas covering the array area and offshore ECC (Aquafact, 2021; Fugro, 2021a; Fugro, 2021b; Fugro, 2021c; Fugro, 2021d; Partrac, 2022).

1.4.7 The output from the review is a list of the available literature and data sources and where possible a summary of findings associated with the study area. Details of the key data sources, utilised in the development of the characterisation of the receiving environment for physical processes, are presented the Physical Processes Technical Baseline.

Assessment methodology

1.4.8 The assessment of the potential effects on physical processes has been considered in terms of a source-pathway-receptor model whereby:

- The source is the initiator event;
- The pathway is the link between the source and the receptor impacted by the effect (e.g., sediment transport processes); and
- The receptors are the receiving entities.

[8] Cefas forms part of the Department for Environment, Food and Rural Affairs in the UK

1.4.9 A receptor can only be exposed to change if a pathway exists through which an effect can be transmitted between the source activity and the receptor.

1.4.10 In order to assess the potential effects upon the marine physical environment relative to the existing (receiving) environment, a combination of analytical methods has been used. These include:

- Project specific hydrodynamic and wave modelling; and
- Analytical assessment of project specific and non-project specific data sources within the study area.

1.4.11 The assessment also considers likely naturally occurring variability in, or long-term changes to, physical processes within the project lifetime due to natural cycles and/or climate change (e.g. sea level rise). This is important as it enables a reference baseline level to be established against which the potentially modified physical processes can be compared, throughout the project lifecycle.

1.4.12 Baseline conditions are described in detail within the 'Receiving environment' section (Section 1.6) and include for the potential effects of natural variations, including climate change.

Site specific modelling

1.4.13 Full details of the methodology used in the site-specific modelling is provided in the Physical Processes Modelling Report. For ease of reference, Figure 2 presents the locations of the modelled simulations undertaken to inform this chapter of the EIAR.

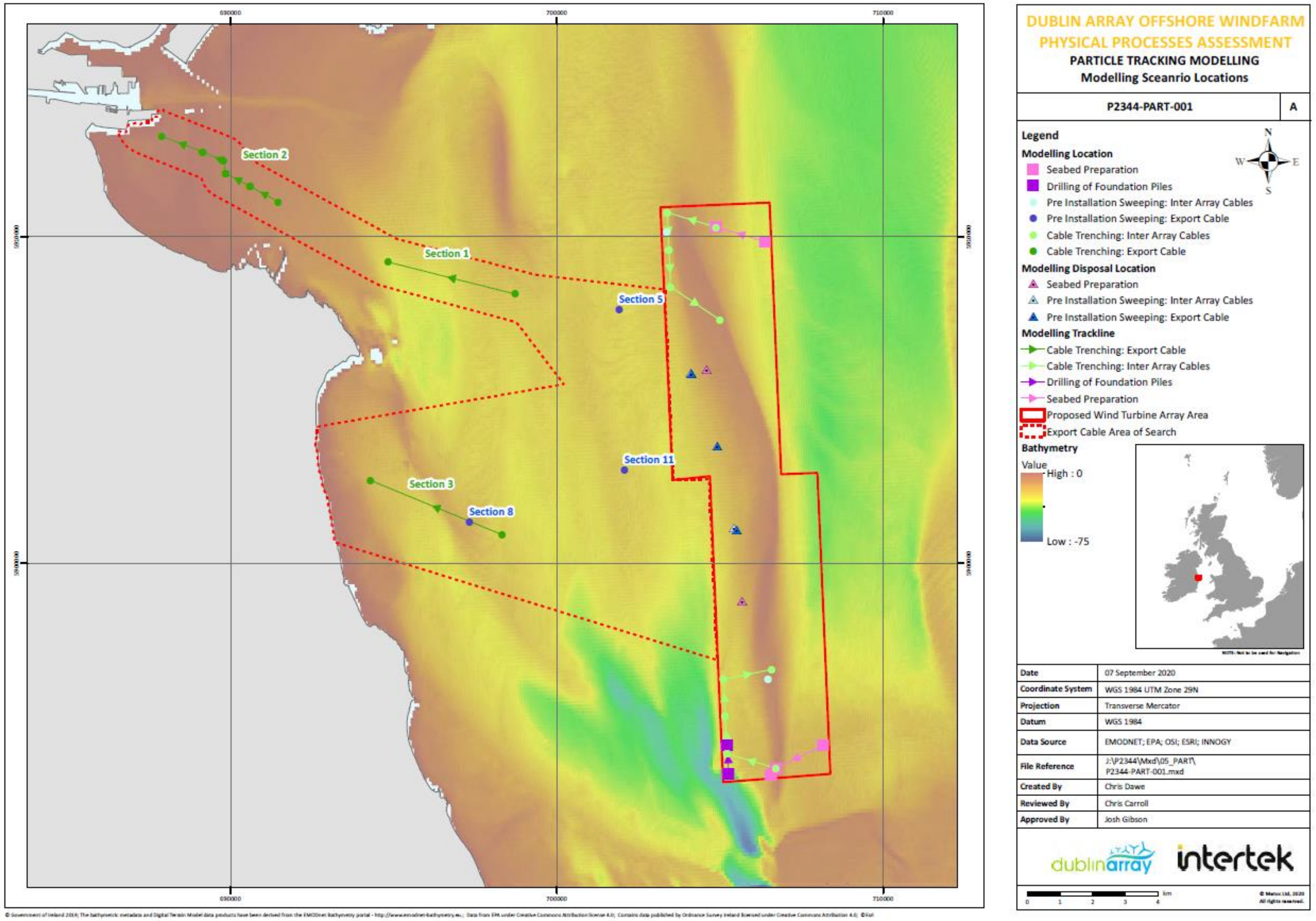


Figure 2 Modelled scenario locations (Intertek, 2020)[9]

[9] This figure is taken from the Physical Processes Modelling Report, which was written at an earlier project stage, and therefore the Proposed Wind Turbine Array area and Export Cable Area of Search are not reflective of those being applied for as part of the Dublin Array infrastructure.

1.5 Assessment criteria

1.5.1 This assessment for physical processes is consistent with the EIA methodology presented in the EIA Methodology Chapter. The criteria for determining the sensitivity of the receiving environment and the magnitude of identified impacts for the physical processes assessment are defined in Table 2 and Table 3, respectively. A matrix has been used for the determination of significance in EIA terms (see Table 4). The combination of the magnitude of the impact with the sensitivity of the receptor determines the assessment of significance of effect.

Sensitivity of receptor criteria

1.5.2 The sensitivity of a receptor is a function of its capacity to accommodate change and reflects its ability to recover if affected. Sensitivity is quantified via a consideration of its context; the receptor's adaptability, tolerance and recoverability and value. The criteria used in defining the sensitivity of the identified physical processes receptors are presented in Table 2. Four defined levels of sensitivity have been determined; High, Medium, Low or Negligible and where one of the definitions, for a given level, is met then this will determine the level of sensitivity assigned. Where a receptor could reasonably be assigned more than one level of sensitivity, professional judgement has been used to determine which level is applicable.

Table 2 Sensitivity/ importance of the environment

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. 15 to 60 years) and/or permanent (i.e. over 60 years) and recovery is not anticipated. **Value:** The receptor is designated for international importance and/or very high socio-economic value.
Medium	**Adaptability:** The receptor has a limited capacity to avoid or adapt to an impact. **Tolerance:** The environment has a low capacity to accommodate the proposed form of change. **Recoverability:** The receptor is anticipated to recover fully within the medium term (i.e. seven to 15 years). **Value:** The receptor is designated for international or national importance and/or moderate socio-economic value.
Low	**Adaptability:** The receptor has a reasonable capacity to avoid or adapt to an impact. **Tolerance:** The environment has a moderate capacity to accommodate the proposed form of change. **Recoverability:** The receptor is anticipated to recover fully within the short-term (i.e. one to seven years). **Value:** The receptor is not designated but may be of national or local importance and/or local socio-economic value.
Negligible	**Adaptability:** The receptor has a high capacity to avoid or adapt to an impact. **Tolerance:** The environment has a high capacity to accommodate the proposed form of change. **Recoverability:** The receptor is anticipated to recover fully and effects will be temporary (i.e. lasting less than one year). **Value:** The receptor is not designated but may be of local importance and/or local socio-economic value.

Magnitude of impact criteria

1.5.3 Of note is that a distinction is made throughout the assessment between the magnitude, as defined by the extent, duration[10], frequency, probability[11] and consequences[12] of the impact and the resulting significance of the 'effects' upon physical processes receptors. The descriptions of magnitude are specific to the assessment of physical processes impacts and are considered against the magnitude descriptions presented in Table 3. Potential impacts have been considered in terms of whether they are adverse or beneficial effects.

1.5.4 Where an effect could reasonably be assigned to more than one level of magnitude, professional judgement has been used to determine which level is the most appropriate for the impact. The level has been assigned based on the most appropriate potential consequences of the impact as defined for each level of magnitude (see Table 3). For example, an impact may occur constantly throughout the O&M period but is not discernible or measurable in practice, therefore it would be concluded to be of a Negligible magnitude despite the frequency of the impact.

1.5.5 For the purposes of the definitions in Table 3 and the assessment, near-field has been defined as within the array area and offshore ECC. Far-field has been defined as extending beyond these limits up to the ZoI (see Section 1.4).

[10] Note: this is the duration of the impact and not the time taken for the receptor to recover.
[11] All impacts assessed within this EIAR chapter are considered reasonably likely to occur, and so the probability of the impact has not been a consideration in defining the magnitude of the impact.
[12] The degree of change relative to the baseline level and the change in character.

Table 3 Magnitude of the impact

Magnitude	Definition
High	**Extent:** Impact across the near-field[13] and far-field[14] areas beyond the study area. **Duration:** The impact is anticipated to be permanent (i.e. over 60 years). **Frequency:** The impact will occur constantly throughout the relevant project phase. **Consequences: Permanent changes to key characteristics or features of the particular environmental aspect's character or distinctiveness.**
Medium	**Extent:** The maximum extent of the impact is restricted to the study area. **Duration:** The impact is anticipated to be medium-term (i.e. seven to 15 years) to long-term (15 to 60 years). **Frequency:** The impact will occur constantly throughout a relevant project phase. **Consequences: Noticeable change to key characteristics or features of the particular environmental aspect's character or distinctiveness.**
Low	**Extent:** The maximum extent of the impact is restricted to the near-field and adjacent far-field areas. **Duration:** The impact is anticipated to be temporary (i.e. lasting less than one year) to short-term (i.e. one to seven years). **Frequency:** The impact will occur frequently throughout a relevant project phase. **Consequences: Barely discernible to noticeable change to key characteristics or features of the particular environmental aspect's character or distinctiveness.**
Negligible	**Extent:** The maximum extent of the impact is restricted to the near-field and immediately adjacent far-field areas. **Duration:** The impact is anticipated to be momentary (seconds to minutes) to brief (lasting less than a day). **Frequency:** The impact will occur once or infrequently throughout a relevant project phase. **Consequences: Not discernible to barely discernible change to key characteristics or features of the particular environmental aspect's character or distinctiveness.**

Defining the significance of effect

1.5.6 The significance of effect associated with the impact will be dependent upon the sensitivity of the receptor and the magnitude of the effect. The assessment methodology of the significance of potential effects is described in Table 4. Effects defined as Significant, Very Significant and Profound are considered significant in EIA terms (EPA, 2022).

[13] Defined as within the array area and offshore ECC.
[14] Defined as extending beyond the limits defined by the near-field, up to the ZoI.

Table 4 Significance of potential effects

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

*Moderate levels of effect have the potential, subject to the assessor's professional judgement, to be 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.

1.6 Receiving environment

1.6.1 The study area encompasses the array area as well as the offshore ECC, up to and including the intertidal zone at the landfall, in addition to the modelled tidal ellipse buffer area (Figure 1). The array area, offshore ECC and the modelled tidal ellipse buffer area effectively characterise the predicted zone of potential primary (direct) and secondary (indirect) impacts of the development on physical processes receptors respectively. The offshore infrastructure has been broken down into three sections, the array area, the offshore ECC and the landfall. These sections have been assessed individually in terms of their potential impacts on physical processes for each stage of the proposed development.

1.6.2 The Physical Processes Technical Baseline has been prepared to provide a detailed characterisation of the receiving baseline within the ZoI and provide regional context. A summary of the key findings from that study has been provided below.

Offshore Environment

Meteorology

1.6.3 As presented in Figure 3, the wind direction typically experienced at the Kish Lighthouse (53.3108°N, 5.9257°W, between July 2011 to June 2015), located immediately to the north of the array, is predominantly from the south and westerly directions. Furthermore, the higher wind speeds are also associated with these directions. This site is considered to be representative of the wind directions within the array area and in the offshore ECC.

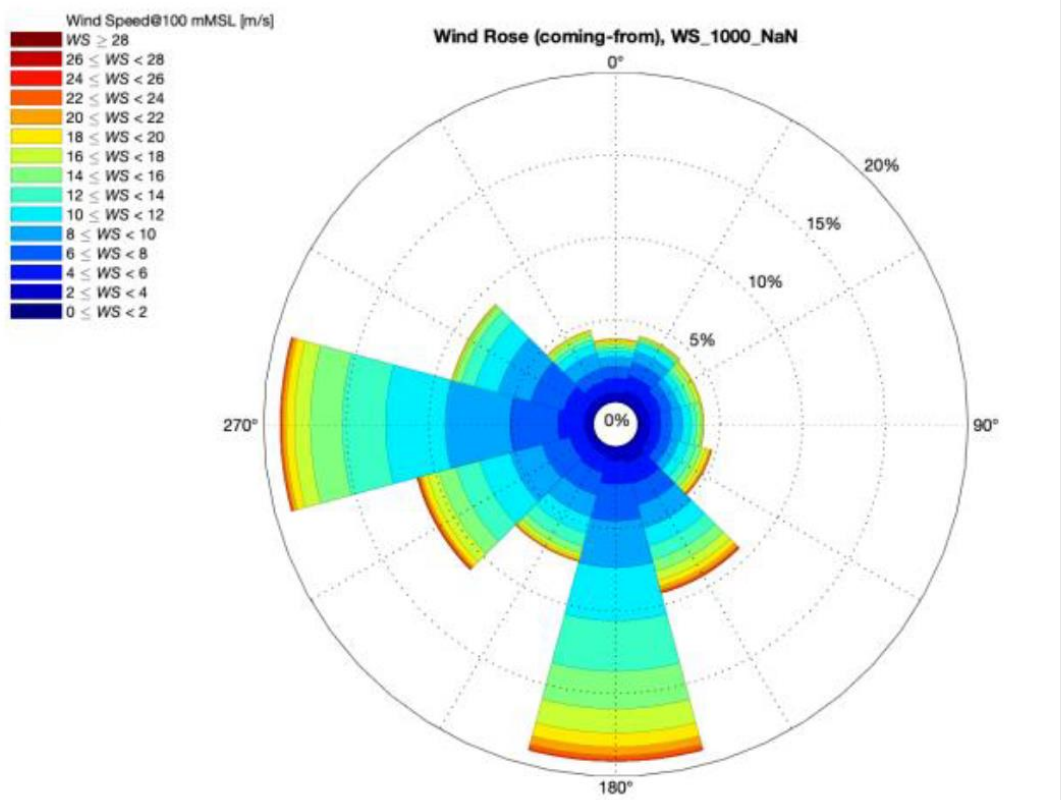


Figure 3 Wind rose derived from the Kish Lighthouse LiDAR measurements (C2wind, 2019)

Wave regime

1.6.4 Wave heights experienced in the Irish Sea are generally lower than those experienced on the more exposed Atlantic coast due to sheltering effects afforded by the land mass of Ireland. In general, there is a reduction in wave height as water depth decreases, although waves may become focussed by refraction as they pass over the shallow areas of the Kish and Bray Banks, resulting in a relatively vigorous wave environment with breaking waves experienced on the crests. Data collected from the banks recorded maximum significant wave heights of 2.5 m and 2.3 m for the Kish and Bray Banks, respectively, between November 2021 and March 2022. Maximum significant wave heights of 4.4 m and 3.8 m were recorded between March and June 2022, for the Kish and Bray Banks, respectively (Partrac, 2022).

1.6.5 The wave climate in the array area is dominated by waves approaching from a south to southeasterly direction, both in terms of magnitude and frequency. Southerly waves in particular may approach the site from the Atlantic and are therefore relatively large and exhibit a stronger swell influence. Waves also approach the site from the north, northeast and easterly directions; however, these waves have shorter fetch lengths and therefore tend to exhibit lower heights and shorter periods than Atlantic waves; they also occur less frequently than waves from south and southeasterly directions.

1.6.6 Analysis of the Met Éireann data from the M2 buoy, located at 53.4800°N 05.4250°W (approximately 20 km east of Lambay Island), indicated that there was a dominance in wave conditions from a southerly direction and a maximum significant wave height of over 7 m was derived. This is consistent with the concept that waves arriving from the south are a result of channelling from the Atlantic, whereas those from other orientations are a result of the relatively short fetch of the Irish Sea.

1.6.7 As part of the EIAR, a spectral wave (SW) model (part of the Dublin Array Physical Process Modelling System (DAPPMS)) has been constructed to characterise and quantify the wave climate in the study area. The significant wave heights, in the DAPPMS SW model, from waves coming from a southerly direction during in a 1:1 year event scenario, are shown in Figure 4. Details of the model, its calibration and validation and results are provided in the Spectral Wave Model Calibration and Validation Report. The data from this model are the primary source of information to inform effects and pathways associated with waves within the EIAR.

1.6.8 A sheltering effect from waves originating from the east will be afforded to the crest of the sandbanks as these waves will break from the raised bathymetry of the sandbank slopes. In addition, waves shoaling on the eastern slope of the bank will change their direction through refraction. The existence of Codling Bank to the south of the development may result in dampening of any southerly waves by shoaling[15].

1.6.9 The wave climate in the offshore ECC is dominated by waves approaching from a south to southeasterly direction. As presented in Figure 4, there is a decrease in wave height as they propagate towards land (and into the shallower water), particularly within Dublin Bay.

[15] Wave shoaling is the effect by which surface waves entering shallower water change in wave height.

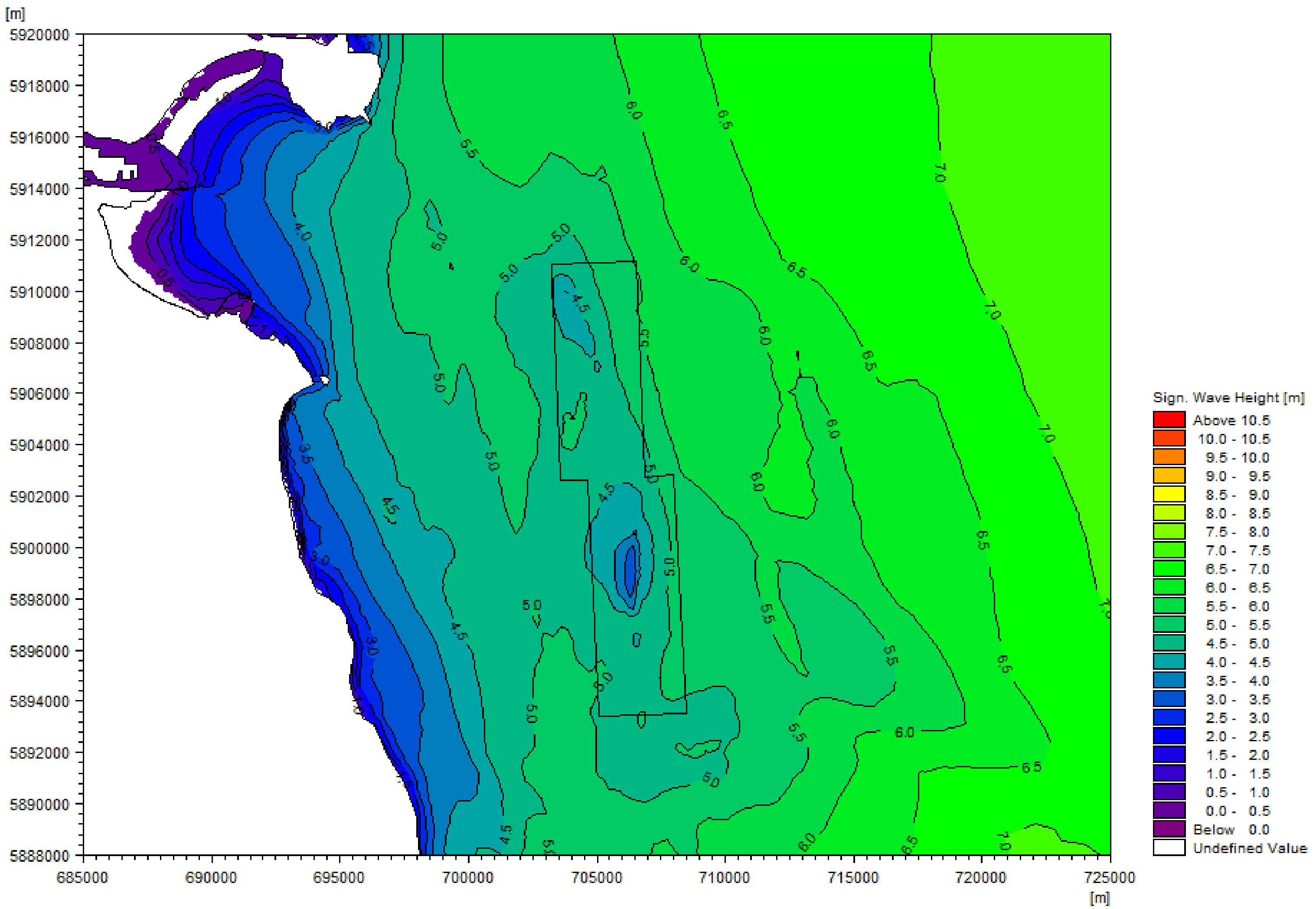


Figure 4 Significant wave heights from the south (a 1 in 1 year event) (DAPPMS)

Tidal Levels

1.6.10 The array area experiences southern flow during ebb tide and approximately northern flow during the flood tide (see Figure 7 and Figure 8). The hydrodynamics of the area are tidally-dominated, and the tidal regime is semi-diurnal at Dublin Port (UK Hydrographic Office (UKHO), 2019).

1.6.11 As part of the EIAR, a hydrodynamic modelling system (DAPPMS) has been constructed to characterise and quantify the tidal currents and water levels within the study area. Details of the DAPPMS, calibration and validation and results are presented in the Hydrodynamic Calibration and Validation Report. The data from this model are the primary source of information to characterise the water levels within the study area, and to inform effects and pathways associated within tidal currents within the EIAR.

1.6.12 The DAPPMS shows that tidal range has limited variation over the array area and the adjacent far-field areas, with little spatial variation in water level at each tidal state. Within the array area, the predicted mean spring and mean neap tidal ranges are of the order of 3.3 m and 1.9 m, respectively.

1.6.13 The DAPPMS shows that tidal range does not vary much over the proposed offshore ECC and the surrounding locations, with little spatial variation in water level at each state of the tide. Mean spring and mean neap tidal ranges are identified as, approximately, 3.8 m and 1.8 m, respectively. Further details are presented in Figures A1 to A8 in the Physical Processes Modelling Report.

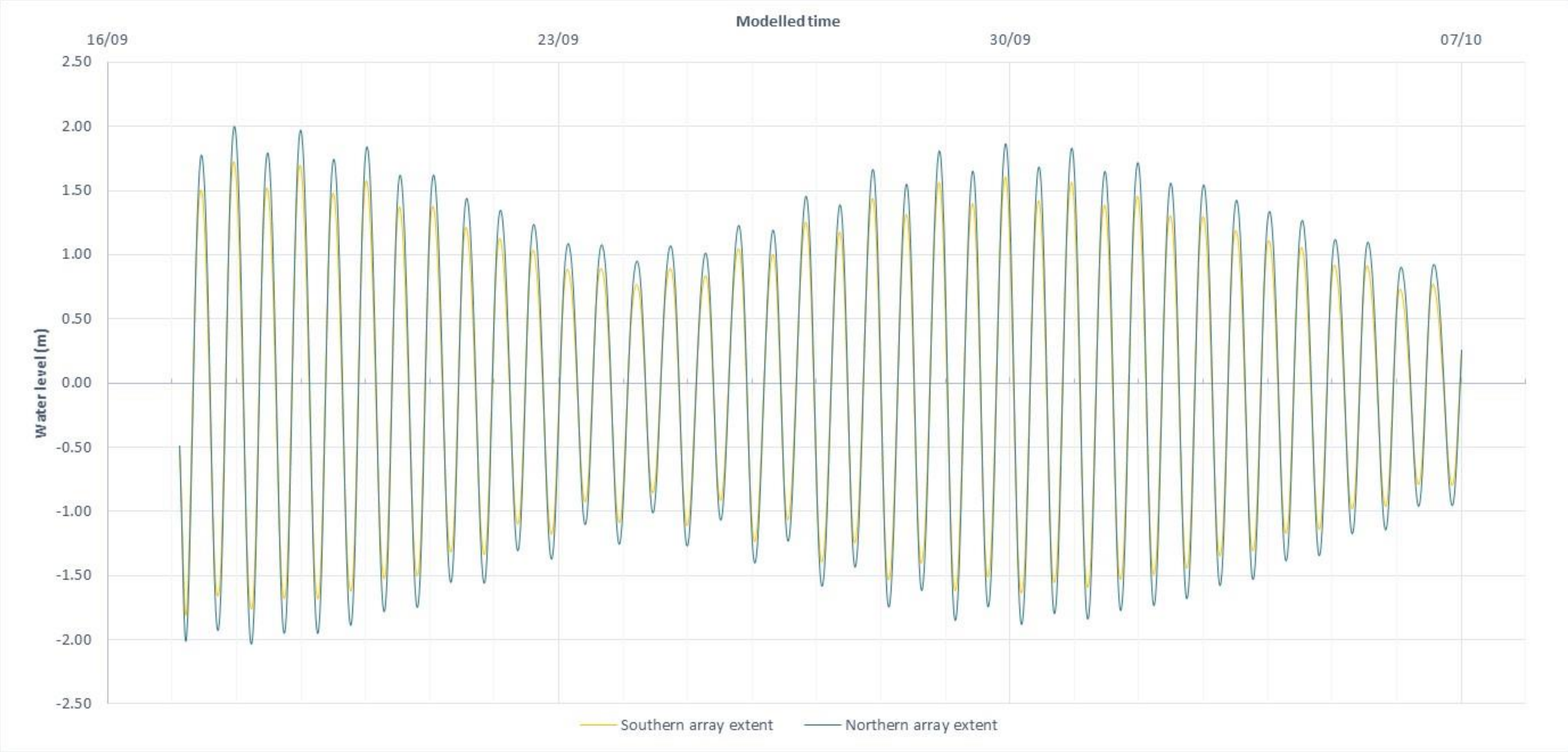


Figure 5 Modelled water levels within the array area (DAPPMS)

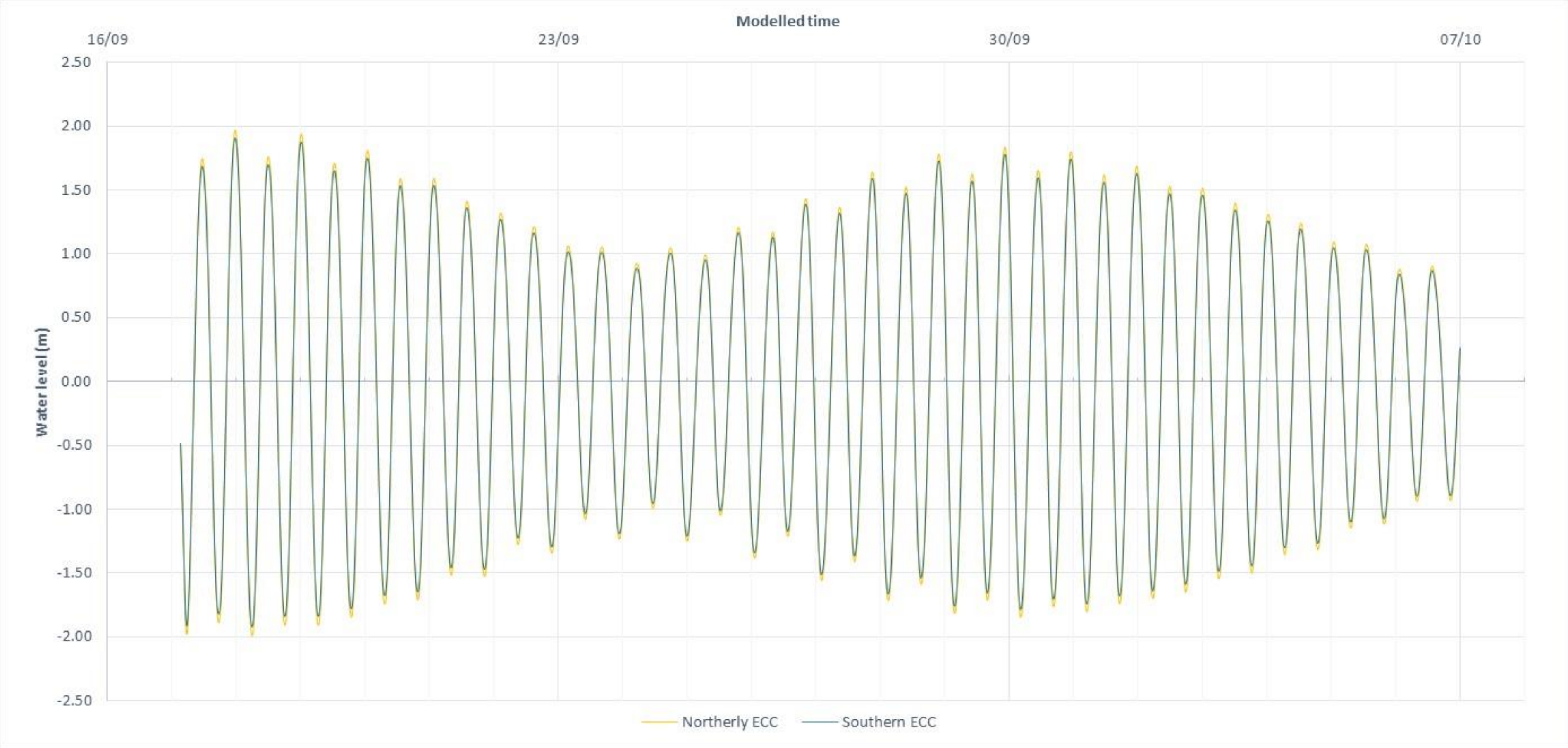


Figure 6 Modelled water levels within the offshore ECC (DAPPMS)

Tidal Currents

1.6.14 Strong currents and tidal flows are experienced around the Kish and Bray Banks (see Figure 7 to Figure 9). Wavebuoy data taken from the banks (Partrac, 2022) measured spring near-surface current velocities between 0.8 m/s and 1.0 m/s at the Kish Bank location, and between 1.2 m/s and 1.4 m/s at the Bray Bank location. The Kish and Bray Banks experience a southern flow direction during the ebb tide and a northern flow direction during the flood tide. Further details are presented in the Physical Processes Technical Baseline and in Figures A9 to A16 in the Physical Processes Modelling Report.

1.6.15 Tidal streams run parallel to the Irish coast, ebbing southwards (Admiralty, 1974). This is supported by the DAPPMS output (see Figure 7 and Figure 8). The currents within Dublin Bay are noticeably slower than in the rest of the ZoI and wider area (see Figure 7 to Figure 9). Typically, the current speeds are marginally higher during mid-ebb conditions than mid-flood within Dublin Bay and along the shoreline.

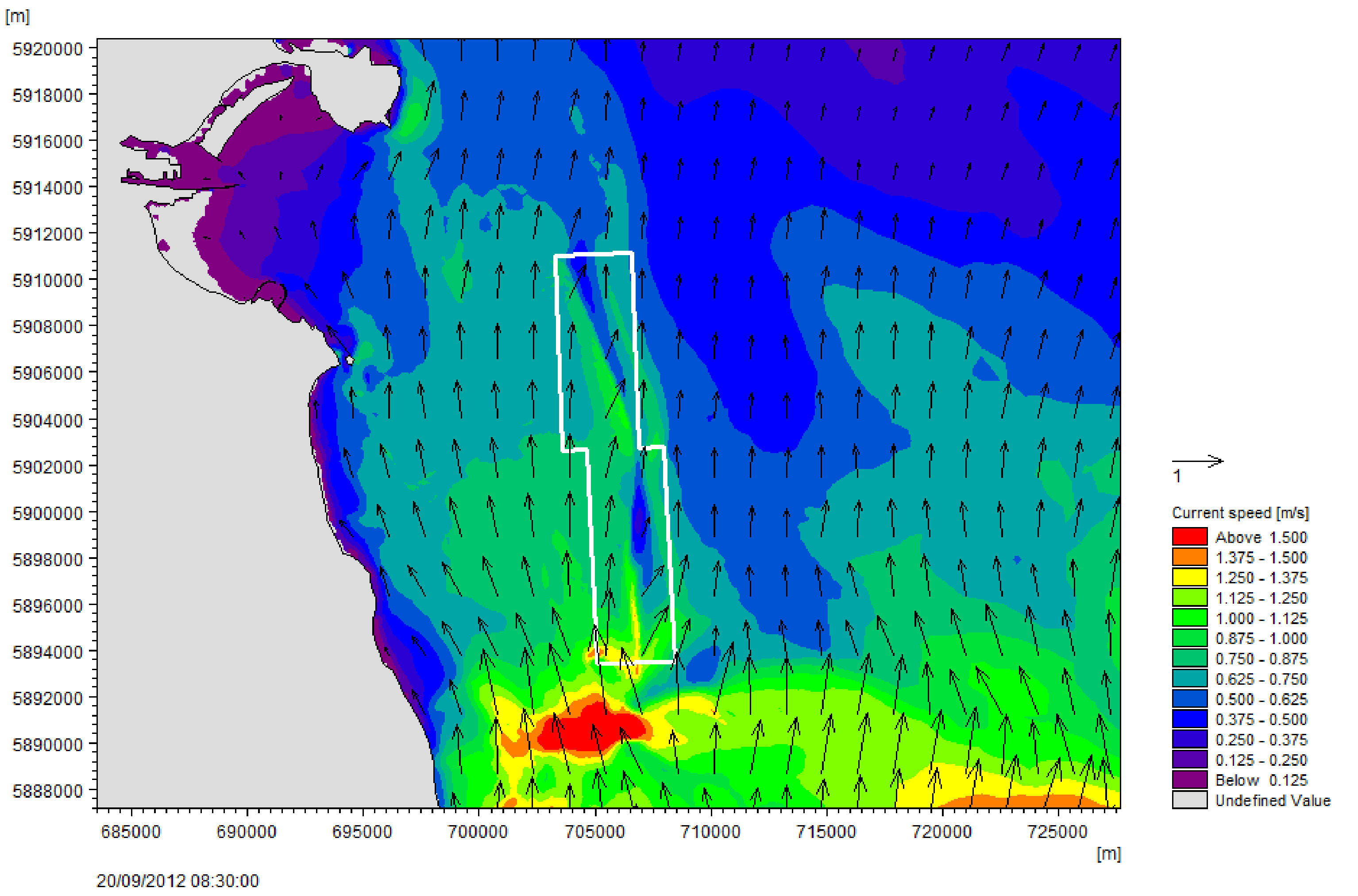


Figure 7 Mean spring tide current speeds at peak flood (DAPPMS)

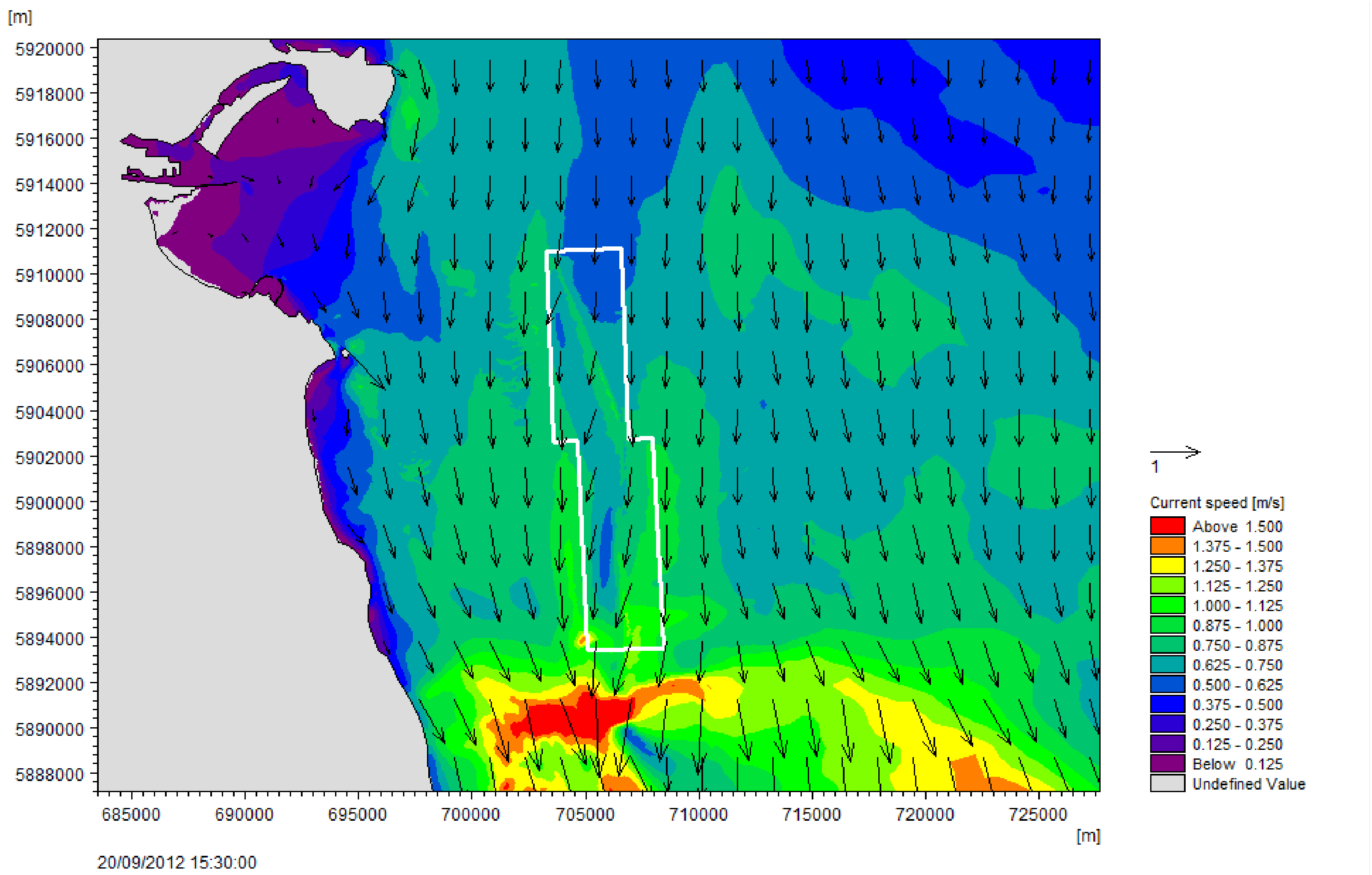


Figure 8 Mean spring tide current speeds at peak ebb (DAPPMS)

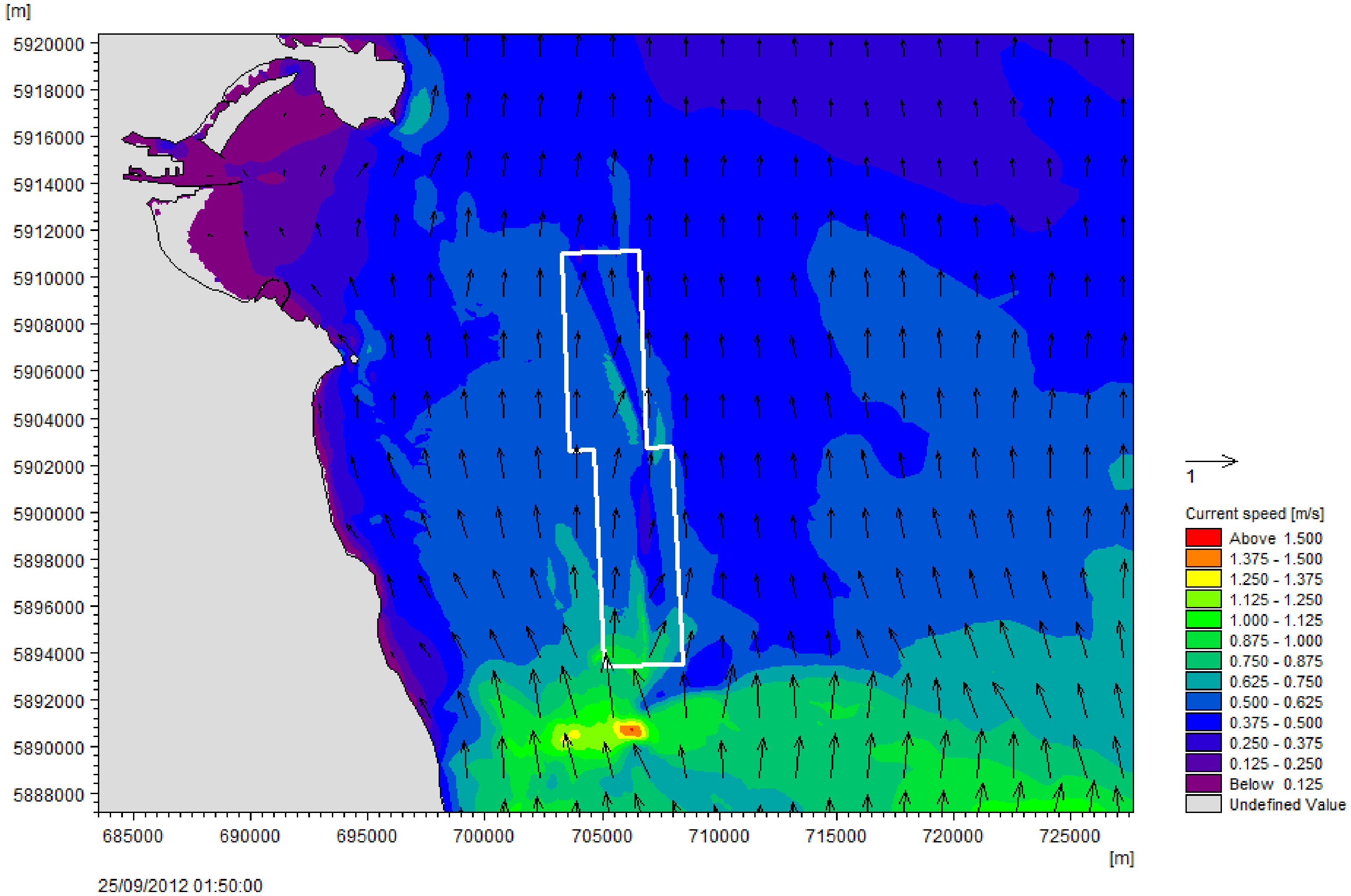
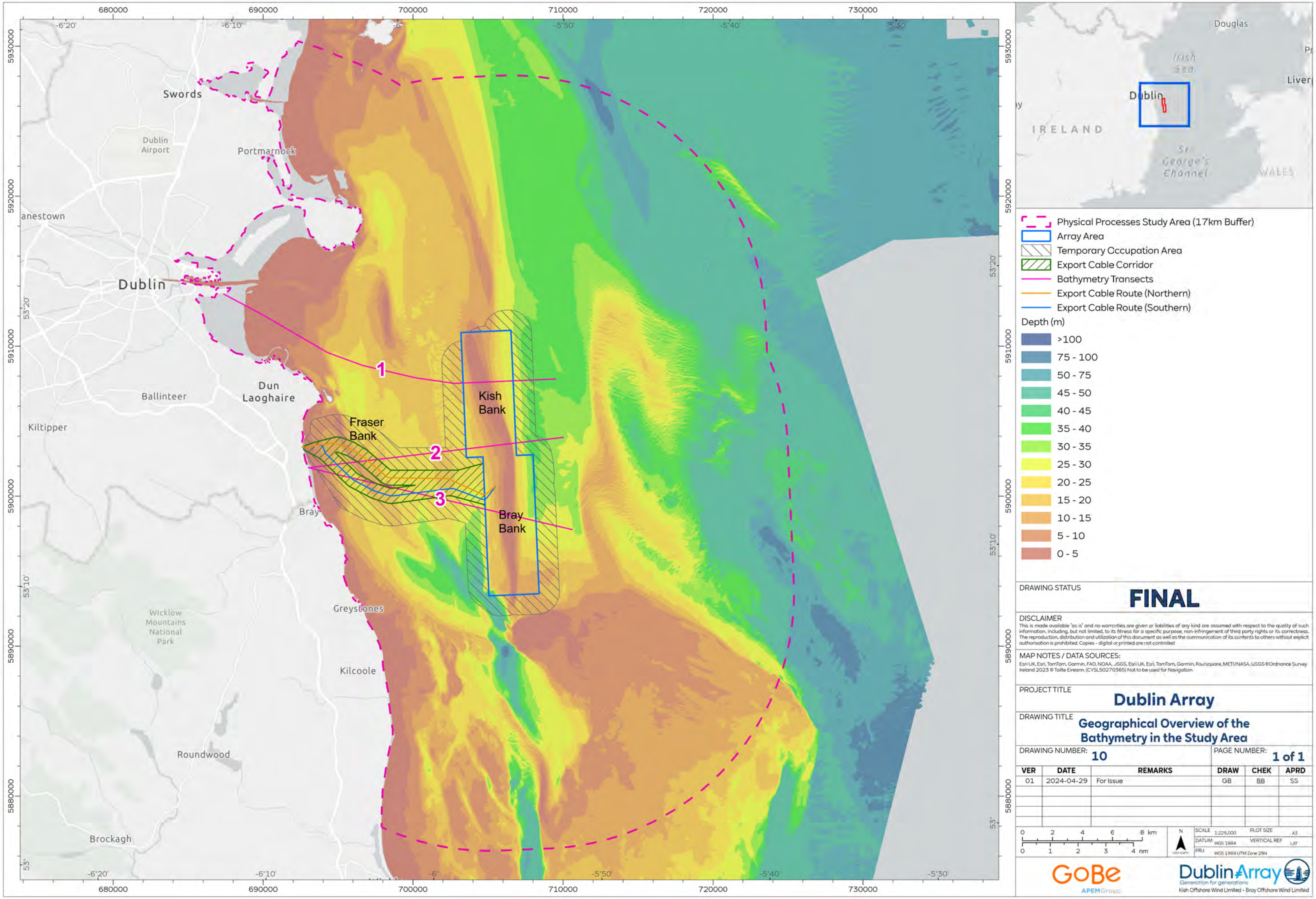


Figure 9 Mean neap tide current speeds at peak flood (DAPPMS)

Seabed bathymetry

1.6.16 The array area includes water depths ranging from 3.4 m to 64.3 m (Lowest Astronomical Tide (LAT) (Fugro, 2021b) and includes a bathymetric high in the form of the Kish and Bray Banks (Figure 13 below). The banks are distinct seabed features and are permanently submerged (Fugro, 2021a; Figure 11). The INFOMAR data confirms water depths on the Kish and Bray Banks vary between 2 m to 26 m (see Figure 10) and this is further confirmed by project specific surveys (Fugro, 2021c). However, the project specific surveys recorded deeper water to the eastern edge of the array area and to the southwest corner. The area of the banks shallower than 20 m (LAT) covers an area of approximately 35 km^2, of which approximately 10 km^2 is shallower than 10 m (LAT).

1.6.17 Water depths increase along the offshore ECC with distance from shore up until the Kish and Bray Banks. Water depths within the offshore ECC reach approximately 32 m (LAT) (Fugro, 2021d). This is illustrated in Figure 11 which presents the INFOMAR bathymetry data along transects (see Figure 10) within the offshore ECC and the array area, with the red dotted lines on the figures indicating the section of the transect within the array. Further illustration of the profile of the offshore ECC is provided in Figure 12, along both potential routes.



680000
690000
700000
710000
720000
730000
5930000
5920000
5910000
5900000
5890000
5880000
-6°20'
-6°10'
-6°
-5°50'
-5°40'
-5°30'
53°20'
53°10'
53°
Swords
Dublin Airport
Portmarnock
anestown
Dublin
Ballinteer
Dun Laoghaire
Kiltipper
Bray
Greystones
Wicklow Mountains National Park
Kilcoole
Roundwood
Brockagh
1
2
3
Kish Bank
Fraser Bank
Bray Bank
Douglas
Irish Sea
Dublin
IRELAND
St George's Channel
WALES
Physical Processes Study Area (17km Buffer)
Array Area
Temporary Occupation Area
Export Cable Corridor
Bathymetry Transects
Export Cable Route (Northern)
Export Cable Route (Southern)
Depth (m)
>100
75 - 100
50 - 75
45 - 50
40 - 45
35 - 40
30 - 35
25 - 30
20 - 25
15 - 20
10 - 15
5 - 10
0 - 5
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PROJECT TITLE
Dublin Array
DRAWING TITLE
Geographical Overview of the Bathymetry in the Study Area
DRAWING NUMBER: 10
PAGE NUMBER: 1 of 1
VER | DATE | REMARKS | DRAW | CHEK | APRD
01 | 2024-04-29 | For Issue | GB | BB | SS
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VERTICAL REF LAT
PRJ WGS 1984 UTM Zone 29N
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

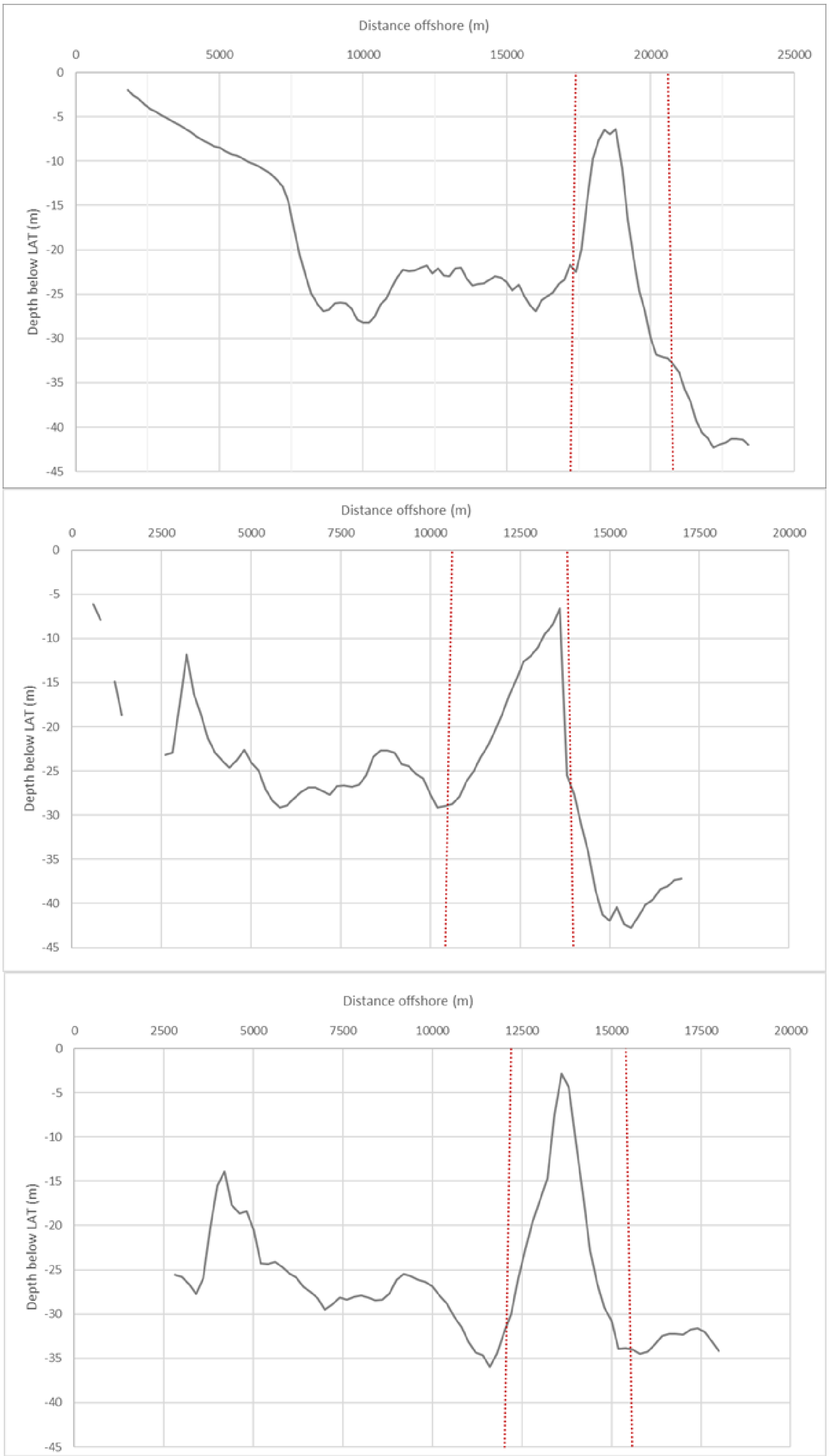


Figure 11 Transects of bathymetry within Dublin Array (Transect 1, 2 and 3 from west to east as shown on Figure 10), with red dotted lines indicating the section of the transect within the array (INFOMAR)

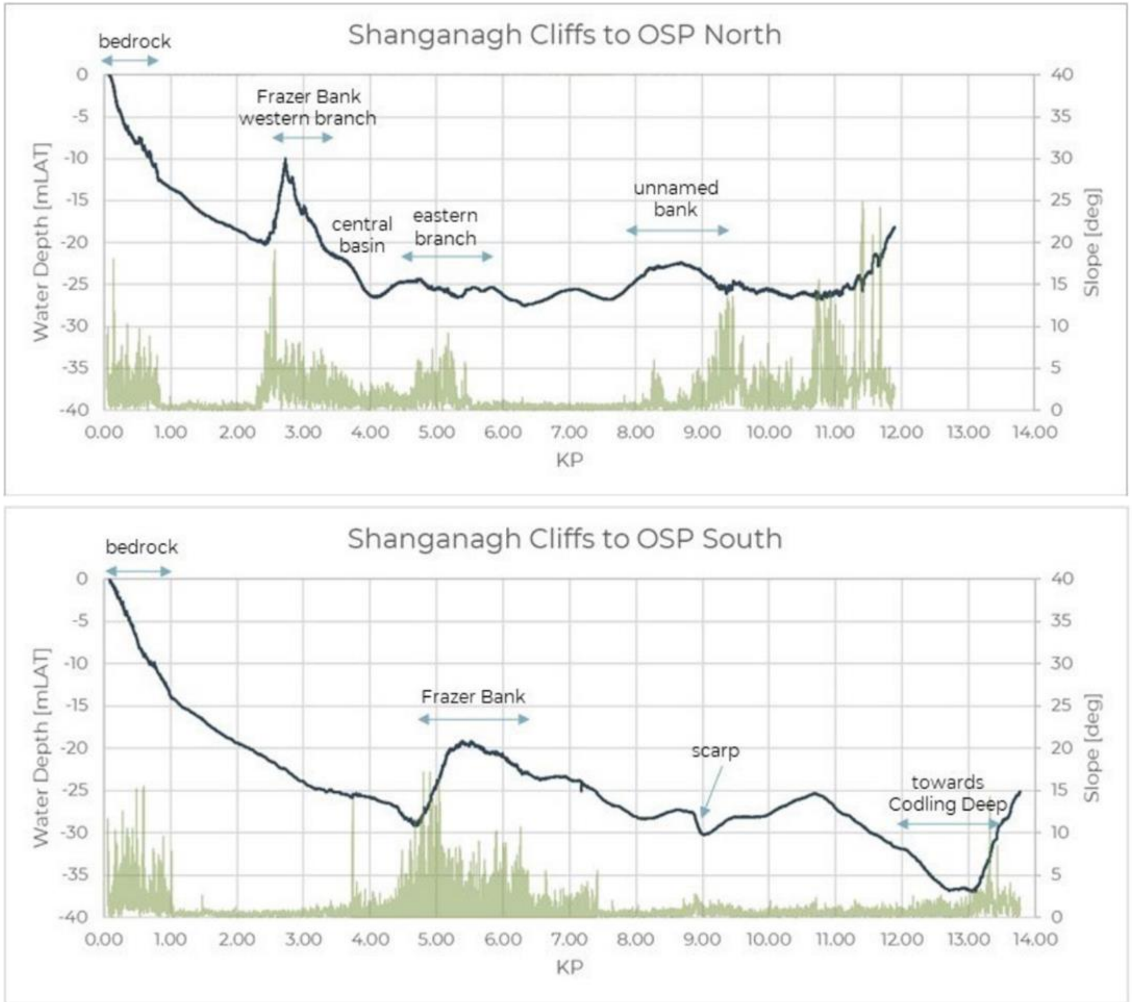


Figure 12 Transect of bathymetry along the offshore ECC routes (as shown on Figure 10, with KP referring to kilometre point along the respective routes)

Seabed geomorphology

1.6.18 The predominant large-scale seabed features within the study area are the Kish and Bray sandbanks. These sandbanks occur as part of a series of coast-parallel north to south trending offshore banks along the east coast of Ireland, which are defined by Kenyon and Cooper (2005) as "Open-Shelf Linear Banks". A lesser bank feature known as Fraser Bank is present in the southerly offshore ECC route, as indicated in Figure 13.

1.6.19 A detailed assessment of the seabed geomorphology and associated benthic habitats was undertaken as part of the project specific surveys (Fugro, 2021a; 2021b; 2021c). Further detail on the benthic habitats is provided in the Benthic Ecology Chapter. These surveys provide evidence to show that the Kish and Bray Banks demonstrate features which are consistent with the Annex I habitat 'Sandbanks which are slightly covered by sea water all the time'. This is due to the following observed characteristics:

- The feature is permanently submerged;
- Water depths are seldom greater than 20 m; and
- Seabed sediments are predominately composed of sand.

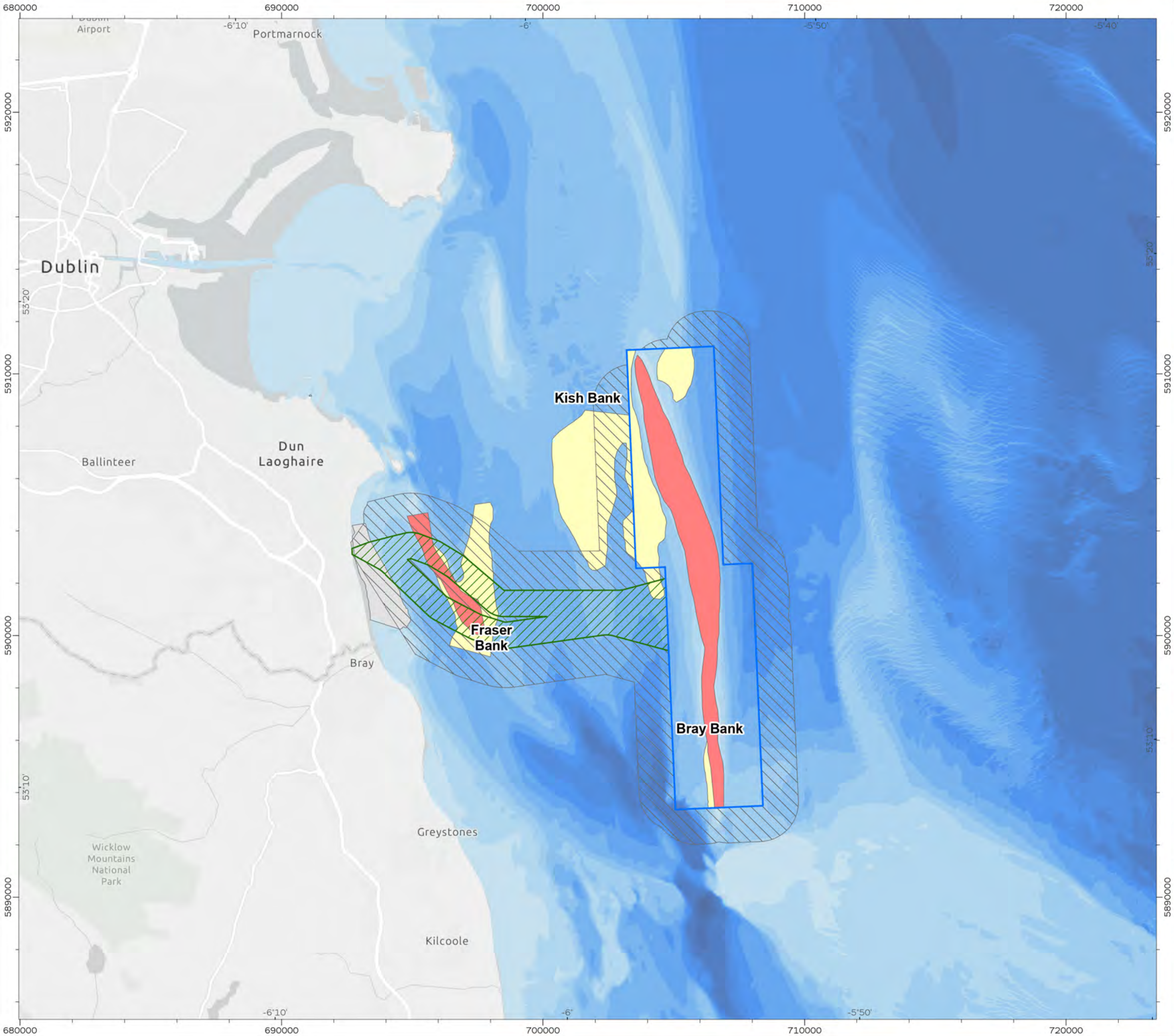
1.6.20 Although demonstrating features consistent with this Annex I habitat, the Kish and Bray Banks are not designated as a European site under the EC (Birds and Natural Habitat) Regulations 2011, as amended[16]. A complete assessment of potential impacts to these features as a result of Dublin Array offshore infrastructure is therefore provided in this EIAR, rather than within the NIS (Part 4: Habitats Directive Assessments, Volume 4: NIS).

1.6.21 In addition to the assessment of the Kish and Bray Banks (as an Annex I habitat) in this chapter from the perspective of physical processes, and the benthic chapter from the perspective of benthic biotope receptors, sandbanks are also appropriately considered across other ecological receptor assessments where relevant (e.g. within the Fish and Shellfish Ecology Chapter it is acknowledged that the sandbanks support a variety of demersal fish and elasmobranch species, and within Volume 4, Appendix 4.3.6-1: Ornithology Technical Baseline Report the potential association between some ornithological receptors and presence of shallow sandbanks is described). While sandbanks are not expressly referred to in those chapters (specifically in the context of being an Annex I habitat), they are considered substantively by reference to the link between the sandbanks and ecological receptor in question, and the biodiversity function the sandbank serves.

[16] Four European sites have been designated for the habitat type 'sandbanks which are slightly covered by seawater all of the time': Blackwater Bank SAC (002953); Hempton's Turbot Bank SAC (002999); Long Bank SAC (002161); and Lower River Shannon SAC (002165)

1.6.22 As presented in Figure 13, sandwaves[17] have been identified from survey data in the northern and southern extents of the array area and along the proposed ECC routes approximately 2.5 km offshore (associated with Fraser Bank). Analysis indicates that the surficial sediments on the banks are actively mobile and migrating in a clockwise direction, with bedforms migrating northwards on the western flank of the banks, and southwards on the eastern flank. Further details of the sediment transport regime are provided in the Physical Processes Technical Baseline.

[17] Sandwaves (sometimes known as flow-transverse bedforms) are large, ridge-like structures on the seabed resembling a water wave. Details of their formation is provided in the Physical Processes Technical Baseline.



Array Area
Temporary Occupation Area
Export Cable Corridor
Exposed Bedrock
Sediment Waves
Banks

Depth (m)

- >100
- 75 - 100
- 50 - 75
- 45 - 50
- 40 - 45
- 35 - 40
- 30 - 35
- 25 - 30
- 20 - 25
- 15 - 20
- 10 - 15
- 5 - 10
- 0 - 5

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Data Source: Bathymetry data from INFOMAR, Seabed features from GDG

PROJECT TITLE

Dublin Array

DRAWING TITLE

Dominant Seabed Features in the Proposed Development

DRAWING NUMBER: 13

PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

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0 0.8 1.5 2.3 3 nm

N
GRID NORTH

SCALE	1:150,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

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APEM Group

Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

Sediments and geology

Geology

1.6.23 The current seabed landscape is mainly a result of glacial advance and retreat resulting in the deposition of glacial and post-glacial sediments on top of primarily Palaeozoic sedimentary bed rock. The morphology and distribution of surficial sediments in the region has resulted largely from glacial deposition/scour processes combined with reworking and redeposition as a result of riverine input and tidal processes.

Seabed sediments

1.6.24 The array area is dominated by sand sized sediments (Figure 14). INFOMAR backscatter data suggests there are finer sand sediments on the bank crest with coarser sand on the flanks and to the south of the features. Sediment mapping, based on both sampling and sonar techniques indicate that the upper parts of the banks are composed of extensive thicknesses of sand-to-gravel sized material, with evidence of sediment fining towards the north of the bank.

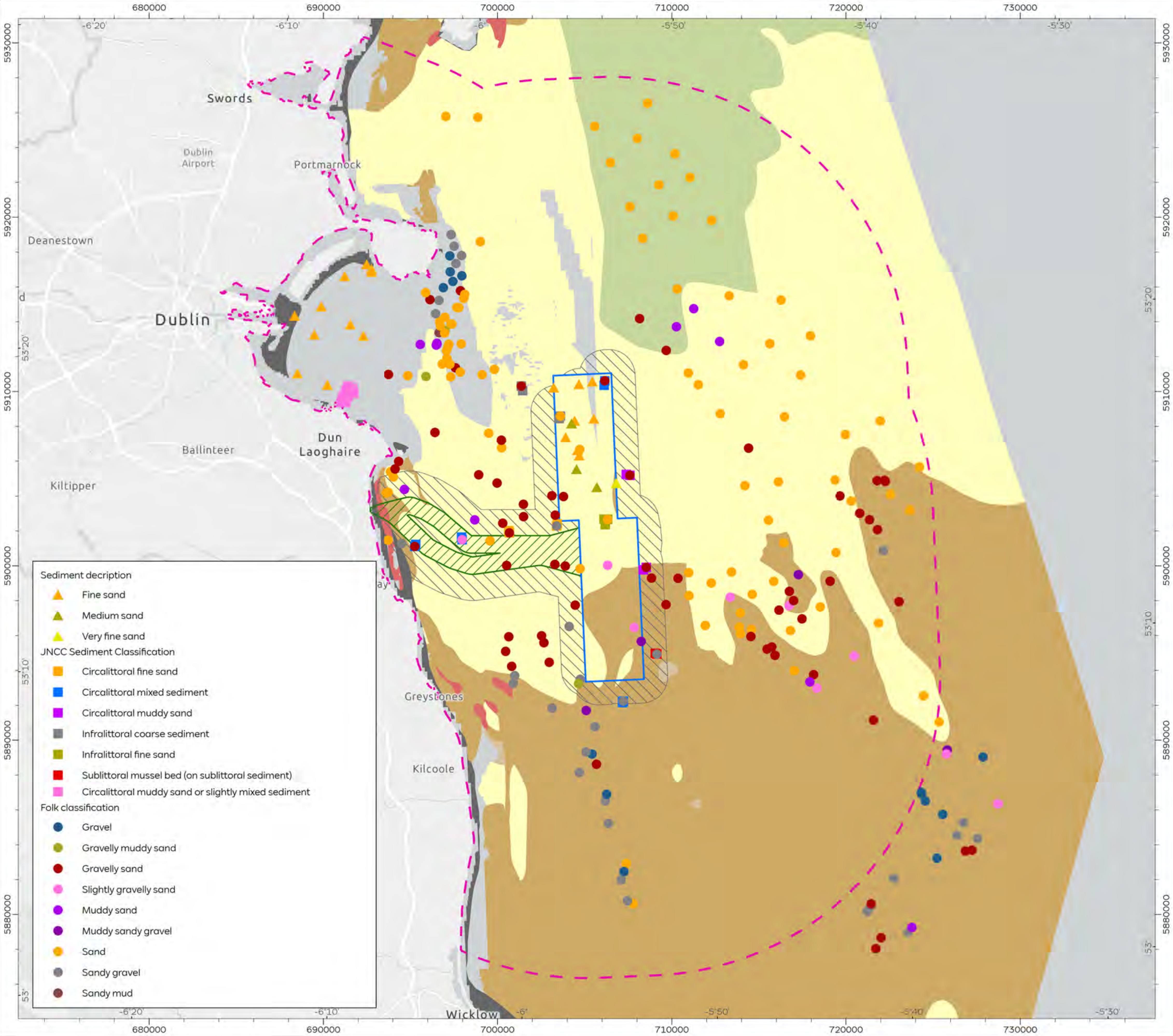
1.6.25 Project specific surveys have shown that the seabed sediments are homogeneous (Fugro, 2021a, with Particle Size Distribution (PSD) analysis indicating a predominately sandy sediment (Fugro, 2021b). Specifically, the sediment samples are classified as gravelly sand, sand and muddy sand, representing 43%, 43% and 14% of the 28 samples collected (Fugro, 2021b). The finer sediments are observed along the, proposed, the export cable route which was associated with the now obsolete Poolbeg ECC route and to the seaward extent of Fraser Bank, the location of which is shown on Figure 15.

1.6.26 As shown in Figure 14, there is generally good agreement between the regional sediment data (INFOMAR), and site specific grab samples collected (Fugro, 2021a and 2021b). Therefore, the regional data is considered to be representative and appropriate for the purposes of EIA characterisation within the array area.

1.6.27 Overall, net sediment transport characteristics reveal a clockwise circulation along the Kish and Bray Banks with a northwards trending residual flow on the west side and southwards trending residual flow on the east. Such pattern maintains the sandbanks integrity by retaining sediment within the circulation whilst resulting in a northerly transport of sediment, see the Physical Processes Technical Baseline for further details.

1.6.28 Regional sediment classification, as shown in Figure 14, indicates that the seabed within the offshore ECC has potential for rock exposure close to the coast, progressing to sandy mud/ muddy sand and mixed sediments further offshore.

1.6.29 Project specific intertidal surveys at the landfall location included Particle Size Analysis (PSA) for six stations, ranging from the upper to lower shore extents (Aquafact, 2021; location shown on Figure 15). Sand was the predominant surficial sediment present, with samples classified as sand, sandy gravel or slightly gravelly sand. Fines represented less than 0.2% at all stations.



Physical Processes Study Area (17km Buffer)
Array Area
Temporary Occupatioin Area
Export Cable Corridor
INFOMAR Seabed Substrate
Coarse sediment
Mixed sediment
Rock
Sand
Unclassified Substrate
Mud to muddy Sand

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Data Source: INFOMAR - Seabed Substrate

PROJECT TITLE
Dublin Array

DRAWING TITLE
Sediment Classification of the Array Area

DRAWING NUMBER: **14** PAGE NUMBER: **1 of 1**

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

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0 1 2 3 4 nm

SCALE	1:225,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

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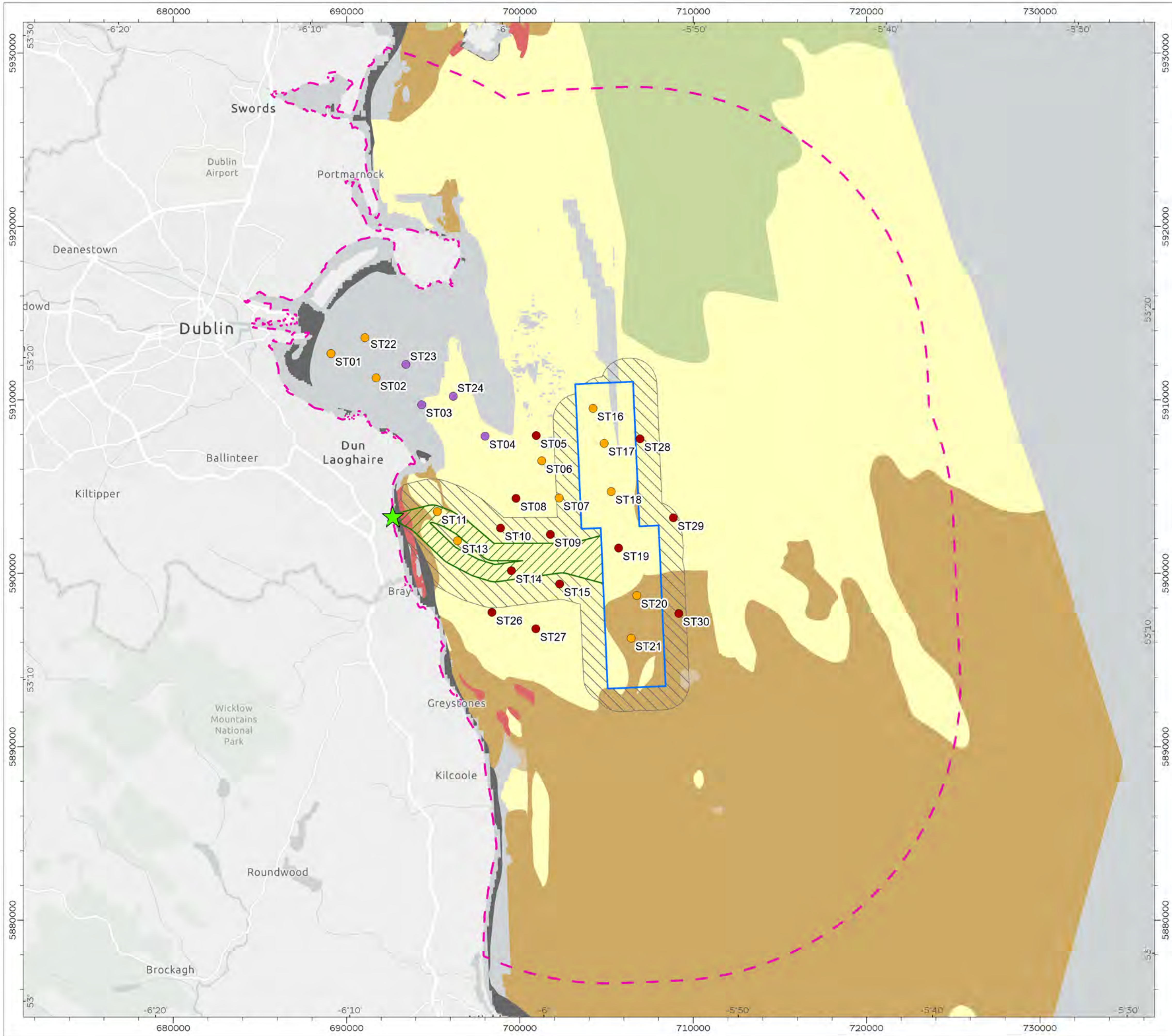

Physical Processes Study Area (17km Buffer)
Array Area
Temporary Occupation Area
Export Cable Corridor
Intertidal Survey Location

INFOMAR Seabed Substrate
- Coarse sediment
- Mixed sediment
- Rock
- Sand
- Unclassified Substrate
- Mud to muddy Sand

Folk Classification (Fugro, 2021)
- Sand
- Gravelly sand
- Muddy sand

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Data Source: INFOMAR - Seabed Substrate

PROJECT TITLE
Dublin Array

DRAWING TITLE
Seabed Sediment Classification Based on Project Specific and Regional (INFOMAR) Data

DRAWING NUMBER: 15
PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

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0 1 2 3 4 nm

N

SCALE	1:225,000	PLOT SIZE	A3
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

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Dublin Array
Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

Suspended solids

1.6.30 The spatially gridded, annual average of non-algal Suspended Particulate Matter (SPM) across the study area is presented in Figure 17 (Cefas, 2016). These data are based on information collected by satellite and the derived Ifremer OC5 algorithm (Gohin, 2011). The annual average surface SPM across the array area is approximately 5 mg/l (Figure 17). There is a general trend of decreasing SPM concentrations with distance offshore, with the highest concentrations recorded in the study area observed in Dublin Port. The data indicates that the highest monthly average concentrations, throughout the year, for the study area occur in December (see Figure 16 and Figure 18), increasing to approximately 7 mg/l to 8 mg/l. This is likely to be a result of higher storm frequency during the winter months.

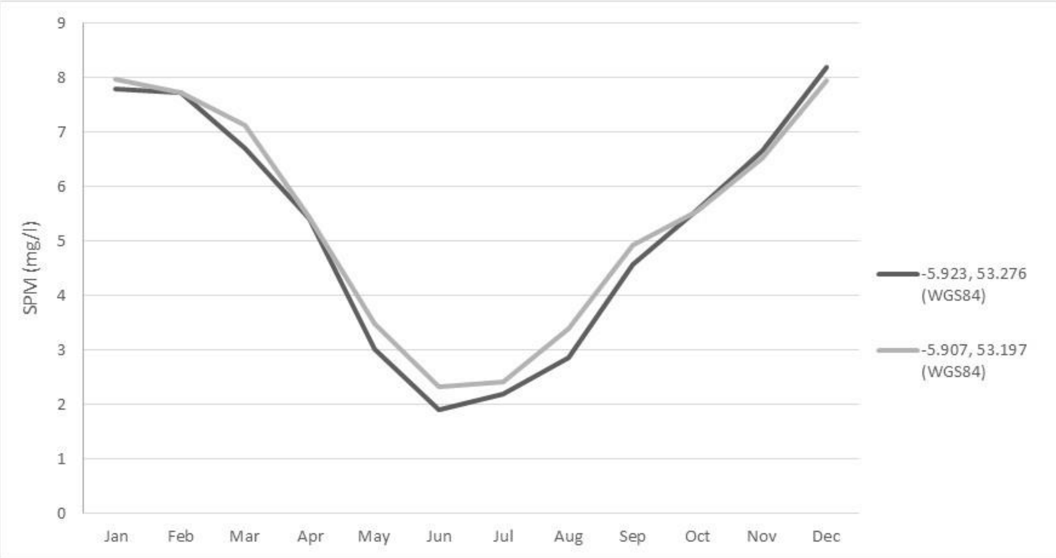
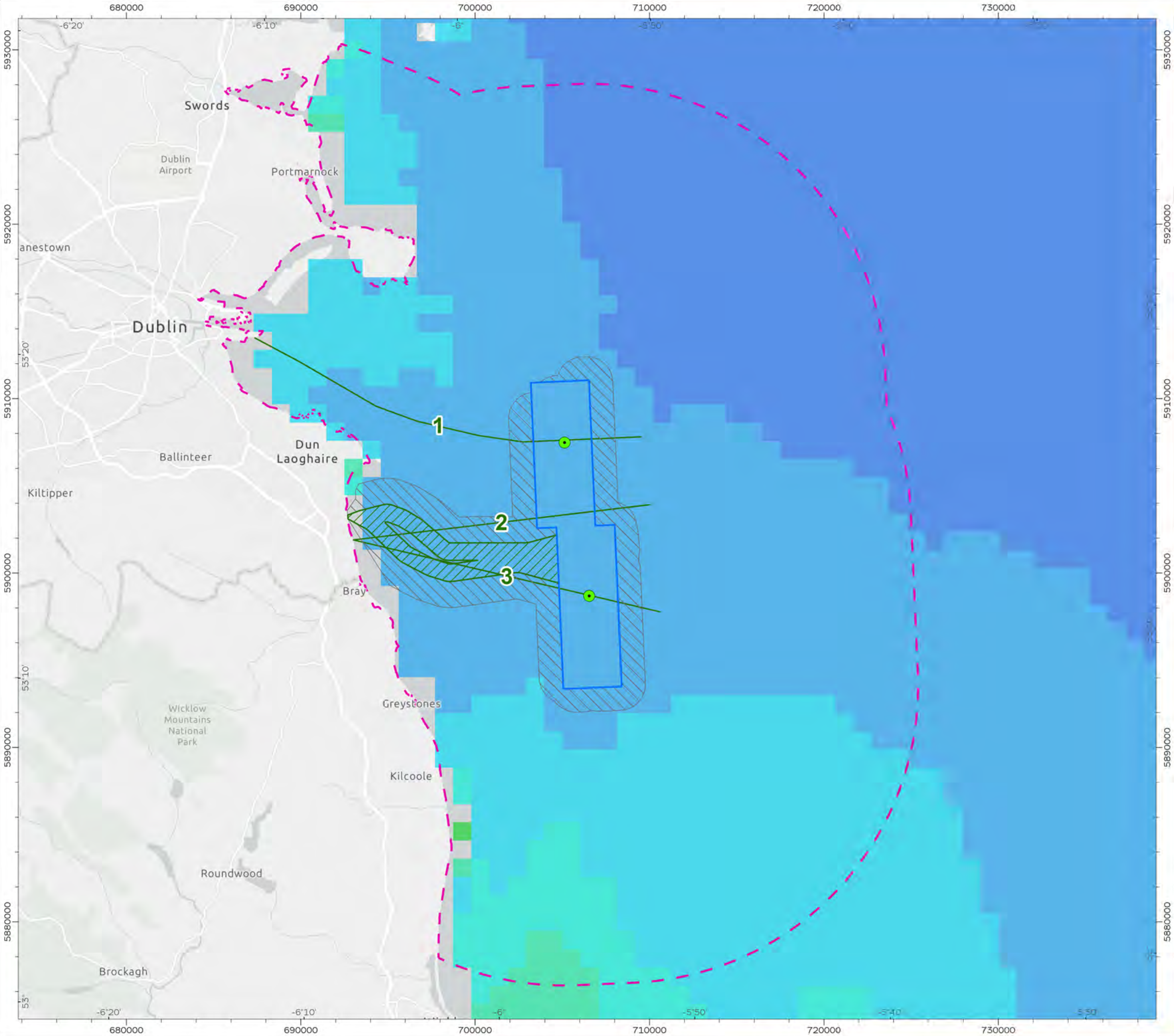


Figure 16 Monthly average Suspended Particulate Matter (SPM) in array (Cefas, 2016)



Physical Processes Study Area (17km Buffer)
Array Area
Temporary Occupation Area
Export Cable Corridor
Suspended Particular Matter Transects
Suspended Particular Matter Points

Suspended Particular Matter - Annual Mean (1998-2015) (CEFAS)

- 0.085 - 0.97
- 0.97 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- >16

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Data Source: Cefas: DOI: http://doi.org/10.14466/CefasDataHub.31

PROJECT TITLE
Dublin Array

DRAWING TITLE
Geographical Overview of Suspended Particulate Matter - Annual Mean (1998 - 2015)

DRAWING NUMBER: 17 | PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
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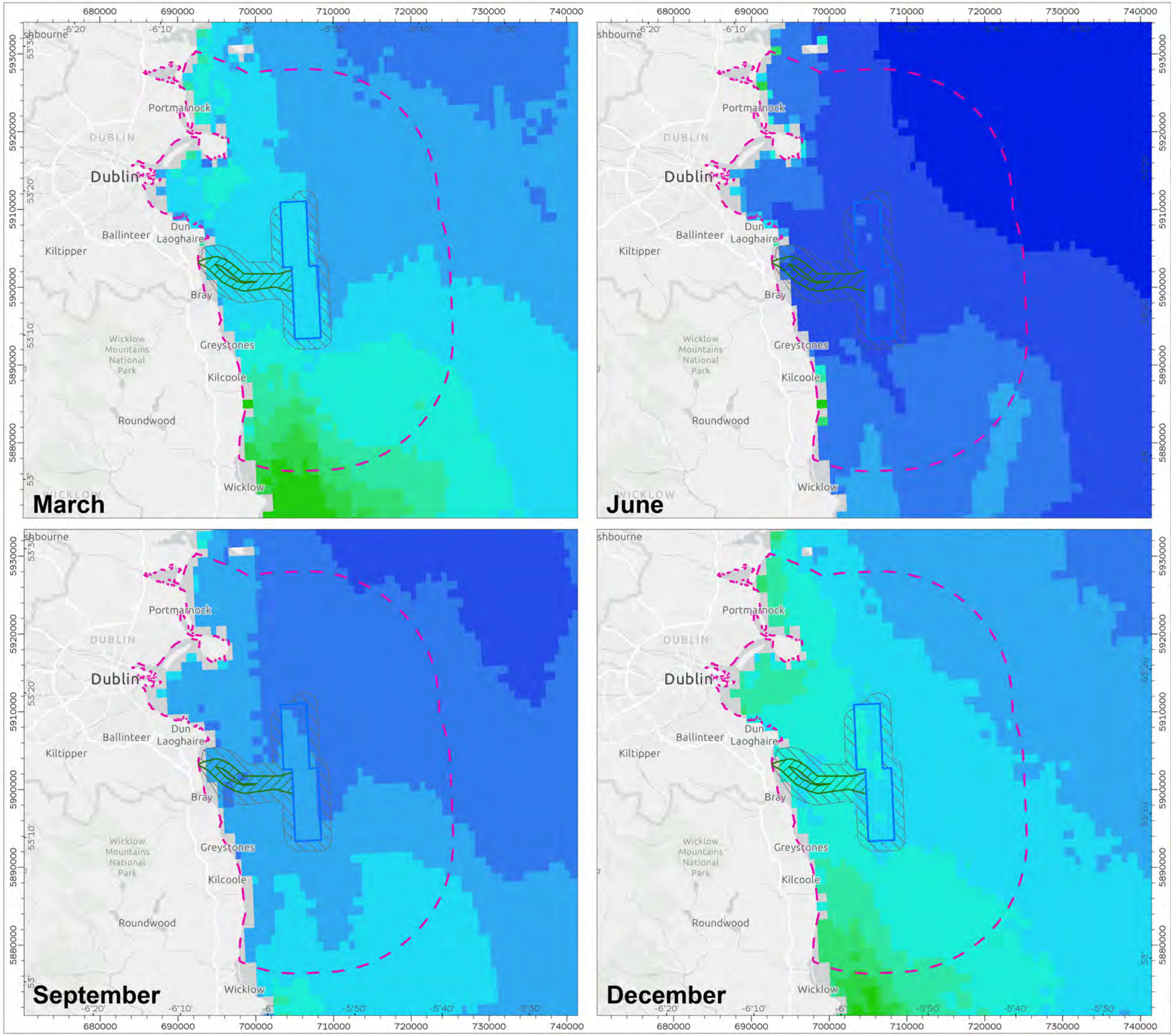
DATUM	WGS 1984	VERTICAL REF	LAT
PRJ	WGS 1984 UTM Zone 29N		

Kish Offshore Wind Limited - Bray Offshore Wind Limited



Physical Processes Study Area (17km Buffer)
Array Area
Temporary Occupation Area
Export Cable Corridor

Suspended Particulate Matter - Monthly Mean (1998-2015) (CEFAS)
- 0.085 - 0.97
- 0.97 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- >16

DRAWING STATUS
FINAL

DISCLAIMER

MAP NOTES / DATA SOURCES:
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Data Source: Cefas; DOI: http://doi.org/10.14466/CefasDataHub.31

PROJECT TITLE
Dublin Array

DRAWING TITLE
Geographical Overview of Suspended Particulate Matter - Monthly Means (1998 - 2015)

DRAWING NUMBER: 18
PAGE NUMBER: 1 of 1

VER	DATE	REMARKS	DRAW	CHEK	APRD
01	2024-04-29	For Issue	GB	BB	SS

0 4.5 9 13.5 18 km
0 2.5 5 7.5 10 nm
N GRID NORTH

SCALE 1:500,000 PLOT SIZE A3
DATUM WGS 1984 VERTICAL REF LAT
PRJ WGS 1984 UTM Zone 29N

GoBe APEM Group
Dublin Array Generation for generations
Kish Offshore Wind Limited - Bray Offshore Wind Limited

1.6.31 As presented above, there is a general trend of decreasing SPM concentrations with distance offshore, with the highest concentrations recorded in the study area observed in Dublin Port (see Figure 17 and Figure 18).

1.6.32 The Marine Institute monitor water quality at two locations in Dublin Bay, one location in the Liffey Estuary and one location in Broadmeadow Water. The mean turbidity at the sites is typically low in Dublin Bay (less than 20 Nephelometric Turbidity Units (NTU)[18]) and relatively high in Broadmeadow Water (83 NTU) (Marine Institute, 2020).

1.6.33 All sites demonstrated episodic events of elevated turbidity. There is typically good temporal agreement between all four sites when higher concentrations occur, which suggests that they are correlated to storm events. Figure 19 presents some of the highest recorded peaks of turbidity (in the order of 100s to 1000s of mg/l) in the datasets against measured wave heights (in Dublin Bay); this analysis shows that turbidity is elevated following larger wave heights, i.e. during storm events.

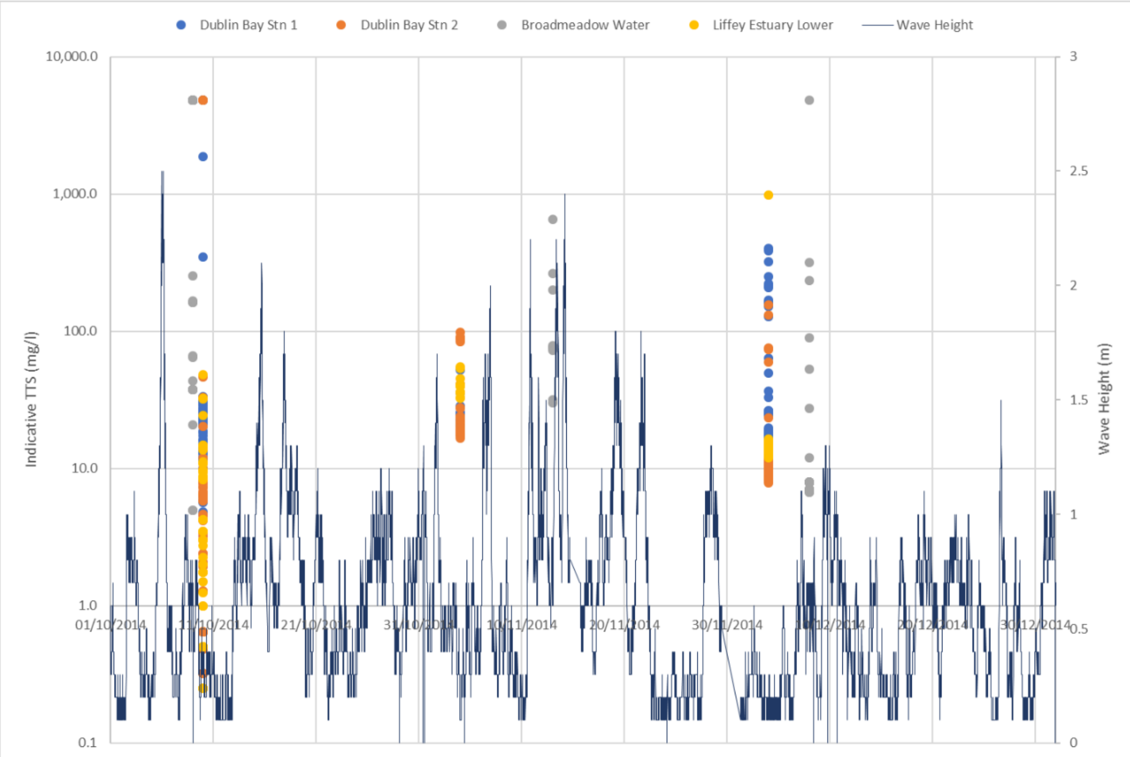

Figure 19 Turbidity monitoring data (Marine Institute) and wave heights (The Commissioners of Irish Lights – Dublin Bay buoy) (Q4 2014)

[18] Turbidity refers to the clarity of water caused by the presence of suspended particles. Nephelometric Turbidity Units (NTU) provide a measure of turbidity utilising light scattering. Suspended Particulate Matter (SPM) refers to the relative concentration of particles suspended within water, with Suspended Sediment Concentrations (SSC) referring to inorganic particles in suspension. Both SPM and SSC provide an indication of turbidity and are measured in mg/l.

Landfall

1.6.34 The eastern coast of Ireland is especially susceptible to coastal erosion owing to the presence of unconsolidated sediments (Dublin City Council, 2019). The eastern counties of County Dublin and Wicklow are susceptible to wave action, tidal and storm surges (Devoy, 2008) and they are predisposed to geomorphological changes from active erosion and deposition processes (Caloca-Casado, 2018) and flooding (OPW, 2010).

1.6.35 Shingle and gravelly shores are present in South Dublin and County Wicklow along with sandy beaches/sand-dune systems edged by low rocky cliffs (McConnell *et al.*, 1994*).* The Shanganagh coastline is typically characterised by heterogenous cliffs consisting of clay, gravel and diamict[19]. The landfall area is highly susceptible to coastal erosion, with storm events often undercutting the cliff features. Erosion along the coastline has been observed to result in exposed amenities, for example drainage pipes (Aquafact, 2021).

Figure 20 Cliff features at the proposed Shanganagh landfall (source: Aquafact, 2021)

1.6.36 A study undertaken by Caloca-Casado (2018) assessed aerial photography, satellite data and ground-truthed[20] the vegetation lines between 1952-2017. This study estimated that the annual coastal retreat rates between Shanganagh and Bray were 0.65 m/year. The study also sought to identify areas of vulnerability of coastal erosion due to future sea level rise. A moderate vulnerability for the Shanganagh landfall zone was predicted and was concluded as a potential 'hot spot' (i.e. particular sensitive areas to sea level rise and the associated implications of coastal erosion and flooding).

[19] Diamict is a terrigenous sediment (a sediment resulting from dry-land erosion) that is unsorted to poorly sorted and contains particles ranging in size from clay to boulders, suspended in a matrix of mud or sand.
[20] Ground-truthing assesses the accuracy of remotely sensed data by comparing it with physical measurements collected at ground level.

1.6.37 Studies have also been undertaken by Trinity College, Dublin to generate a digital elevation model of the Shanganagh cliffs to quantify the rate of retreat. Surveys were conducted annually between 2016 to 2018 to compare the cliff extent. The studies concluded that the rate of retreat exceeded the upper limits of previous studies (Bourke, 2019) and that rates of retreat were greater between 2017-18 than 2016-17. This suggests that areas especially vulnerable to coastal erosion are likely to be retreating at a faster rate than 0.65 m/ year.

1.6.38 Updated maps, published as part of the National Coastal Flood Hazard Mapping 2021 project, indicated that the coastline at the landfall area is vulnerable to flood events of one in 10-year return periods, resulting in depths of inundation between 1 m to 2 m (OPW, 2021).

1.7 Likely future receiving environment

1.7.1 The Physical Processes Technical Baseline provides a characterisation of the future receiving baseline. A summary of the key findings from that study has been incorporated into the description of the receiving environment below.

Sea level rise

1.7.2 Satellite observations indicate sea level rise around Ireland in the order of, approximately, 2 to 3 mm/year since the early 1990s (Cámaro García *et al.*, 2021; Noone *et al.*, 2023). Historically, tidal gauges, pre-1990, observed a slower rate of, approximately, 1 to 2 mm/year for Ireland's coastlines (EPA, 2017). An updated sea level dataset for Dublin Bay was presented by Shoari Nejad *et al.* (2022) which accounts for apparent biases arising from various instrument relocations and other changes. From this data, historic rates of sea level rise are estimated as 1.1 mm/year from 1953 to 2016, and 7 mm/year from 1997 to 2016. The increases in Mean Sea Level (MSL) will be a primary driver in magnifying the impacts of changing storm surge and wave patterns in coastal area (Desmond *et al.*, 2017), including the east coast of Ireland.

1.7.3 To account for the anticipated rise in sea level rise over the lifetime of the development the DAPPMS was configured to model the future baseline environment. This was based on the advice / projections presented in 'A summary of the State of Knowledge on Climate Change Impacts for Ireland' (EPA, 2017), which suggests a sea level rise of 0.55 m to 0.60 m by 2100 (which encompasses the lifespan of the development). These modelling runs have been primarily used to characterise the future receiving environment for sea level rise – see the Physical Processes Modelling Report for further details.

Waves and surge

1.7.4 Significant wave heights are projected to decrease around Ireland during the remainder of the next century, however, the future behaviour of extreme waves around Irish coasts is uncertain (Dabrowski *et al.*, 2023). This is principally related to changes in storminess in the North Atlantic sector, which remain highly uncertain (Seneviratne *et al.*, 2021; Noone *et al.*, 2023).

1.7.5 Lowe *et al.* (2009) projects an increase by ≤ 9 mm/ year (for a 20 to 30 year return period) storm surge event, which is approximately equivalent up to a 9 cm rise by 2100.

Coastal flooding

1.7.6 Coastal flooding occurs when high tides, surges and wave-overtopping combine to inundate coastal areas. Coastal erosion, which is intrinsically linked with coastal flooding, occurs when the sea progressively encroaches on to low lying coastal areas. As noted in the sections above, sea level rise, storm surge and wave heights are projected to increase throughout this century and are likely to exacerbate coastal flooding in future climate scenarios.

1.8 Do-nothing environment

1.8.1 Should Dublin Array not be constructed, the baseline environment is unlikely to show future natural variations outwith that presented in the previous section (taking into account the inherent uncertainty regarding characterisation and climate projections of the future baseline as presented in Paragraph 1.10.4).

1.9 Defining the sensitivity of the baseline

1.9.1 The sensitivity for the receptors for each potential effect, using the criteria outlined in Section 1.5, are presented in Section 1.14 to 1.16.

1.10 Uncertainties and technical difficulties encountered

1.10.1 Some aspects of the baseline are well understood, such as the underlying geology and tides. However, some data sources or assumptions are less well studied and/or quantified for the study area. This section seeks to identify areas of uncertainty and potential data gaps. Where possible, this assessment has been based on conservative assumptions, such as maximum design parameters and modelling scenarios, in order to add further precaution into its findings.

1.10.2 Grab sampling, while providing detailed information on the sediment types (and fauna) present, cannot cover wide swaths of the seabed and consequently represent point samples that must be interpreted in combination with the other appropriate datasets. As noted, several surveys undertaking grab samples have been conducted in the area which show good validation against the INFOMAR predictive substrate model. Therefore, the INFOMAR data are considered sufficient to characterise the study (and wider) area.

1.10.3 Available geophysical survey data does not cover the full extent of the offshore ECC as outlined in the Physical Processes Technical Baseline. However, the existing geophysical data gives good agreement with the regional bathymetry data provided by INFOMAR, and the overlap between the two data sources has been considered sufficient to characterise the study area.

1.10.4 Uncertainty exists with regards to characterisation of the future baseline (Palmer *et al.*, 2018). Key areas of uncertainty include the extent to which future changes in storminess may occur and the potential associated changes to the wave regime. There is also considerable uncertainty with regards to exactly how the coast may respond to a modified wave climate acting in combination with higher than present sea levels. These uncertainties have been addressed through a thorough literature review and the use of a precautionary assessment approach.

1.10.5 There is some uncertainty associated with the assessment of sediment plumes and accompanying changes to bed levels due to construction related activities. This arises due to uncertainty regarding how the seabed geology will respond to construction activities such as drilling and jetting. The exact volume of material entrained into the water column will be dependent upon a number of factors including the type of drilling/ cable installation equipment used, the mechanical properties of the geological units and the metocean conditions at the time of the works. In the absence of detailed installation and construction methodologies from the appointed contractor, a series of potential release scenarios have been considered. Together, these scenarios capture the worst-case impacts in terms of the highest concentration suspended sediment plumes, the most persistent suspended sediment plumes, the maximum changes in bed level elevation and the greatest spatial extent of change in bed level.

1.10.6 The modelled area is broken up into ‘cells’, allowing for governing equations to be solved for each discrete model cell. The DAPPMS was built using the MIKE21 Flexible Mesh (FM) modelling system, which utilises an unstructured mesh of irregular triangular elements, allowing the model resolution to vary throughout the domain, with the array area and cable routes having a resolution of, approximately, 100 m (further details on the model resolution are provided in the Physical Processes Modelling Report, the Hydrodynamic Calibration and Validation Report, and the Spectral Wave Calibration and Validation Report). Where activity occurs within one model cell, this process can be considered to occur at a sub-grid scale, and no meaningful interpretation for the size or concentration of the plume within the cell can be inferred. Therefore, where this has occurred, the analysis has been supplemented with information based on expert judgement and analogous projects to allow meaningful interpretation of the potential impacts.

1.10.7 The assessment of effects upon physical processes are considered to provide realistically likely results based on the information available, but it should be recognised that there is inherent uncertainty in morphological assessments of this type due to variability in the environmental conditions that might be experienced at a given time, and the actual interaction of processes and response of the environment to any potential change (Kroon *et al.,* 2017).

1.10.8 A full description of the uncertainties associated with the characterisation of the baseline for the purposes of this assessment is presented in the Physical Processes Technical Baseline.

1.10.9 However, despite the above uncertainties, it should be noted that there is robust data available on the sediment types present within the study area. The seabed in the area is well studied and surveyed, including but not limited to the redevelopment of Dublin Port within the study area. As such, the available evidence base is considered to be sufficiently robust to underpin the assessment presented here and an overall high confidence is placed on the assessment.

1.11 Scope of the assessment

Pathways

1.11.1 For the most part physical processes are not in themselves receptors per se but are instead 'pathways'. However, changes to physical processes have the potential to indirectly impact other environmental receptors (Lambkin et al., 2009). For instance, the creation of sediment plumes (which is considered in the physical processes assessment) may lead to the settling of material onto benthic habitats and thus the smothering of benthos. The potential significance of this particular change is assessed in the Benthic Ecology Chapter. This distinction between assessments of pathways and receptors is summarised in Table 5, for each of the potential impacts/ changes identified and considered within the assessment section.

1.11.2 Where pathways are identified which may indirectly impact other (non-physical processes receptors), then the magnitude of the impact will be determined in this assessment (Table 5). The associated sensitivity of the environmental receptors and consequently the significance of the effect will be defined in the relevant assessments within this EIAR.

Potential impacts

1.1.6 Whilst physical processes can largely be considered as pathways as described above, a number of receptors which may be sensitive to changes to physical processes have been identified within the study area. These principally include sand banks, sandwaves and the coastline. Therefore, the following impacts will be assessed and their significance in EIA terms will be determined:

- Construction (including pre-construction activities) (Section 1.12):
  - Impacts to sandbank and sandwave receptors; and
  - Impacts to coastlines.
- Operation and Maintenance (Section 1.13):
  - Scour of seabed sediments;
  - Impacts to sandbank and sandwave receptors; and
  - Impacts to coastlines.
- Decommissioning (Section 1.14):

- Impacts to sandbank and sandwave receptors; and
- Impacts to coastlines.

1.1.7 A consideration of the future baseline with the proposed development *in situ* is provided in Physical Processes Modelling Report, and has informed the assessment provided within this EIAR.

Table 5 Potential impacts/ changes identified considered within the physical processes assessment

Potential impact / change	Pathway / Impact
Construction (Section 1.12)	
Increases in Suspended Sediment Concentrations (SSC) and deposition of disturbed sediments to the seabed due to dredging for seabed preparation prior to foundation installation.	Pathway 1
Increases in SSC and deposition of disturbed sediments to the seabed due to the release of drill arisings during foundation installation.	Pathway 2
Increases in SSC and deposition of disturbed sediment to the seabed due to inter-array cable (IAC) installation.	Pathway 3
Increases in SSC and deposition of disturbed sediment to the seabed due to export cable installation.	Pathway 4
Increases in SSC and deposition of disturbed sediment to the seabed due to release of drilling mud.	Pathway 5
Increases in SSC and deposition of disturbed sediment to the seabed due to sandwave clearance.	Pathway 6
Sandwave crest level preparation resulting in a change to local hydrodynamic, wave and sediment transport processes.	Pathway 7
Impacts to sandbank and sandwave receptors from construction activities.	Impact 1
Impacts to coastal processes from construction activities.	Impact 2
Operation and Maintenance (Section 1.13)	
Changes to the tidal regime.	Pathway 8
Changes to the wave regime.	Pathway 9
Changes to sediment transport and sediment transport pathways.	Pathway 10
Increases in SSC and deposition of disturbed sediment to the seabed during O&M.	Pathway 11
Scour of seabed sediments.	Pathway 12
Impacts to sandbank and sandwave receptors during the O&M phase.	Impact 3
Impacts to coastal processes during the measures phase.	Impact 4
Decommissioning (Section 1.14)	
Increases in SSC and deposition of disturbed sediment to the seabed during decommissioning.	Pathway 13
Impacts to sandbank and sandwave receptors from decommissioning activities.	Impact 5
Impacts to coastal processes from decommissioning activities.	Impact 6

Potential impact / change	Pathway / Impact
Cumulative	
Cumulative temporary increases in SSC and seabed levels	Pathway 14
Cumulative changes to the wave and tidal regimes as a result of the operational presence of other offshore wind farms (OWFs).	Impact 7

Scoped out from further evaluation in this EIAR

Temporary Works

1.11.3 The use of jack-up vessels and anchors during the construction, O&M, and decommissioning phases is considered to be inconsequential to the receiving environment unlike those activities outlined in Table 5. This is primarily as their use will result in the suspension of very small sediment volumes close to the seabed, which will rapidly settle from suspension within the immediate area. Therefore, the use of jack-up vessels and anchors will not result in notable changes in Suspended Sediment Concentrations (SSC) and associated sediment deposition on physical processes receptors.

1.11.4 Similarly, although jack-up legs may result in seabed indentations, these features will be highly localised and short-term, with depressions expected to be subject to natural infill processes once the leg is removed. It is likely that any depressions would be infilled over timescales of months to years. Evidence available from post-construction scour monitoring undertaken at several established offshore windfarm sites in the UK demonstrates that the seabed recovers quickly from jack-up leg indentations in areas characterised by mobile sands, as is found within the array area (DECC, 2008). No likely significant effects are anticipated for the use of jack-up vessels and any further assessment has been scoped out of this EIAR for physical processes receptors.

1.11.5 No pathways on physical processes receptors which could result in significant effects in EIA terms have been identified for the pre-construction surveys. Therefore, these surveys have been scoped out for further consideration in this EIAR for physical processes receptors.

1.12 Key parameters for assessment

1.12.1 As set out in the Application for Opinion under Section 287B of the Planning and Development Act 2000, flexibility is being sought where details or groups of details may not be confirmed at the time of the Planning Application. In summary, and as subsequently set out in the ABP Opinion on Flexibility (detailed within Volume 2, Chapter 3: EIA Methodology) the flexibility being sought relates to those details or groups of details associated with the following components (in summary - see further detail in see Volume 2, Chapter 6: Project Description):

- WTG (model – dimensions and number);
- OSP (dimensions);
- Array layout;

- Foundation type (WTG and OSP; types and dimensions and scour protection techniques); and
- Offshore cables (IAC and ECC; length and layout).

1.12.2 To ensure a robust, coherent, and transparent assessment of the proposed Dublin Array project for which development consent is being sought under section 291 of the Planning Act, the Applicant has identified and defined a Maximum Design Option (MDO) and Alternative Design Option(s) (ADO) for each environmental topic/receptor. The MDO and ADO have been assessed in the EIAR to determine the full range and magnitude of effects, providing certainty that any option within the specified parameters will not give rise to environmental effects more significant than that which could occur from those associated with the MDO. The extent of significant effects is therefore defined and certain, notwithstanding that not all details of the proposed development are confirmed in the application.

1.12.3 The range of parameters relating to the infrastructure and technology design allow for a range of options in terms of construction methods and practices, which are fully assessed in the EIAR. These options are described in the project description and are detailed in the MDO and ADO tables within each offshore chapter of the EIAR. This ensures that all aspects of the proposed Dublin Array project are appropriately identified, described and comprehensively environmentally assessed.

1.12.4 In addition to the details or groups of details associated with the components listed above (where flexibility is being sought), the confirmed design details and the range of normal construction practises are also assessed within the EIAR (see Volume 2, Chapter 6: Project Description). Whilst flexibility is not being sought for these elements (for which plans and particulars are not required under the Planning Regulations), the relevant parameters are also incorporated into the MDO and alternative option(s) table herein (Table 6) to ensure that all elements of the project details are fully considered and assessed.

1.12.5 With respect to project design features where flexibility is not being sought, such as trenchless cable installation methodology at the landfall, the MDO and alternative design option(s) are the same (as there is no alternative). With respect to the range of normal construction practises that are intrinsic to installation of the development, such as the nature and extent of protection for offshore cables and the design of cable crossings, but which cannot be finally determined until after consent has been secured and detailed design is completed, the parameters relevant to the receptor being assessed are quantified, assigned and assessed as a maximum and alternative, as informed by the potential for impact upon that receptor. In the event of a favourable decision on the Planning Application they will be agreed prior to the commencement of the relevant part of the development by way of compliance with a standard 'matters of detail' planning condition (see Policy Chapter). Throughout, an explanation and justification is provided for the MDO and alternative(s) within the relevant tables, as it relates the details or groups of details where statutory design flexibility is being sought, and wider construction practises where flexibility is provided by way of planning compliance condition.

1.12.6 The assessment is supported by the use of DAPPMS, the full details of the design and environmental scenarios modelled are available in the Physical Processes Modelling Report which was based on an earlier design iteration. Not all scenarios modelled are consistent with the current MDO identified in Table 6 and assessed within this EIAR chapter, however, following a detailed assessment (Paragraph 1.12.7), the MDO will not give rise to an effect that is more significant than those of the modelled scenarios.

1.12.7 This is evidenced within a full comparison of the modelled scenarios and MDO presented in the Physical Processes Modelling and Design Options Comparison Report. This report demonstrates that the parameters used within the modelling scenarios are generally comparable to those that now represent the MDO, representing either an increase of less than 10% (for discrete scenarios), or a decrease. Increases of less than 10% are considered as generally comparable for discrete unit scenarios given the large scale of the receiving environment. Additionally, these scenarios represent conservative estimates of the works to take place, with many individual scenarios likely to be less in practice. Furthermore, since the model development, there have been no major changes to the large-scale hydrodynamic, sedimentological and morphological characteristics of the area, and this model is therefore considered to provide a realistic characterisation of the typical tidal and wave climate conditions at the site. In conclusion, the modelled scenarios, although in some cases precautionary in comparison to the MDO, nevertheless provide a suitable means of assessing the project for EIA purposes.

Table 6 Maximum and Alternative Design Options assessed

Maximum design option	Alternative design options	Justification
Construction		
Pathway 1: Increases in Suspended Sediment Concentrations (SSC) and deposition of disturbed sediments to the seabed due to dredging for seabed preparation prior to foundation installation.		
The maximum design option is set out below as it relates to Pathway 1. Where relevant, summary calculations are provided below, Annex B: Physical Processes Design Options Annex (hereafter referred to as the Physical Processes Design Options Annex) should be referred to for further detail on the parameters that inform the maximum design option. **Method for seabed preparation:** Trailer Suction Hopper Dredger (TSHD). **Maximum area of seabed affected:** - Option B: Up to 45 wind turbine generators (WTGs) on 4-legged suction bucket foundations x 100% of WTGs requiring seabed preparation x 5,184 m^2 per WTG = 233,280 m^2 for the WTGs; and - One Offshore Substation Platform (OSP) with jacket foundation x 100% of OSPs requiring seabed preparation x 5,625 m^2 per OSP = 5,625 m^2 for the OSP. **Total = 233,280 m^2 (WTGs) + 5,625 m2 (OSPs) = 238,905 m2.** **Maximum volume of disturbed sediment:** - Option B: Up to 45 WTGs x 3,888 m^3 per WTG (5,184 m^2 x 0.75 m depth) = **174,960 m^3 for the WTGs**; and - One OSP x 4,219 m^2 per OSP (5,625 m^2 x 0.75 m depth) = **4,219 m^3 for the OSP**. **Total = 174,960 m^3 (WTGs) + 4,219 m^3 (OSPs) = 179,179 m^3.**	Alternative options include the potential for fewer locations requiring seabed preparation. All seabed preparation operations of this type will take place using TSHD. Preparation for alternative foundation types and WTG options may also give rise to varying areas of seabed affected and volumes of sediment disturbed, all less than those which arise from the maximum design option. Details of the parameters that inform these alternative design options are provided in Table 33, Table 34, and Table 35 of the Physical Processes Design Options Annex. The alternative option which results in the smallest volume of fine sediment release into the water column is presented below. **Method for seabed preparation:** TSHD. **Area of seabed affected:** - Option A: Where 17 WTGs out of 50 WTGs on monopile foundations require seabed preparation x 484 m^2 per WTG = 8,228 m^2 for the WTGs; and - One OSP x 100% of OSPs requiring seabed preparation x 5,625 m2 per OSP = 5,625 m^2 for the OSP. **Total = 8,228 m^2 (WTGs) + 5,625 m^2 (OSPs) = 13,853 m^2.** **Volume of disturbed sediment**: - Option A: Where 17 WTGs out of 50 WTGs x 363 m^3 per WTG (484 m^2 x 0.75 m depth) = **6,171 m^3 for the WTGs**; and - One OSP x 4,219 m^2 per OSP (5,625 m^2 x 0.75 m depth) = **4,219 m^3 for the OSP**. **Total = 6,171 m^3 (WTGs) + 4,219 m^3 (OSPs) = 10,390 m^3.**	The maximum design option presented results in the largest seabed footprint and the greatest disturbed sediment volumes from the WTG and foundation options. It is derived from a combination of foundation type, size and number which requires the largest area of seabed to be cleared. This maximum design option leads to the greatest potential for impact associated with Pathway 1 and informs the subsequent detailed assessment. The alternative design options within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option. Table 33, Table 34, and Table 35 of the Physical Processes Design Options Annex provides a detailed breakdown of the parameters that inform the maximum and alternative design options.
Disposal: For the purposes of this assessment, the material is dredged by a TSHD into the vessels hopper and transported to a disposal area within the array area where the dredged contents are released. Disposal areas will be positioned in areas of similar sediment type, and in areas with high current speeds in order for dredged material to be redistributed into the sediment transport system.	**Disposal**: For the purposes of this assessment, the material is dredged by a TSHD into the vessels hopper and transported to a disposal area within the array area where the dredged contents are released. Disposal areas will be positioned in areas of similar sediment type, and in areas with high current speeds in order for dredged material to be redistributed into the sediment transport system.	

Maximum design option	Alternative design options	Justification
Pathway 2: Increases in SSC and deposition of disturbed sediments to the seabed due to the release of drill arisings during foundation installation.		
The maximum design option is set out below as it relates to Pathway 2. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option. **Foundation type**: - Option C: 39 WTGs with 4-legged jacket foundations (with drilling required at 100% of locations); and - Jacket pin-piles foundations for one OSP. **Maximum volume of drill arisings:** - **415,638 m^3** for the WTGs; and - **30,536 m^3** for the OSP. **Total = 415,638 m^3 (WTGs) + 30,536 m^3 (OSP) = 446,174 m^3**	Foundation installation using driven piles and vibro-piles will result in no release of drill arisings. This approach would not result in the creation of any SSC plumes and would therefore represent the minimum scale of effect, i.e. 0 m^3 of drill arisings. Alternative options include the potential for varying percentages (less than 100%) of foundation locations requiring drilling. Alternative foundation types and WTG options will give rise to varying volumes of drill arisings, all less than the maximum design option. Details of the parameters that inform these alternative design options are provided in the Physical Processes Design Options Annex. The alternative option which includes the use of foundation drilling, but otherwise results in the smallest volume of fine sediment release into the water column, is presented below. **Foundation type**: - Option A: 50 WTGs with 3-legged jacket foundations (with drilling required at one WTG location); - Monopile foundations for one OSP. **Volume of drill arisings:** - **5,453 m^3** for the WTG; and - **622 m^3** for the OSP. **Total = 5,453 m^3 (WTGs) + 622 m^3 (OSP) = 6,075 m^3** For all options where foundation drilling will take place, the volume of drill arisings will range between **6,075 m^3** to **446,174 m^3**.	The maximum design option presented results in the largest volume of fine sediments released into the water column from the WTG options. It is derived from a combination of foundation type, size and number which results in the highest volume of drill arisings. This maximum design option leads to the greatest potential for impact associated with Pathway 2 and informs the subsequent detailed assessment. The alternative design options within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option. Table 36 and Table 37 of the Physical Processes Design Options Annex provides a detailed breakdown of the parameters that inform the maximum and alternative design options.
Disposal: The drilling spoil will be released at, or above the water surface, which will put sediment into suspension prior to being deposited onto the seabed. The nature of this potential change will be determined by the rate and total volume of material to be drilled, the nature of the seabed/ underlying geology, the drilling method (affecting the texture and grain size distribution of the drill spoil) and metocean conditions at the time of works. An assessment of the material grain size is provided in the Physical Processes Modelling Report.	**Disposal**: For all options where foundation drilling will take place, the drilling spoil will be released at, or above the water surface, which will put sediment into suspension prior to being deposited onto the seabed. The nature of this potential change will be determined by the rate and total volume of material to be drilled, the nature of the seabed/ underlying geology, the drilling method (affecting the texture and grain size distribution of the drill spoil) and metocean conditions at the time of works. An assessment of the material grain size is provided in the Physical Processes Modelling Report.	
Pathway 3: Increases in SSC and deposition of disturbed sediment to the seabed, due to inter-array cable (IAC) installation.		
The maximum design option is set out below as it relates to Pathway 3. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option. The maximum design option has been identified as the use of a plough, with Mass Flow Excavator (MFE) used to backfill the trench once the cable is laid. The maximum total length of IAC has been identified as 120 km. Although the total length may be less than this, depending on final routeing options yet to be decided, the total value will not exceed 120 km.	Alternative options for cable installation involve the use of different cable installation methodologies, as described in Table 38 of the Physical Processes Design Options Annex. These include jet-trenching, rock cutting, and mechanical chain excavating in addition to ploughing and MFE methods (which are outlined within the maximum design option). The alternative option which results in the smallest volume of fine sediment release into the water column is presented below.	The maximum design option presented results in the greatest sediment disturbance from the cable installation options. It is derived from the installation method/equipment which will mobilise the greatest volume of sediment above the seabed. The maximum design option has been identified as the use of a plough, with MFE used to backfill the trench once the cable is laid. MFE is considered as the maximum design option as it will produce both a wide area of disturbance and also have the greatest potential to fluidise and suspend fine sediments. This maximum design option leads to the greatest potential for impact associated with Pathway 3 and informs the subsequent detailed assessment.
Method: Ploughing **Rate of cable installation:** Average rate 125 m/hr to maximum of 250 m/hr.	**Method:** Simultaneous Lay & Burial (Ploughing) **Rate of cable installation**: Average rate 125 m/hr to maximum of 250 m/hr.	

Maximum design option	Alternative design options	Justification
Assumptions: - V-shape trench; width = 12 m; depth = 3 m; - Controlled displacement of sediment onto the seabed, with approximately 15% of sediment ejected from trench (spill factor). Ploughing techniques involve the controlled displacement of sediment on the seabed (outlined further in Table 38 of the Physical Processes Design Options Annex). Fine sediments therefore have a much lower potential to be elevated into suspension than techniques such as MFE, although limited disturbance may still occur. In order to quantify this, a spill factor of 15% has been assumed, based on the surficial sediment characterisation across the site (Fugro, 2021b). **Maximum volume of sediment disturbed**: 12 m (trench width) x 3 m (trench depth) x 120 km (maximum total length of IAC) x 0.5 (V-shape) = **2,160,000 m^3.** **Backfill method**: MFE. **Rate of cable installation:** Average rate 100 m/hr to maximum of 180 m/hr. **Assumptions**: - Width of disturbance = 10 m; depth = 1 m; - Assume up to 100% of material is elevated above the seabed (spill factor); - Up to two backfill passes expected (for spoil mounds either side of the trenches). **Maximum volume of sediment disturbed:** 10 m (disturbance width) x 1 m (disturbance depth) x 120 km (maximum total length of IAC) x 2 (backfill for either side of trench) = **2,400,000 m^3.** **Total = 2,160,000 m^3 (ploughing) + 2,400,000 m^3 (backfill via MFE) = 4,560,000 m^3.**	**Assumptions:** - V-shaped trench; width = 1.5 m; depth = 3 m; - Controlled displacement of sediment on the seabed, effective spill factor 15%. Ploughing techniques involve the controlled displacement of sediment on the seabed (outlined further in Table 38 of the Physical Processes Design Options Annex). Fine sediments therefore have a much lower potential to be elevated into suspension than techniques such as MFE, although limited disturbance may still occur. In order to quantify this, a spill factor of 15% has been assumed, based on the surficial sediment characterisation across the site (Fugro, 2021b). **Volume of sediment disturbed**: 1.5 m (trench width) x 3 m (depth) x 120 km (length of IAC) x 0.15 (spill factor) = **81,000 m^3.** **Total = Total volume of sediment disturbance from all other cable installation options will therefore fall within the range of 81,000 m^3 to 4,560,000 m^3.**	The alternative design options within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option. Table 38 of the Physical Processes Design Options Annex provides a detailed comparison of cable installation methodologies, that inform the maximum and alternative design options. A V-shaped trench has been assumed for both cable installation methodologies based on the behaviour of cohesionless soils (such as sands) (Kraus and Carter, 2018). Trench walls will collapse and flow back into the trench, leading to a final trench shape characterised by sloping sides (Department for Business, Enterprise and Regulatory Reform (BERR), 2008). The use of MFE is considered here as a backfill methodology, rather than a cable installation methodology, and therefore a V-shape is not assumed. A conservative estimate of 1 m depth of disturbed sediment is provided for the use of MFE techniques for trench backfill. In reality, this will primarily be based on the scale of spoil berms left either side of the trench by the ploughing operations. This is likely to be less than 1 m, however this value is considered to provide an appropriate basis for assessment given the difficult in predicting the exact form of the spoil berms in situ. A conservative estimate of 100% has been provided for the spill factor, or percentage of material that is disturbed and brought into suspension by the operations, for MFE techniques. Areas and volumes of disturbed sediment have been calculated based on the assumption of 3 m burial depth (below the mobile sediment layer) in standard conditions. In some areas higher burial depths may be required, however, the assumption of these depths along the entire length of the cable is not considered to provide a realistic MDO. The volume of the disturbed material stated in this assessment will not be exceeded.
Pathway 4: Increases in SSC and deposition of disturbed sediment to the seabed, due to export cable installation.		
The maximum design option is set out below as it relates to Pathway 4. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option. **Method**: Ploughing **Rate of cable installation**: Average rate 125 m/hr to maximum of 250 m/hr **Assumptions**: - V-shape trench; width = 12 m; depth = 3 m; - Controlled displacement of sediment onto the seabed, with, effective spill factor 15%; - Up to two cables to be installed in separate trenches.	Alternative options for cable installation involve the use of different cable installation methodologies, as described in Table 38 of the Physical Processes Design Options Annex. These include ploughing, rock cutting, and mechanical chain excavating in addition to jet-trenching and MFE methods (which are outlined within the maximum design option). The alternative option which results in the smallest volume of fine sediment release into the water column is presented below. **Method**: Simultaneous Lay & Burial (Ploughing) **Rate of cable installation**: Average rate 125 m/hr to maximum of 250 m/hr. **Assumptions**: - V-shape trench; width = 1.5 m; depth = 3 m; - Controlled displacement of sediment onto the seabed, effective spill factor 15%; - Up to two cables to be installed in separate trenches.	The maximum design option presented results in the greatest sediment disturbance from the cable installation options. It is derived from the installation method/equipment which will mobilise the greatest volume of sediment above the seabed. The maximum design option has been identified as the use of a plough, with MFE used to backfill the trench once the cable is laid. MFE is considered as the maximum design option as it will produce both a wide area of disturbance and also have the greatest potential to fluidise and raise fine sediments into suspension. This maximum design option leads to the greatest potential for impact associated with Pathway 4 and informs the subsequent detailed assessment. The alternative design options within the range of parameters set out in the

Maximum design option	Alternative design options	Justification
Ploughing techniques involve the controlled displacement of sediment, rather than fluidisation (outlined further in Table 38 of the Physical Processes Design Options Annex). Fine sediments therefore have a much lower potential to be elevated into suspension, although limited disturbance may still occur. In order to quantify this, a spill factor of 15% has been assumed, based on the surficial sediment characterisation across the site (Fugro, 2021b). **Maximum volume of sediment disturbed**: 12 m (trench width) x 3 m (trench depth) x 18.35 km (maximum length of one cable) x 0.5 (V-shape) x 2 (# of cables) = **660,600 m^3.** __Backfill method__: MFE. **Rate of cable installation**: Average rate 100 m/hr to maximum of 180 m/hr. **Assumptions**: - Width of disturbance = 10 m; depth = 1 m; - Assume up to 100% of material elevated above the seabed (spill factor). - Up to two backfill passes expected (for spoil mounds either side of the trenches). **Maximum volume of sediment disturbed**: 10 m (disturbance width) x 1 m (disturbance depth) x 18.35 km (maximum length of one cable) x 2 (# of cables) x 2 (backfill for either side of trench) = **734,000 m^3.** **Total = 660,600 m^3 (ploughing) + 734,000 m^3 (backfill via MFE) = 1,394,600 m^3.**	Ploughing techniques involve the controlled displacement of sediment, rather than fluidisation (outlined further in Table 38 of the Physical Processes Design Options Annex). Fine sediments therefore have a much lower potential to be elevated into suspension, although limited disturbance may still occur. In order to quantify this, a spill factor of 15% has been assumed, based on the surficial sediment characterisation across the site (Fugro, 2021b). **Volume of sediment disturbed**: 1.5 m (trench width) x 3 m (trench depth) x 17.95 km (length of one cable) x 0.5 (V-shape) x 2 (# of cables) x 0.15 (spill factor) = **12,116 m^3.** **Total = The total volume of sediment disturbed from all design options will therefore range from 12,116 m^3 to 1,394,600 m^3.**	project description will not give rise to an effect which is more significant than the maximum design option. Table 38 of the Physical Processes Design Options Annex provides a detailed comparison of cable installation methodologies, that inform the maximum and alternative design options. A V-shaped trench has been assumed for both cable installation methodologies based on the behaviour of cohesionless soils (such as sands) (Kraus and Carter, 2018). Trench walls will collapse and flow back into the trench, leading to a final trench shape characterised by sloping sides (BERR, 2008). The use of MFE is considered here as a backfill methodology, rather than a cable installation methodology, and therefore a V-shape is not assumed. A conservative estimate of 1 m depth of disturbed sediment is provided for the use of MFE techniques for trench backfill. In reality, this will primarily be based on the scale of spoil berms left either side of the trench by the ploughing operations. This is likely to be less than 1 m, however this value is considered to provide an appropriate basis for assessment given the difficult in predicting the exact form of the spoil berms in situ. A conservative estimate of 100% has been provided for the spill factor, or percentage of material that is disturbed and brought into suspension by the operations, for MFE techniques. Areas and volumes of disturbed sediment have been calculated based on the assumption of 3 m burial depth in standard conditions. In some areas higher burial depths may be required, however, the assumption of these depths along the entire length of the cable is not considered to provide a realistic MDO. The volume of the disturbed material stated in this assessment will not be exceeded.
Pathway 5: Increases in SSC and deposition of disturbed sediment to the seabed due to release of drilling mud.		
The maximum design option is set out below as it relates to Pathway 5. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option. For the purposes of the assessment this is assumed to be an instantaneous release as this is the most conservative assumption for the purposes of the study/assessment model.	Alternative options are presented, involving the lowest volume of drilling fluid potentially discharged into the marine environment. No alternative options have been considered for the use of trenchless techniques, as this is considered the most appropriate option.	The maximum design option presented results in the largest volumes of drilling fluid potentially discharged into the marine environment from the use of trenchless techniques. This maximum design option leads to the greatest potential for impact associated with Pathway 5 and informs the subsequent detailed assessment. The alternative design options within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option. Table 39 of the Physical Processes Design Options Annex provides a detailed breakdown of the parameters that inform the maximum and alternative design options.
Use of drilling fluid (landfall) using trenchless techniques: - The drilling fluid is anticipated to be a low concentration bentonite/water mixture. - Drill head will stop short of punch out, flush bentonite, and complete the final 10 m in order to mitigate bentonite release on punch out. - Total mud losses on the seabed = <20 m^3.	**Use of drilling fluid using trenchless techniques:** - The drilling fluid is anticipated to be a low concentration bentonite/water mixture. - Drill head will stop short of punch out, flush bentonite, and complete the final 10 m in order to mitigate bentonite release on punch out. - Total mud losses on the seabed = <10 m^3.	

Maximum design option	Alternative design options	Justification
Total = total mud losses on the seabed = <20 m^3.	**Total = total volume of drilling mud released at the seabed from all design options will therefore range from <10 m^3 to 20 m^3.**	
Pathway 6: Increases in SSC and deposition of disturbed sediment to the seabed due to sandwave clearance.		
The maximum design option is set out below as it relates to Pathway 3. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option. The maximum total length of IAC has been identified as 120 km. Although the total length may be less than this, depending on final routeing options yet to be decided, the total value will not exceed 120 km.	Alternative options include the potential for lesser percentages of total cable lengths requiring sandwave clearance. All seabed preparation operations of this type will take place using TSHD. The alternative option which represents the lowest sediment volumes to be removed is presented below.	The maximum design option presented represents the maximum sediment volumes to be removed during sandwave levelling. This maximum design option leads to the greatest potential for impact associated with Pathways 6 and 7 and Impact 1, and informs the subsequent detailed assessments. The alternative design options within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option. TSHD is considered the worst case as it results in the disposal of the dredged material elsewhere within the array area. Areas and volumes of disturbed sediment have been calculated based on the assumption of 4 m removed from the sandwave crests. In some areas higher sandwaves may be present, requiring removal of up to 6 m. However, it was not considered to provide a realistic MDO to assume these clearance depths along the entire length of the cable. The volume of the disturbed material stated in this assessment will not be exceeded.
IAC (excluding Sandbank Crossing) **Method**: Dredging using TSHD to undertake sandwave clearance **Maximum area of seabed affected:** - Total length of IAC = 120 km, up to 50% requiring seabed preparation; - 60 km (50% of the total IAC length) x 40 m (maximum width of disturbance) = **2,400,000 m^2.** **Maximum volume of disturbed sediment:** - 2.4 km2 x 4 m depth = up to **9,600,000 m^3** (based on assumption of removal of 4 m from the sandwave crests)	**IAC (excluding Sandbank Crossing)** **Method**: Dredging using TSHD to undertake sandwave clearance. **Area of seabed affected:** - Total length of IAC = 120 km, up to 25% requiring seabed preparation; - 30 km (25% of the total IAC length) x 40 m (maximum width of disturbance) = **1,200,000 m^2.** **Volume of disturbed sediment:** - 1.2 km2 x 4 m depth = up to **4,800,000 m^3** (based on assumption of removal of 4 m from the sandwave crests)	
IAC: Sandbank Crossing **Method**: Dredging using TSHD to undertake sandwave clearance across the Kish and Bray sandbanks, in two locations with three cables at each site, to allow the IAC cables to cross the sandbank. **Maximum area of seabed affected:** 6 x 1,000 m crossings, 100% of which requiring seabed preparation; 1,000 m x 60 m (maximum width of disturbance) x 6 = **360,000 m^2.** **Maximum volume of disturbed sediment:** - Trench width at seabed = 60 m, and width at base = 20 m; with an average depth of 4 m the cross-sectional area = 160 m^2; - 6 x 1,000 m x 160 m2 = 960,000 m^3; - Potential additional dredging of 25% to take place due to natural backfill processes; - 960,000 m3 x 1.25 = **1,200,000 m^3**	**IAC: Sandbank Crossing** No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option. Area of seabed affected = **360,000 m^2;** and volume of disturbed sediment = **1,200,000 m^3**	
Export Cables **Method**: Dredging using TSHD to undertake sandwave clearance **Maximum area of seabed affected:** - Total length of export cable = 18.35 km x 2 = 36.7 km, up to 70% requiring seabed preparation; - 25,690 m (70% of 36.7 km) x 40 m (width of disturbance) = **1,027,600 m^2.**	**Export Cables** **Method**: Dredging using TSHD to undertake sandwave clearance **Area of seabed affected:** - Total length of export cable = 17.95 km x 2 = 35.9 km, up to 25% requiring seabed preparation; - 8,975 m (25% of 35.9 km) x 40 m (width of disturbance) = **359,000 m^2.**	

Maximum design option	Alternative design options	Justification
Maximum volume of disturbed sediment: - 1,027,600 m2 x 4 m depth = up to **4,110,400 m³** (removal of 4 m from the sandwave crests).	**Volume of disturbed sediment:** - 359,000 m2 x 4 m depth = up to **1,436,000 m³** (removal of 4 m from the sandwave crests)	
Total = total area of seabed affected will be 3,787,600 m². **Total = total volume of sediment disturbed will be 14,190,400 m³.**	**Total = total area of seabed affected from all design options will therefore range from 1,919,000 m² to 3,787,600 m².** **Total = total volume of sediment disturbed from all design options will therefore range from 7,436,000 m³ to 14,190,400 m³.**	
Disposal: The MDO methodology for the purposes of this assessment has been defined as TSHD. For general sandwave clearance operations, the material is extracted by the TSHD into the vessel hopper and transported to a disposal area within the lease area. The dredged material will then be released and will settle to the seabed. For the sandbank crossing, sediment will be stored temporarily alongside the trench and utilised as backfill to ensure the cable is closed after cable installation operations have taken place.	Disposal: The methodology for all alternative options is the use of TSHD. For general sandwave clearance operations, the material is extracted by the TSHD into the vessel hopper and transported to a disposal area within the array area. The dredged material will then be released and will settle to the seabed. For the sandbank crossing, sediment will be stored temporarily alongside the trench and utilised as backfill to ensure the cable is closed after cable installation operations have taken place.	
Pathway 7: Sandwave crest level preparation resulting in a change to local hydrodynamic, wave and sediment transport processes.		
As above. See Pathway 6: Increases in SSC and deposition of disturbed sediment to the seabed due to sandwave clearance.		
Impact 1: Impacts to sandbank receptors (due to construction activities).		
As above. See Pathway 6: Increases in SSC and deposition of disturbed sediment to the seabed due to sandwave clearance.		
Impact 2: Impacts to coastal processes (due to construction activities).		
The maximum design option is set out below as it relates to Impact 2. Where relevant, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option.		The maximum design scenario presented results in the greatest disturbance to the coastal environment from the use of trenchless techniques. This maximum design option leads to the greatest potential for impact associated with Impact 2 and informs the subsequent detailed assessment. The alternative design options within the parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option. Table 39 of the Physical Processes Design Options Annex provides a detailed breakdown of the parameters that inform the maximum and alternative design options.
Landfall methodology: Trenchless installation (via HDD or direct pipe tunnelling) beneath the beach, cliffs and intertidal area to be undertaken at Shanganagh. Excavation pits to be excavated and reinstated using back hoe dredge. Material will be stored to minimise loss of sediment as far as is reasonably practicable.	No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	
- Drilling punch-out location: Subtidal; - One per cable (2); - Excavation pits: Up to one per cable (2); - Maximum excavation pit dimensions: 30 m (long) x 5 m (wide) x 2.5 m (depth); - Estimated maximum excavated volume = 375 m3 x 2 (number of cables) = **750 m³;** - Maximum length of drill = 856 m; and - Installation period: 40 weeks subject to suitable weather conditions, inclusive of site mobilisation and demobilisation.		

Maximum design option	Alternative design options	Justification
Operation and Maintenance		
Pathway 8: Changes to the tidal regime		
Lifetime of the proposed development: 35 years (operating life) **Presence of foundations:** - Option B: 45 WTGs on 4-legged bucket foundations (with stiffeners); - One OSP on 4-legged multi-leg foundations; - **46 total structures** within the array area; - All WTGs assumed to be at the minimum spacing (1,000 m x 1,000 m); - OSPs will have a minimum separation distance from adjacent structures (500 m x 500 m). **Cable protection** Cable protection measures may be required, where the desired burial depth is not achieved. **IAC:** - Cable protection measures may be placed alone or in combination, and may be secured to the seabed if considered necessary and subject to license approval; - Length of cable requiring additional protection where optimum burial is not achieved = 24.6 km; - Total WTG and OSP approach protection (based on 100 m at each cable end) = 10 km (Option A: 50 WTGs) + 0.2 km (OSP) = 10.2 km; - Maximum footprint of cable protection = 34.8 km (total length requiring protection) x 6 m (width at base) = **208,800 m^2**; - Assumed isosceles trapezoid shaped rock berm, with height = 1 m, width at base = 6 m, and width at top = 1 m (cross-sectional area = 3.5 m^2); and - Maximum volume of cable protection = 34.8 km (length requiring protection) x 3.5 m^2 = **121,800 m^3**.	**Lifetime of the proposed development: 35 years** (operating life) **Presence of foundations:** - Option C: 39 WTGs on monopile foundations; - One OSP on 4-legged multi-leg foundations; - **40 total structures** within the array area; - All WTGs assumed to be at the minimum spacing (1,112 m x 1,112 m); - OSPs will have a minimum separation distance from adjacent structures (500 m x 500 m). **Cable protection** Alternative options include the potential for varying percentages of the cable routes to require cable protection, up to that assessed as the maximum design option. The alternative option which represents the minimum scale of effect is presented below. **IAC:** - Cable protection measures may be placed alone or in combination, and may be secured to the seabed if considered necessary and subject to license approval; - Total WTG and OSP approach protection (based on 100 m at each cable end) = 10 km (Option A: 50 WTGs) + 0.2 km (OSP) = 10.2 km; - Maximum footprint of cable protection = 10.2 km (total length requiring protection) x 6 m (width at base) = **61,200 m^2**; - Assumed isosceles trapezoid shaped rock berm, with height = 1 m, width at base = 6 m, and width at top = 1 m (cross-sectional area = 3.5 m^2); and - Maximum volume of cable protection = 10.2 km (length requiring protection) x 3.5 m^2 = **35,700 m^3**.	The maximum design option presented results in the greatest net blockage to waves and flows from the WTG options, cable protection and cable crossing design options, with the potential to impact on sediment transport processes and coastal and seabed receptors. This maximum design option leads to the greatest potential for impact associated with Pathways 8, 9, and 10, and Impacts 3 and 4, and informs the subsequent detailed assessment. The alternative design options within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option. Table 40, Table 41, Table 42, and Table 43 of the Physical Processes Design Options Annex provide a detailed breakdown of the parameters that inform the maximum and alternative design options. The maximum and alternative design options for the presence of foundations are based on a consideration of the vertical cross-section of each foundation, their solidity ratio and the spacing between structures. Of note is that the maximum design option presented here is different to that identified for the Physical Processes Numerical Modelling. The latter was based on Project design information at an earlier stage of the Project and is therefore not reflective of the current planned infrastructure. A comparison of the options is provided in Volume 4, Appendix 4.3.1-5: Physical Processes Modelling and Design Options Comparison Report (hereafter referred to as the Physical Processes Modelling and Design Options Comparison Report). The maximum design option will not give rise to an effect which is more significant than the modelled design option. The maximum design option accounts for the fact that a larger number of smaller turbines placed closer together will have a greater blockage effect upon flows than a smaller number of larger turbines placed further apart. The minimum spacing WTG layout has the higher potential capacity for interaction of wake type effects between adjacent foundations in comparison to the indicative WTG layout. The maximum design option also accounts for the maximum footprints and volumes of cable protection material, including cable crossings, as well as the largest areas and volumes of scour protection.
Export cables: - Cable protection measures may be placed alone or in combination and may be secured to the seabed where appropriate; - Up to 6 km per cable x 2 (# of cables) + 0.2 km (OSP) = 12.2 km; - Maximum footprint of cable protection = 12.2 km (length requiring protection) x 6 m (width at base) = **73,200 m^2**; - Assumed isosceles trapezoid shaped rock berm, with height = 1 m, width at base = 6 m, and width at top = 1 m (cross-sectional area = 3.5 m^2); and - Maximum volume of cable protection = 12.2 km (length requiring protection) x 3.5 m^2 = **42,700 m^3**.	**Export cables:** - Cable protection measures may be placed alone or in combination and may be secured to the seabed where appropriate; - Up to 0.8 km per cable x 2 (# of cables) = 1.6 km; - Maximum footprint of cable protection = 1.6 km (length requiring protection) x 6 m (width at base) = **9,600 m^2**; - Assumed isosceles trapezoid shaped rock berm, with height = 1 m, width at base = 6 m, and width at top = 1 m (cross-sectional area = 3.5 m^2); and - Maximum volume of cable protection = 1.6 km (length requiring protection) x 3.5 m^2 = **5,600 m^3**.	
Overall development: - Maximum footprint of cable protection = 208,800 m^2 + 73,200 m^2= **282,000 m^2**; and - Maximum volume of cable protection = 121,800 m^3 + 42,700 m^3 = **164,500 m^3.** **Total = total footprint of cable protection will be 282,000 m^2.**	**Overall development:** - Maximum footprint of cable protection = 61,200 m^2 + 9,600 m^2= **70,800 m^2**; and - Maximum volume of cable protection = 35,700 m^3 + 5,600 m^3 = **41,300 m^3**. **Total = total footprint of cable protection from all design options will therefore range from 70,800 m^2 to 282,000 m^2.**	
Total = total volume of cable protection will be 164,500 m^3.	**Total = total volume of cable protection from all design options will therefore range from 41,300 m^3 to 164,500 m^3.**	

Maximum design option	Alternative design options	Justification
Cable crossings The MDO considered cable crossings in addition to rock berms. **IACs:** - Assumes a maximum of two cable crossings of Dublin Array cables; - Assumed to be constructed of both concrete mattresses (six per crossing) and rock berm; - Total footprint of all IAC cable crossings = 2,400 m^2 (footprint of the berm) + 72 m2 (footprint of mattresses) x 2 (# of crossings) = **4,944 m^2**; and - Maximum volume of all IAC cable crossings = 1,400 m3 (volume of the berm) + 32.4 m^3 (volume of the mattresses) x 2 (# of crossings) = **2,865 m^3**. **Export cables:** - Assumes a maximum of 6 cable crossings for all of the export cable; - Maximum total footprint of all crossings = 2,400 m^2 (berm footprint) + 72 m^2 (mattress footprint) x 6 (# of crossings) = up to **14,832 m^2**; and - Maximum total volume of protection material of all crossings = 1,400 m^3 (berm volume) + 32.4 m^3 (mattress volume) x 6 (# of crossings) = up to **8,595 m^3**. **Overall development:** - Maximum footprint of all cable crossings = 4,944 m^2 + 14,832 m^2 = **19,776 m^2**; and - Maximum volume of protection material of all cable crossings = 2,865 m^3 + 8,595 m^3 = **11,460 m^3**. **Total = total footprint of cable crossings will be 19,776 m^2.** **Total = total volume of cable crossings will be 11,460 m^3.**	**Cable crossings** Alternative options for cable crossings include the use of alternative materials, namely that of concrete mattresses placed in isolation, rather than in addition to rock berms as in the maximum design option. **IACs:** - Assumes a maximum of two cable crossings of Dublin Array cables; - Assumed to be constructed of concrete mattresses (18 per crossing); - Total footprint of all IAC cable crossings = 324 m^2 (footprint of mattresses) x 2 (# of crossings) = **648 m^2**; and - Maximum volume of all IAC cable crossings = 97.2 m^3 (volume of the mattresses) x 2 (# of crossings) = **194 m^3.** **Export cables:** - Assumes a maximum of 6 cable crossings for all of the export cable; - Total footprint of all crossings = 324 m^2 (mattress footprint) x 6 (# of crossings) = up to **1,944 m^2**; and - Maximum total volume of protection material of all crossings = 97.2 m^3 (mattress volume) x 6 (# of crossings) = up to **583 m^3**. **Overall development:** - Maximum footprint of all cable crossings = 648 m^2 + 1,944 m^2 = **2,592 m^2**; and - Maximum volume of protection material of all cable crossings = 194.4 m^3 + 583.2 m^3 = **778 m^3**. **Total = total footprint of cable crossings from all design options will therefore range from 2,592 m^2 to 19,776 m^2.** **Total = total volume of cable crossings from all design options will therefore range from 778 m^3 to 11,460 m^3.**	(See previous page)
Foundation scour protection: The MDO for foundation scour protection is presented below. **WTGs:** - Maximum scour protection area for WTG foundations (Option A: 50 WTGs) with 4-legged multi-leg foundations with suction buckets) = **615,815 m^2**; and - Maximum scour protection volume for WTG foundations (Option B: 45 WTGs) with 3-legged multi-leg foundations with suction buckets) = **1,036,933 m^3**. **OSPs:** - Maximum scour protection area for the OSP foundation (jacket with suction bucket) = **11,310 m^2**; and - Maximum scour protection volume for the OSP foundation (jacket with suction bucket) = **16,965 m^3**. **Overall development:** - Maximum footprint of scour protection = 615,815 m^2 + 11,310 m^2 = **627,125 m^2**; and	**Foundation scour protection:** Alternative foundation types and WTG options will give rise to varying areas and volumes of scour protection, all less than the maximum design option. Details of the parameters that inform these alternative design options are provided in the Physical Processes Design Options Annex. The alternative option which results in the smallest area and volume of scour protection is presented below. **WTGs:** - Minimum scour protection area for WTG foundations (Option C: 39 WTGs) with monopile foundations): **89,319 m^2**; and - Minimum scour protection volume for WTG foundations (Option C: 39 WTGs) with monopile foundations) = **130,731 m^3**. **OSPs:** - Minimum scour protection area for the OSP foundation (monopile) = **1,810 m^2**; and - Minimum scour protection volume for the OSP foundation (monopile) = **2,570 m^3**. **Overall development:** - Maximum footprint of scour protection = 89,319 m^2 + 1,810 m^2 = **91,129 m^2**; and	

Maximum design option	Alternative design options	Justification
- Maximum volume of scour protection = 1,036,933 m^3 + 16,965 m^3 = **1,053,898 m^3**	- Maximum volume of scour protection = 130,731 m^3 + 2,570 m^3 = **133,301 m^3**.	
Total = total footprint of scour protection will be 627,125 m^2. **Total = total volume of scour protection from all design options will be 1,053,898 m^3.**	**Total = total footprint of scour protection from all design options will therefore range from 91,129 m^2 to 627,125 m^2.** **Total = total volume of scour protection from all design options will therefore range from 134,436 m^3 to 1,053,898 m^3.**	
Pathway 9: Changes to the wave regime		
As above. See Pathway 8: Changes to the tidal regime		
Pathway 10: Changes to sediment transport and sediment transport pathways		
As above. See Pathway 8: Changes to the tidal regime		
Impact 3: Impact to sandbank and sandwave receptors (due to wind farm operation).		
As above. See Pathway 8: Changes to the tidal regime		
Impact 4: Impacts to coastal feature receptors (due to wind farm operation)		
As above. See Pathway 8: Changes to the tidal regime		
Pathway 11: Increases in SSC and deposition of disturbed sediment to the seabed within the array area and offshore ECC		
The maximum design option is set out below as it relates to Pathway 11. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option. **Cable activities**: - Methodology: Jetting tools potentially followed by rock dumping and / or concrete mattress installation; - Remedial burial of cables: 10 km per event x 5 reburial events assumed over the project lifetime = 50 km; - For IAC repairs seabed disturbance will be 3,300 m x 10 m (trench width) = up to 33,000 m^2 per event. An estimated four events over the project lifetime = 33,000 m^2 x 4 = **132,000 m^2**; - For export cable repairs seabed disturbance will be 600 m x 10 m (trench width) = up to 6,000 m^2 per event. An estimated two events over the project lifetime = 6,000 m^2 x 2 = **12,000 m^2**; - Total area of seabed disturbance = 132,000 m^2 + 12,000 m^2 = **144,000 m^2;** - Total volume of sediment disturbed = 144,000 m^2 x 3 m (maximum trench depth) = **432,000 m^3.**	Alternative options for the use of maintenance activities involve the requirement for fewer maintenance events to be required over the lifetime of the Project. The alternative option which results in the lowest disturbance to the seabed is presented below. **Cable activities:** - Methodology: Jetting tools potentially followed by rock dumping and / or concrete mattress installation; - Remedial burial of cables: 10 km per event x 3 reburial events assumed over the project lifetime = 30 km; - For IAC repairs seabed disturbance will be 3,300 m x 10 m (trench width) = up to 33,000 m^2 per event. An estimated two events over the project lifetime = 33,000 m^2 x 2 = **66,000 m^2**; - For export cable repairs seabed disturbance will be 600 m x 10 m (trench width) = up to 6,000 m^2 per event. An estimated one event over the project lifetime = 6,000 m^2 x 1 = **6,000 m^2**; - Total area of seabed disturbance = 66,000 m^2 + 6,000 m^2 = **72,000 m^2;** - Total volume of sediment disturbed = 72,000 m^2 x 3 m (maximum trench depth) = **216,000 m^3.** **Total = total area of seabed disturbance from cable repair for all design options will therefore range from 72,000 m^2 to 144,000 m^2.** **Total = total volume of sediment disturbed from cable repair for all design options will therefore range from 216,000 m^2 to 432,000 m^2.**	The maximum design option presented results in the greatest disturbance to the seabed from O&M activities during the lifetime of the Project. This maximum design option leads to the greatest potential for impact associated with Pathway 11 and informs the subsequent detailed assessment. The alternative design options within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option. Precautionary assumptions have been made in terms of repair and maintenance requirements. Cables may become un-buried due to seabed mobility and require reburial. For other repairs, a length of cable is assumed to be pulled from a trench.
Pathway 12: Scour of seabed sediments.		
The maximum design option is set out below as it relates to Pathway 12. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option.	Alternative options include the use of different foundation types for the WTG layout options. These will result in different scour areas, with the minimum areas affected by scour occurring from the following:	The maximum design option presented results in the greatest potential for scour during the lifetime of the Project. This maximum design option leads to the greatest potential for impact

Maximum design option	Alternative design options	Justification
Presence of foundations: - Option B: Up to 45 WTGs on monopile foundations (diameter of up to 13 m); and - One OSP on 4-legged multi-leg foundations. - 46 total structures within the array area.	**Presence of foundations:** - Option A: 50 WTGs with 3-leg multi-leg foundations with pin-piles (pile diameter of up to 4.75 m); and - One OSP on monopile foundations. - 51 total structures within the array area.	associated with Pathway 12 and informs the subsequent detailed assessment. The alternative design options within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option. Table 44, Table 45, and Table 46 of the Physical Processes Design Options Annex provides a detailed breakdown of the parameters that inform the maximum and alternative design options.
Decommissioning		
Pathway 13: Increases in SSC and deposition of disturbed sediment to the seabed within the array area and the offshore ECC.		
The maximum design option is set out below as it relates to Pathway 13. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option. .- Removal of structures is expected to be undertaken as an approximate reverse of the installation process; - It is anticipated that piled foundations will be cut at a level just below the seabed; - Buried cables to be cut and left in situ (but to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time of decommissioning); - Scour and cable protection left in situ; and - Decommissioning activities lasting approximately three years for both onshore and offshore works. **Removal of foundations:** - Option A: 50 WTGs; and - One OSP. - **51 total structures within the array area.**	Decommissioning activities are expected to be the same for all design options. Alternative design options are represented by varying numbers of total structures within the array area (represented by different WTG options), as shown below. **Removal of foundations:** - Option C: 39 WTGs; and - One OSP. - **40 total structures within the array area.** **Presence of foundations:** - Option B: 45 WTGs; and - One OSP. - **46 total structures within the array area.** The total number of structures within the array area will therefore consist of either **40**, **46**, or **51** structures. No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	The maximum design option presented results in the greatest potential seabed disturbance from the WTG options. When removing foundations, the greatest disturbance will be associated with the layout containing the greatest number of structures. Given that foundations will be cut below the seabed, this will result in the greatest number of structures remaining after decommissioning. This maximum design option leads to the greatest potential for impact associated with Impact 5 and informs the subsequent detailed assessment. The alternative design option within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option.
Impact 5: Impacts to sandbank and sandwave receptors from decommissioning activities.		
The maximum design option is set out below as it relates to Impact 5. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option.	Decommissioning activities are expected to be the same for all design options. Alternative design options are represented by varying numbers of total structures within the array area (represented by different WTG options), as shown below.	The maximum design option presented results in the greatest potential seabed disturbance from the WTG options. When removing foundations, the greatest disturbance will be associated with

Maximum design option	Alternative design options	Justification
.- Removal of structures is expected to be undertaken as an approximate reverse of the installation process; - It is anticipated that piled foundations will be cut at a level just below the seabed; - Buried cables to be cut and cable protection left in situ (but to be determined in consultation with key stakeholders as part of the decommissioning plan and following best practice at the time of decommissioning); - Scour protection left in situ; and - Decommissioning activities lasting approximately three years for both onshore and offshore works. **Removal of foundations:** - Option A: 50 WTGs; and - One OSP. - **51 total structures within the array area.**	Decommissioning activities are expected to be the same for all design options. **Removal of foundations:** - Option C: 39 WTGs; and - One OSP. - **40 total structures within the array area.** **Removal of foundations:** - Option B: 45 WTGs; and - One OSP. - **46 total structures within the array area.** The total number of structures within the array area will therefore consist of either **40**, **46**, or **51** structures. No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	the layout containing the greatest number of structures. Given that foundations will be cut below the seabed, this will result in the greatest number of structures remaining after decommissioning. This maximum design option leads to the greatest potential for impact associated with Impact 5 and informs the subsequent detailed assessment. The alternative design option within the range of parameters set out in the project description will not give rise to an effect which is more significant than the maximum design option.
Impact 6: Impacts to designated coastal feature receptors (due to decommissioning activities).		
The maximum design option is set out below as it relates to Impact 6. Where relevant, summary calculations are provided below, the Physical Processes Design Options Annex should be referred to for further detail on the parameters that inform the maximum design option. Landfall infrastructure will be left in situ where considered appropriate. Any requirements for decommissioning at the landfall will be agreed with statutory consultees; and It is likely judged that cable removal will bring about further environmental impacts. At present it is therefore proposed that the cables will be left in situ, and this has been assessed within this chapter.	No alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.	This option details the best understanding of the decommissioning works as presented in the Project Description Chapter and licensing requirements at the time of writing.

1.13 Project Design Features and Avoidance and Preventative Measures

1.13.1 As outlined within the EIA Methodology Chapter and in accordance with the EPA Guidelines (2022), this EIAR describes the following:

- Project Design Features: These are features of the Dublin Array project that were selected as part of the iterative design process, which are demonstrated to avoid and prevent potential adverse effects on the environment in relation to physical processes. These are presented within Table 7.
- Other Avoidance and Preventative Measures: These are measures that were identified throughout the early development phase of the Dublin Array project, also to avoid and prevent likely significant effects, which go beyond design features. These measures were incorporated in as constituent elements of the project, they are referenced in the Project Description Chapter of this EIAR and they form part of the project for which development consent is being sought. These measures are distinct from design features and are found within our suite of management plans. These are also presented within Table 7.
- Additional Mitigation: These are measures that were introduced to the Dublin Array project after a likely significant effect was identified during the EIA assessment process. These measures either mitigate against the identified significant adverse effect or reduce the significance of the residual effect on the environment. The assessment of impacts is presented in Sections 1.14, 1.15 and 1.16 of this EIAR chapter.

1.13.2 All measures are secured within Volume 8, Chapter 2: Schedule of Commitments.

1.13.3 Where additional mitigation is identified as being required to reduce the significance of any residual effect in EIA terms, this is presented in Sections 1.14, 1.15 and 1.16.

Table 7 Project design features and other avoidance and preventative measures relating to physical processes

Project design feature / other avoidance and preventative measure	Where secured
Use of trenchless technology at landfall, cables will be installed by trenchless installation technique beneath the intertidal zone and cliffs at landfall. Exit pits will be located within the offshore ECC seaward of the Mean Low Water (MLW) at a point/depth where cable installation vessels can operate. No cable protection will be used inshore of the exit pits. During Drilling Punch Out of the exit pits, material will be stored to minimise loss of sediment as far as is reasonably practicable	Outlined in the Project Description Chapter
Disposal of spoil from TSHD generated by seabed preparation (for foundations and cables) works to be redeposited in the project area within areas of similar sediment type, and in areas where current speeds are such	Outlined in the Project Description Chapter

Project design feature / other avoidance and preventative measure	Where secured
that dredged material would be redistributed into the sediment transport system.	
Backfill of sediment trenches where IACs are to be installed perpendicular to the Kish and Bray Banks, requiring trenching works across the banks. Whilst the trenches are open sediment will be stored temporarily alongside the trench and utilised as backfill material. Measures will be taken to ensure sediment is not lost prior to backfilling including minimising the duration of time the material is stored and the distance the deposited material is located from the excavated trench.	Outlined in the Project Description Chapter
Installation of cables to an optimum cable burial depth - offshore cables will, where possible, be buried in the seabed to the optimal performance burial depth for the specific ground conditions. Where optimum burial depth cannot be achieved secondary protection measure will be deployed e.g. concrete mattress, rock berm, grout bags or an equivalent in key areas.	The Project Description Chapter details the requirement for a Cable Installation Plan (CIP) and Cable Burial Risk Assessment (CBRA) which will be developed upon award of consent and in advance of construction. The CIP and CBRA will provide information on the installation plan for subsea cables. The CBRA, will provide a risk assessment and evaluation for cable protection, unburied or shallow buried cables. The CIP will detail pertinent mitigation measures to be used during cable installation and will be applied throughout the construction phase. The CIP and CBRA will be submitted to the consenting authority in advance of the construction phase.
Scour protection measures, options include rock protection or concentrated mattresses, flow energy dissipation devices, protective aprons or bagged solutions.	The Project Description Chapter sets out the methods for scour protection and outlines the requirement for a Scour Protection Management Plan (SPMP) developed prior to construction for all offshore infrastructure which will include details of the need, location, type, quantity and installation methods for scour protection which will be undertaken in accordance with the design options, quantities & methods outlined the Project Description.

1.14 Environmental Assessment: Construction phase

Construction pathways

1.14.1 All of the identified physical processes receptors will be insensitive to elevated SSC and localised changes in bed level. The potential for these changes to impact other EIA receptor groups are considered elsewhere within the EIAR, such as the:

- MW&SQ Chapter;
- Benthic Ecology Chapter;
- Fish and Shellfish Ecology Chapter;
- Infrastructure and Other Users Chapter; and
- Marine Archaeology Chapter.

1.14.2 The potential increases in SSC and consequential sediment deposition from seabed preparation prior to foundation installation are presented below. This information is provided to inform other inter-related assessments within this EIAR but has not been assessed for significance in EIA terms within this chapter as no physical processes receptors have been identified which could be sensitive to SSC. These changes have been described as pathways, as provided in Table 5.

1.14.3 For the pathways described below (and in subsequent sections) sediment plumes will be described as additive *only* if another activity disturbs sediment within the spatial footprint of active sediment plume from an upstream location. The effect on suspended SSC will *not* be described as additive (i.e. the effects will be as described for single occurrences only) if the areas of effect only meets or overlaps downstream of an advected and dispersed sediment plume. Effects on sediment deposition will be additive if and where the footprints of the deposits overlap.

1.14.4 Where site specific modelling has been used to inform the assessment of pathways and effects, the Physical Processes Modelling Report provides the details of the specific configurations modelled. All modelled locations for sediment plume modelling are presented in Figure 2 for ease of reference. Of note, is that for the purposes of this assessment, fine sediments are characterised as fine sands, silts and muds, whilst coarse sediments are represented by medium sands to very fine gravel. Typically, based on the hydrodynamic regime in the area, the fines are likely to be transported away from the point of disturbance, whilst the latter are anticipated to fall out of suspension within relatively short distances from the release point. Sediment transport within the study area is tidally dominated, although wave-action may enhance mobility in relatively shallow areas such as over the banks. Depth-average current speeds of between approximately 0.43 m/s and 0.53 m/s (dependent on the water depth at the location concerned) are required to transport sediment grains larger than medium sands.

1.14.5 For the design alternative options detailed in Table 7Table 8 which will not result in any sediment disturbance there will be no deviation from the future receiving environment for those activities.

Pathway 1: Increases in SSC and deposition of disturbed sediments to the seabed due to dredging for seabed preparation prior to foundation installation

1.14.6 For the purposes of a precautionary assessment, the MDO for seabed preparation has been assessed as being undertaken prior to foundation installation for which two potential sources of sediment release have been assessed:

- Overspill during the dredging of seabed sediment; and
- The disposal of dredged sediment, from a surface release back to the seabed, at a nearby location within the array area.

1.14.7 Sediment plume modelling, using DAPPMS, has been used to inform the assessment of potential changes to SSC and bed levels arising from dredging. The results and detailed information regarding the modelling simulations are provided within Physical Processes Modelling report and have been summarised below. The Physical Processes Modelling report provides further details of the sediment fractions which have been modelled (either hydrodynamically or empirically) under each proposed activity scenario.

1.14.8 As outlined in Paragraph 1.12.6, the scenarios modelled using DAPPMS are not all consistent with the MDO identified in Table 6. However, the current MDO will not give rise to an effect that is more significant than those of the modelled scenarios, and therefore the results of sediment plume modelling are considered to be appropriate evidence for the assessment provided below. This is evidenced within a detailed comparison of the modelled scenarios and MDO presented in the Physical Processes Modelling and Design Options Comparison Report, as described in Paragraph 1.12.7. This report demonstrates that the modelled scenarios, although in some cases precautionary in comparison to the MDO, nevertheless provide a suitable means of assessing the project for EIA purposes.

1.14.9 The spoil disposal was timed, in the modelling, to coincide with low water, thus minimising the dispersion of the disposal mass and thus presenting a precautionary assessment for both deposition thicknesses on the bed and highest instantaneous SSCs.

Overspill

1.14.10 The fate of the dredged sediment during overspill can be summarised as follows:

- Based on the site specific numerical modelling the fine fractions are predicted to behave as follows:
  - Duration - The plume will not be detectable after an hour following release, with the majority of suspended sediment settling out of the water column within 30 minutes;

  - Concentration - Maximum concentrations will occur on neap tides as the material will be dispersed less (i.e., over shorter distances). The maximum depth-averaged concentrations predicted on a neap and spring tide are, approximately, 140 mg/l and 50 mg/l respectively. This is a consequence of the faster spring tidal currents dispersing the suspended fines over a greater distance. Of note is that background SPM levels within the study area, as presented in Section 1.6.30, are of the order of 5 mg/l to 8 mg/l; and
  - Spatial extent - The plumes direction will be controlled by the direction of the tidal stream. The model predicted that the maximum extent of the detectable plume will be up to 900 m from the location of the overspill release.

- Based on expert judgment (supported by literature (Tillin *et al.*, 2011; Newell and Woodcock, 2013), analogous physical processes studies from other European wind farms and settling velocities from Soulsby (1997), the coarse fractions are predicted to behave as follows:
  - Duration – The coarse fractions will only be in suspension during the active overspill / dredging. Coarse grained sediments (e.g. gravels and coarse sands) will typically fall out of suspension relatively quickly (in the order of minutes) without opportunity to be advected away from the release location to any great extent;
  - Concentrations – The level of SSC caused by all sediment types together is realistically expected to be locally high (in the order of tens to hundreds of thousands of mg/l) at the release location. However, it should be noted that these elevated concentrations of all fractions will be highly localised in nature;
  - Spatial extent – The SSC consisting of coarse grains will be very localised and will only be present over that seabed being actively dredged.

- Sediment deposition as a result of overspill is characterised as follows:
  - Fine fractions: The site specific numerical modelling predicts that settled sediments arising from overspill releases are seen to form discrete sediment patches on the seabed close to the release locations. Where the overspill releases are in close proximity, such as the modelled scenario shown in Figure 22, these depositional footprints may overlap. Further details of this scenario are provided in Section 4.3.1.2 of the Physical Processes Modelling Report. Deposition depths on the seabed are predicted to be up to, approximately, 0.01 m, with the deposition footprint for all thicknesses typically being 600 m by 200 m;
  - Coarse fractions: The sediment released during the overspill will comprise of fine fractions, as coarser sediments will typically fall out of suspension in the order of minutes, without opportunity to be advected away from the release location to any great extent. Coarse fractions are therefore not considered here.

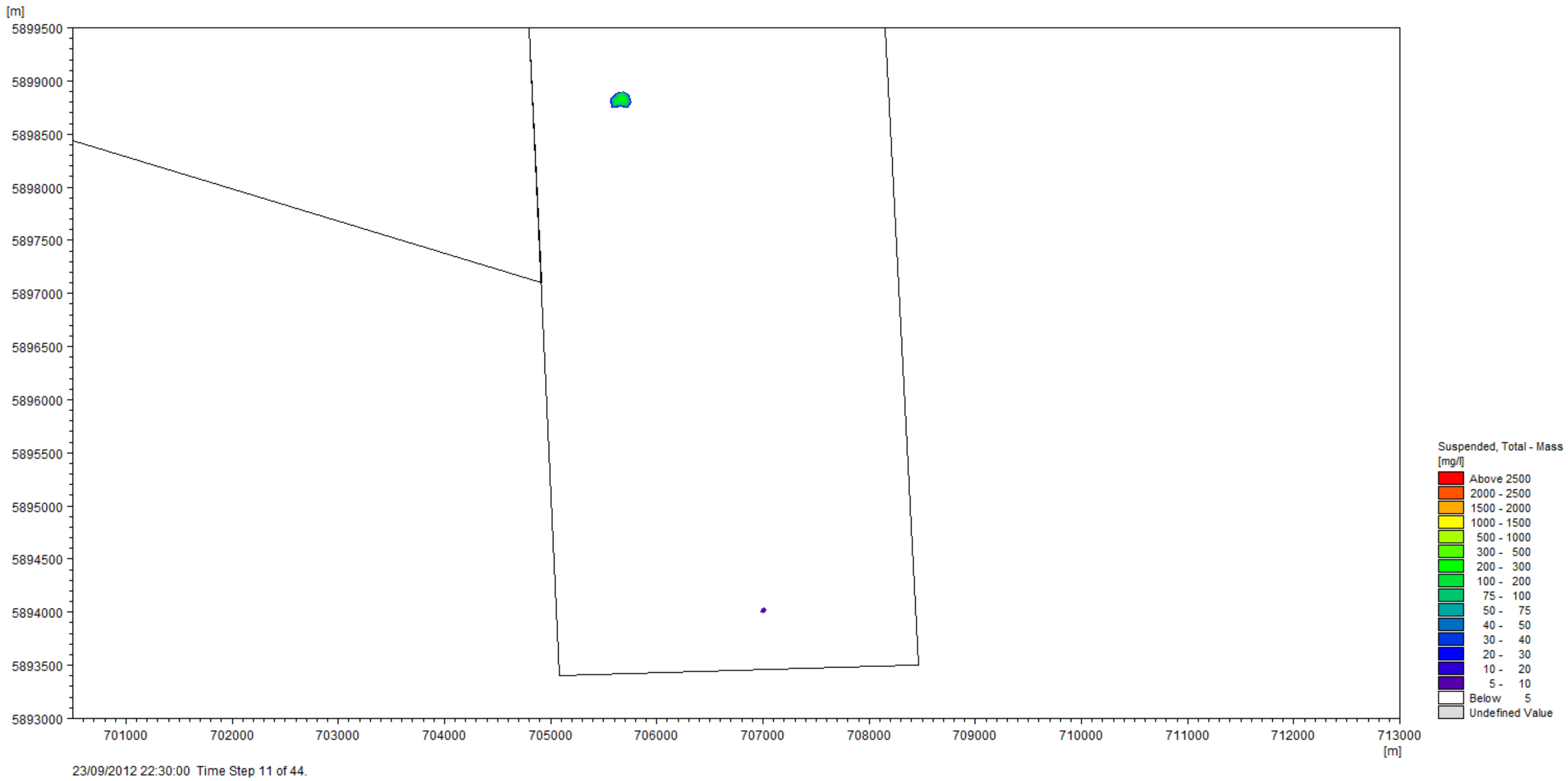

Figure 21 SSC following immediately after release of the dredged material from seabed preparation for foundations (immediately after disposal in the south of the array area on a spring tide, fine fraction only)

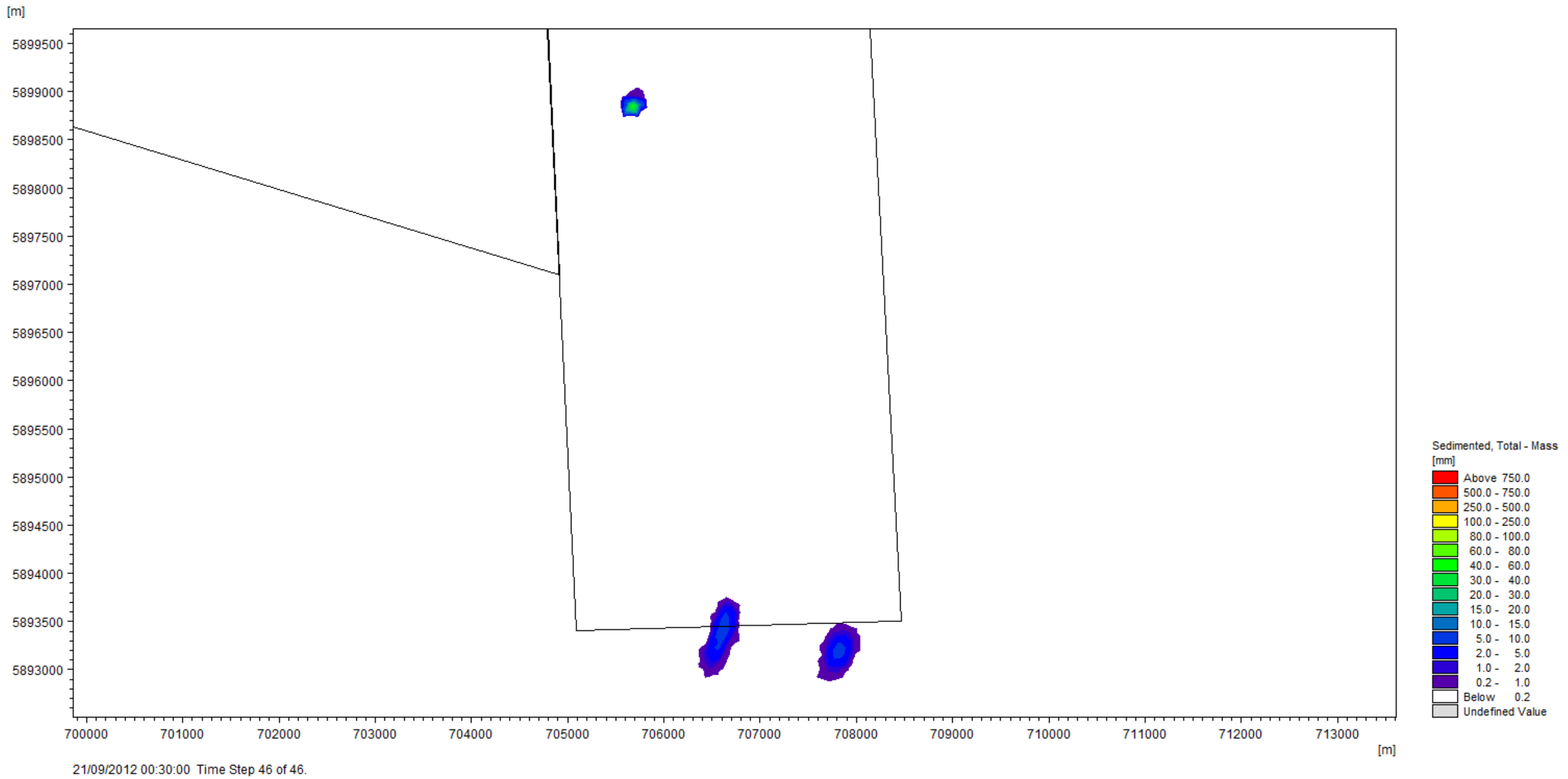

Figure 22 Maximum depth of deposited sediment from seabed preparation for foundations (disposal in the south of the array area on a spring tide, fine fraction only)

Disposal

1.14.11 The fate of the dredged sediment during the subsequent disposal can be summarised as follows:

- Based on the site specific numerical modelling, the fine fractions are predicted to behave as follows:
  - Duration –These processes will occur on a spatial scale smaller than that resolved by the model (110 m to 540 m resolution). Based on expert judgement it can be reasonably considered that the sediment in suspension during disposal will fall out within the order of minutes if deposited near the seabed;
  - Concentration – The DAPPMS predicted a maximum concentration of 300 mg/l for the fine fractions (see Figure 21); and
  - Spatial extent – The SSC plume, resulting from disposal, will be anticipated to extend between tens to low hundreds of metres. The sediments will settle out from suspension relatively quickly and therefore will have limited opportunity for dispersal. This is supported by the predicted deposition footprints presented below.
- Based on expert judgment (supported by literature (Tillin *et al.*, 2011; Newell and Woodcock, 2013), analogous physical processes studies from other European wind farms and settling velocities from Soulsby (1997), when considering SSC caused by all sediment types (fine and coarse combined) they are realistically expected to be locally very high (in the order of millions of mg/l within 5 m of the activity[21]) at the disposal location. The effect will be very localised and temporary, occurring only whilst the disposal is active over that seabed section. As sediment in the plume is redeposited and dispersed both vertically and horizontally with distance and time downstream, SSC is expected to reduce to thousands or high hundreds of mg/l within tens to low hundreds of metres. The sediment in suspension during disposal is expected to fall out within the order of minutes, when deposited near the seabed.

1.14.12 The spoil mound dimensions of the coarse grained sediments were calculated using the US Army Corps of Engineers Short-Term FATE of dredged material disposal in open water (STFATE) model[22] (see the Physical Processes Modelling Report). The deposition of coarse and fine fractions of sediment should be considered as additive in order to represent the magnitude of the potential changes. The Physical Processes Modelling Report provides full details of the results. In terms of the bed level changes associated with the disposal of dredged material arising from foundation preparation, the following summary conclusions are drawn:

- Fine fractions as modelled in the DAPPMS:

[21] I.e. more sediment than water in parts of the local plume.
[22] The STFATE (Short-Term FATE) model was developed by the United States Army Corps of Engineers (USACE) and is applicable for dredged material disposal in open water.

- Spatial extent – The footprint of the disposal plume is distinct, typically of the order of 250 m by 250 m with a maximum thickness of less than, approximately, 0.045 m (see Figure 22).

- Coarse fractions as modelled using the STFATE model:
  - The maximum deposited thickness for one dredger load was of the order of 1.77 m when deposited on a slack tide at low water in the northern extents of the array area[23]. Under equivalent conditions, the maximum deposited thickness was 0.7 m within the southern extent of the array. The maximum footprint, exceeding heights of 0.3 m, is predicted to be 581 m^2 and 4,355 m^2 for the north and south sites, respectively, under slack tide at low water.

Magnitude

1.14.13 The evidence presented above combined with expert judgement has been used to assess the magnitude of the potential change to SSC and seabed height, from seabed preparation for foundation installation. This is summarised in Table 8 based on the methodology outlined in Section 1.5.

Table 8 Determination of magnitude for increases in SSC and deposition of disturbed sediments to the seabed due to for seabed preparation prior to foundation installation

	Maximum design option	Alternative design option
Extent	The DAPPMS model predicted that the maximum extent of the detectable plume will be up to 900 m from the location of the overspill release. The disposal plume will be localised to the disposal site. The maximum deposition footprint will be approximately 120,000 m^2 (600 m x 200 m).	The temporary impact of increased SSC and deposition from construction activities will be restricted to the near field and the adjacent areas of the far-field (within one tidal cycle/ mean spring tidal excursion).
Duration	The effect is anticipated to be temporary (seconds to minutes) or brief (i.e. lasting less than a day) per foundation dredged.	The effect is anticipated to be temporary (seconds to minutes) or brief (i.e. lasting less than a day) per foundation dredged.
Frequency	All foundations may require preparation.	Between 0% and 100% of foundations may require preparation.
Probability	The predicted impacts can reasonably be expected to occur.	The predicted impacts can reasonably be expected to occur.

[23] It should be noted that these predictions are highly precautionary, in terms of height, as sediment will naturally 'slump' as opposed to making steep sided cones. Furthermore, the sediment will naturally disperse laterally in the water column and along the bed when released from the surface by through the hopper doors of a barge in a near instantaneous release of all of material. This will result in lower depositional heights but a larger spatial extent of the disposed material on the seabed.

	Maximum design option	Alternative design option
Consequence	Noticeable or barely discernible change in SSC concentrations frequently occurring during the construction phase within the near-field and the adjacent areas of the far-field. Noticeable (mounds) or barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field.	Noticeable or barely discernible change in SSC concentrations frequently occurring during the construction phase within the near-field and the adjacent areas of the far-field. Noticeable (mounds) or barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field.
Overall magnitude	*The potential magnitude of the predicted changes is rated as Low.*	*The potential magnitude of the predicted changes is rated as Low.*

Pathway 2: Increases in SSC and deposition of disturbed sediments to the seabed due to the release of drill arisings during foundation installation

1.14.14 In some locations, the underlying geology may present an obstacle to piling, in which case, some or all of the seabed material might be drilled from within the pile to assist in the piling process. The MDO for the purpose of this assessment is a maximum of 50% of WTGs (for multileg foundations), as well as the OSP foundation, are assumed to require drilling to assist with installation (see Table 6).

1.14.15 The impact of drilling operations for foundation installation mainly relates to the release of drilling spoil at, or above the water surface, which will put sediment into suspension and will then be subsequently re-deposited to the seabed. The nature of this potential change will be determined by the release rate and total volume of material to be drilled, the nature of the seabed/ underlying geology and the drilling method (affecting the texture and grain size distribution of the drill spoil).

1.14.16 In order to inform the assessment of potential changes to SSC and bed levels arising from drilling, plume modelling has been undertaken using the DAPPMS. The results and detailed information regarding of the modelling simulations are provided within the Physical Processes Modelling Report and are summarised below.

1.14.17 As outlined in Paragraph 1.12.6, the scenarios modelled using DAPPMS are not all consistent with the MDO identified in Table 6. However, the MDO will not give rise to an effect that is more significant than those from the modelled scenarios, and therefore the results of sediment plume modelling are considered to be appropriate evidence for the assessment provided below. A full comparison of the modelled scenarios and MDO is presented in the Physical Processes Modelling and Design Options Comparison Report.

1.14.18 The morphology and distribution of surficial sediments in the region has resulted largely from glacial deposition/scour processes. Therefore, for the purposes of assessment the drill arisings are considered to consist of fine silts through to very fine gravels. Some of the fine materials may form aggregated 'clasts' which would settle out of suspension relatively quickly, whereas disaggregated finer sediments would be more prone to dispersion across the study area.

1.14.19 The fate of the drill arisings overspill can be summarised as follows:

- The DAPPMS predicts that fine fractions will behave as follows:
  - Duration – Plumes of SSC are continuously observable during drilling activity and will advect in the direction of the tidal stream. All sediments are predicted to have settled out of suspension and been deposited within, approximately, three hours following the end of the release;
  - Concentration - Maximum concentrations in the simulation are associated with slack tide, with values of up to, approximately, 200 mg/l and 600 mg/l observable on spring and neap tides, respectively. These concentrations are observed within, circa, 150 m of the release location. As shown in Figure 23, concentrations are very low, typically approximately 8 mg/l, but can reach 12 mg/l and are only slightly greater than background levels within the study area (Section 1.6.30); and
  - Spatial extent - The plumes direction will be controlled by the direction of the tidal stream. Due to the continuous sediment release throughout the tidal cycle, plumes may extend up to, approximately, 10 km from the source, however at this distance these concentrations will be close to ambient conditions and well within the natural variability of the study area. Figure 23 presents the predicted plume 11 hours after the start of sediment release on a spring tide and at the maximum extent of its tidal excursion.
- Based on expert judgment (supported by literature (Tillin *et al.*, 2011; Newell and Woodcock, 2013), analogous physical processes studies from other European wind farms and settling velocities from Soulsby (1997), the coarse fractions and aggregated clasts are predicted to behave as follows:
  - Duration – The coarse fractions will only be in suspension during the period of the active drilling. Coarse grained sediments and aggregated clasts will typically fall out of suspension relatively quickly (in the order of minutes) without any opportunity to be advected away from the location of release to any great extent;
  - Concentrations - The level of SSC caused by all sediment types together is realistically expected to be locally high (in the order of tens to hundreds of thousands) at the location of release. Noting that this will be highly localised and short-lived; and
  - Spatial extent - The SSC consisting of coarse grains will be localised (within circa metres to tens of metres) to the active drilling location.

1.14.20 Sediment deposition as a result of drilling for a single foundation installation are characterised as follows:

- The DAPPMS predicts the behaviour of fine fractions as follows:
  - Both the neap and spring tidal release scenarios show a relatively large depositional footprint with a thickness less than, approximately, 0.002 m (see Figure 24). This is comparable to a 'very coarse' grain of sand, and will not be measurable in practice. Within circa 2 km of the drilling location, the thickness is predicted to be less than 0.02 m.
- Based on expert judgment (supported by analogous physical processes studies from other European wind farms and settling velocities from Soulsby (1997), the coarse fractions and aggregated clasts are predicted to behave as follows:
  - It is anticipated that the coarser fractions of sediment will be concentrated into a 'mound' in the vicinity of the drill locations (within tens of metres) with an average thickness in the order of tens of centimetres to a few metres in height; but will remain highly localised to the release point. The precise configuration of height and spreading distance of each mound will vary across the wind farm site, depending on the prevailing conditions. These mounds will be composed of sediment with a different grain-size and behaviour character (cohesive) to the surrounding sandy seabed and therefore represent the greatest potential for impact associated with mound formation during construction.
  - Evidence from the field is provided by the during- and post-construction monitoring of monopile installation using drill-drive methods into chalk at the Lynn and Inner Dowsing OWF (Centrica Renewable Energy Limited (CREL), 2008), located off the coast of Lincolnshire in the UK. Observation of drill spoil mounds at the site indicated a relatively high, but localised pile of chalk and flint deposits, consisting primarily of pebble and cobble-sizes clasts. The volume of the deposits were similar to the volume of the drilled hole, indicating that the majority of the total drill arisings volume had been deposited locally. Due to the generally large clast size of the drill arisings, they would be unlikely to disperse over a large area (CREL, 2008; ABPmer *et al.*, 2010).

1.14.21 Monitoring of drill arisings on the Lynn and Inner Dowsing OWF found that after four months, mounds had been reduced from 3 m to 1.2 m due to natural redistribution processes, however this figure is only presented as a guide as oceanographic conditions are slightly different at the location of the Dublin array area (CREL, 2008). The Lynn and Inner Dowsing OWFs are located in an area with a less energetic climate and lower speeds of 0.9 m/s to 1.1 m/s (ABPmer *et al.*, 2010), lower than those outlined in Paragraph 1.6.14, particularly on Bray Bank. Drill arising mounds are therefore likely to be redistributed faster within the Dublin array area than observed at the Lynn and Inner Dowsing site.

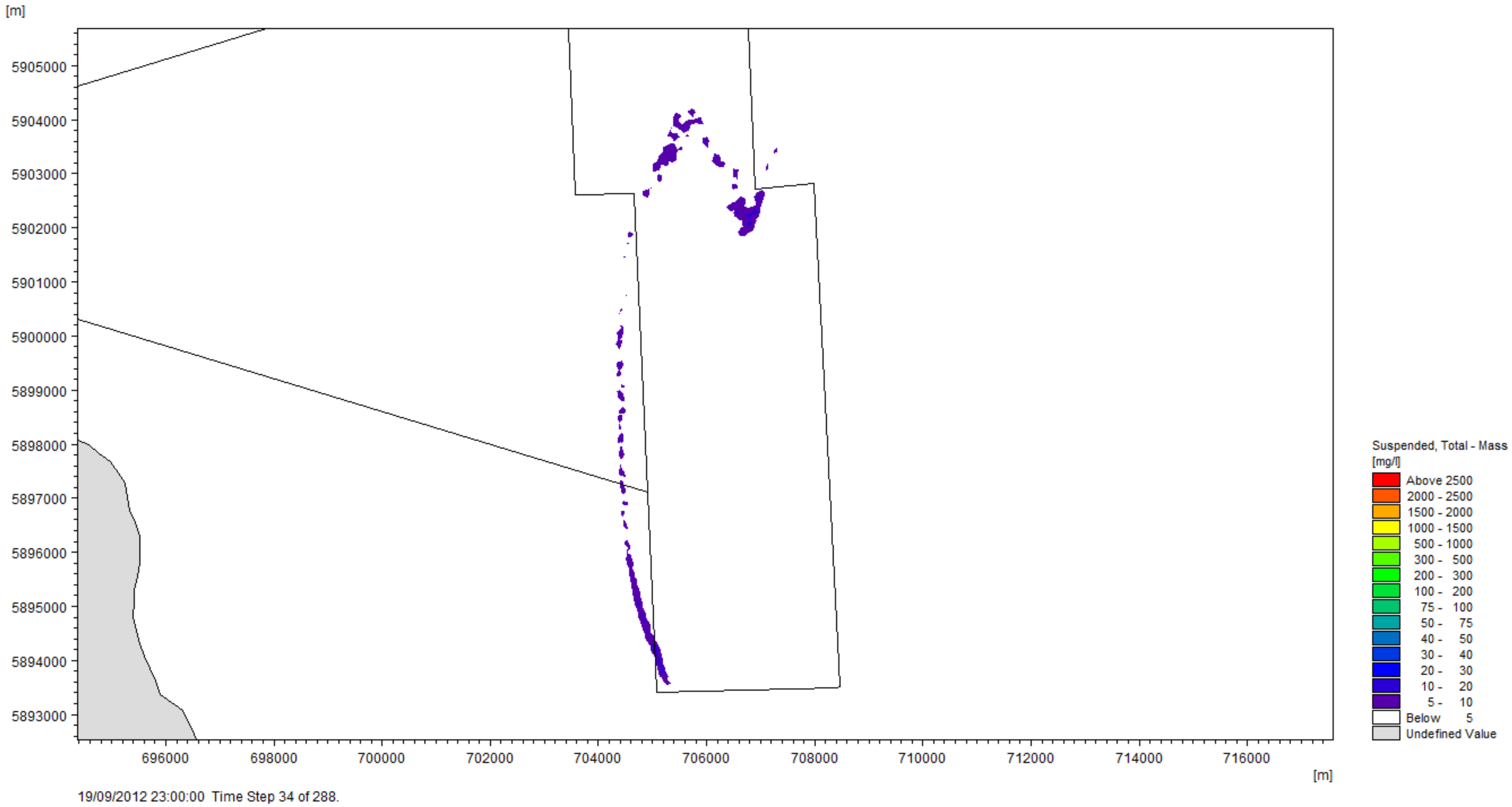

Figure 23 SSC arising from drill arisings (11 hours following the start of the continuous sediment release on a spring tide, fine fraction only)

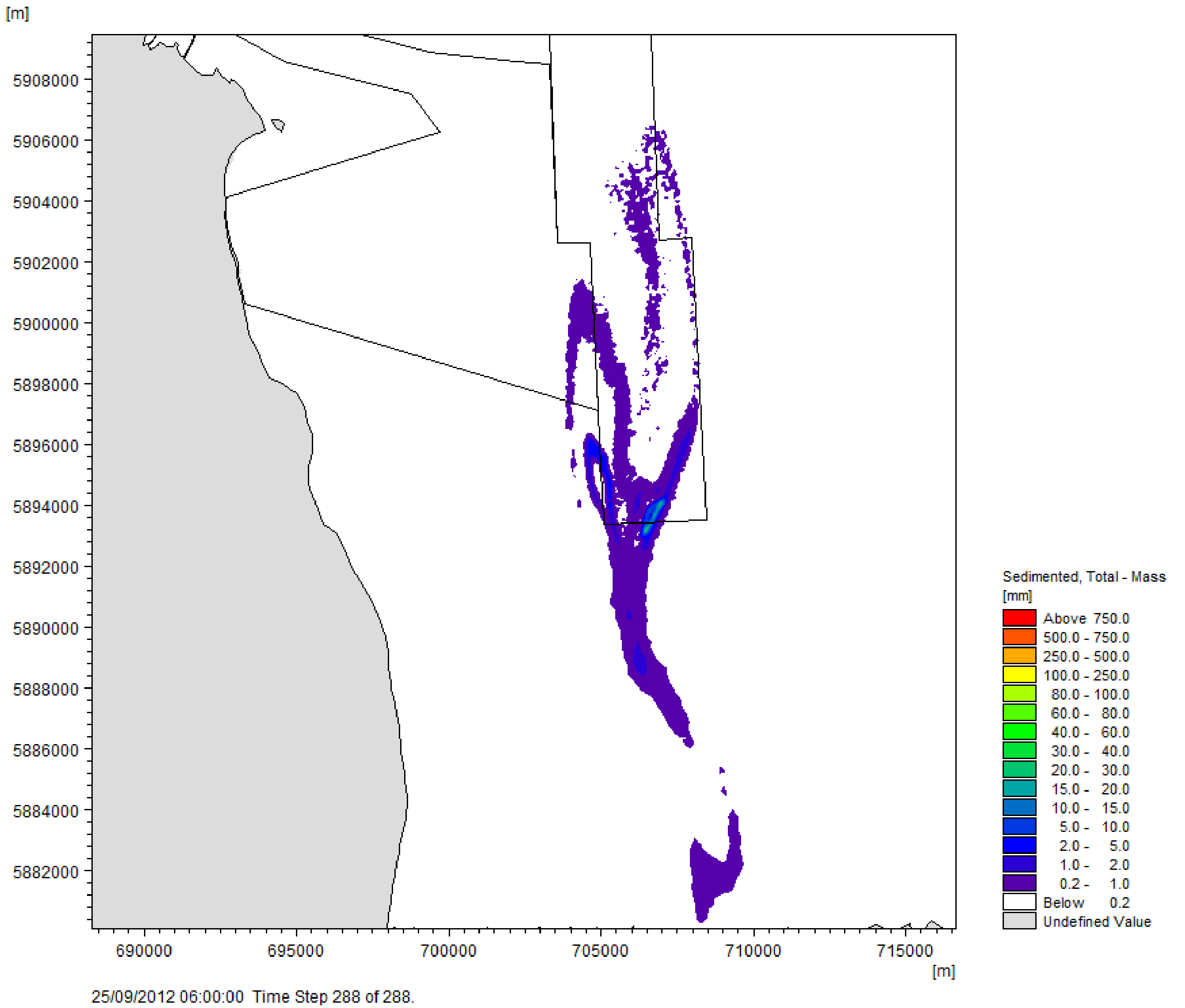

Figure 24 Maximum deposition thickness of a drill arising plume on a spring tide (fine fraction only)

1.14.22 Based on the evidence above and expert judgement, the magnitude of the potential change to SSC and seabed height, resulting from the release of drill arisings, is assessed in Table 9 based on the methodology outlined Section 1.5.

Table 9 Determination of magnitude for increases in SSC and deposition of disturbed sediments to the seabed from the release of drill arisings

	Maximum design option	Alternative design option
Extent	Plumes of SSC may extend up to approximately 10 km from the source, however at this distance these concentrations will be close to ambient conditions and within the natural variability of the study area. The extent of all plumes will be limited to within the study area. Under both the neap and spring tidal release scenarios a relatively large depositional footprint will result, with a thickness less than approximately 0.002 m (see Figure 24) which will not be measurable in practice.	The temporary impact of increased SSC and deposition from construction activities will be restricted to the study area (within one tidal cycle/ mean spring tidal excursion).
Duration	The effect is anticipated to be brief i.e. lasting less than a day per foundation dredged.	The effect is anticipated to be brief (i.e. lasting less than a day) per foundation dredged.
Frequency	50% of WTGs and the OSP may require drilling to assist with installation. Drilling of each of the identified foundations will be undertaken in a single event .	Between 0% and 50% of foundations may require drilling to assist with installation. Drilling of each of the identified foundations will be undertaken in a single event
Probability	The predicted impacts can reasonably be expected to occur if drilling of foundations is required.	The predicted impacts can reasonably be expected to occur if drilling of foundations is required.
Consequence	Noticeable but brief changes in SSC concentrations occurring during the construction phase within the near-field and the adjacent areas of the far-field. Noticeable (mounds) or barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field.	Noticeable but brief changes in SSC concentrations occurring during the construction phase within the near-field and the adjacent areas of the far-field. Noticeable (mounds) or barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field.
Overall magnitude	*The potential magnitude of the predicted changes is rated as Low.*	*The potential magnitude of the predicted changes is rated as Low.*

Pathway 3: Increases in SSC and deposition of disturbed sediment to the seabed due to inter-array cable (IAC) installation

1.14.23 Cable burial operations have been reported to result in a localised and temporary re-suspension and subsequent settling of sediments (Department for Business, Enterprise and Regulatory Reform (BERR), 2008). The exact nature of this disturbance will be determined by the soil conditions within Dublin Array, the length of installed cable, the burial depth, burial method and environmental conditions at the time of installation works.

1.14.24 As outlined in Table 6, with further detail provided in the Physical Processes Design Options Addendum, Mass Flow Excavator (MFE) techniques are considered to have the greatest potential for sediment disturbance. In comparison with other cable installation options, MFE is considered to have the greatest potential to disperse and suspend seabed material, as well as producing a wide trench. MFE is expected to backfill cable trenches once excavated using a cable plough.

1.14.25 The MDO for the purposes of this assessment is therefore based on the use of ploughing to excavate a cable trench, in addition to the use of MFE in order to backfill the trench. A detailed comparison of cable installation methodologies that inform this design option is provided in the Physical Processes Design Options Addendum. MFE utilises high-pressured water jets to fluidise the sediment, which are pumped through a ducted nozzle containing a propeller. These techniques are considered as having the greatest potential for seabed disturbance out of the available cable installation options and are therefore assessed as part of the MDO for the entire cable route.

1.14.26 As outlined in Paragraph 1.12.6, the scenarios modelled using DAPPMS are not all consistent with the MDO identified in Table 6. However, the MDO will not give rise to an effect that is more significant than those of the modelled scenarios, and therefore the results of sediment plume modelling are considered to be appropriate evidence for the assessment provided below. A full comparison of the modelled scenarios and MDO is presented in the Physical Processes Modelling and Design Options Comparison Report.

1.14.27 The fate of the displaced sediment can be summarised as follows:

- Fine fractions based on the DAPPMS predictions:
  - Duration – All sediments settle to the bed within, approximately, 30 to 60 minutes (spring and neap tidal releases respectively);
  - Concentration - During trenching, the predicted plumes have high concentrations (up to approximately 5,000 mg/l) within a single model cell[24], before decreasing rapidly to between, circa, 5 mg/l and 20 mg/l within approximately 200 m of the trench. For reference, annual mean SPM within the array area is identified as between 4 mg/l and 6 mg/l, with winter values reaching up to 8 mg/l (Cefas, 2016; shown in Figure 16 and Figure 17); and

[24] Details of the model resolution is provided in Paragraph 1.10.6.

  - Spatial extent - All of the model simulations predicted high concentrations at the release point reducing to between, approximately, 500 mg/l and 1500 mg/l following the cessation of the MFE activity. Concentrations are predicted to reduce to background levels (e.g. 5 mg/l) within a few hundred metres (see Figure 25).

- Based on expert judgment (supported by analogous physical processes studies from other European wind farms and settling velocities from Soulsby (1997)) the coarse fractions are predicted to behave as follows:

  - Duration – The coarse fractions will only be in suspension during the active trenching. Coarse grained sediments (gravels and coarse sands) will typically fall out of suspension relatively quickly (in the order of minutes) without any great opportunity to be advected away from the release location;

  - Concentrations - The level of SSC caused by all sediment types considered together is realistically expected to be locally high (in the order of tens to hundreds of thousands) at the release location. Of note is that this is both temporary and highly localised; and

  - Spatial extent – Any sediment fractions larger than fine sand are expected to rapidly fall out of suspension. A proportion will fall back into the trench to bury the cable as the MFE progresses.

1.14.28 Sediment deposition resulting from the inter-array cable (IAC) installation is characterised as follows:

- Fine fractions based on the DAPPMS predictions:

  - Sediment is predicted to be deposited as linear features on the seabed. Whilst the finer fractions will remain in suspension longer than coarser materials, the deposition pattern will most likely follow the modelled cable trenching route. The linear features will follow the trench route and may be between, approximately, 0.1 to 0.75 m in height, though areas with a wider footprint will be anticipated to have a lower deposition height on the seabed (see Figure 26).

- Coarse fractions based on expert judgment (supported by analogous physical processes studies from other European wind farms and settling velocities from Soulsby (1997)):

  - Due to the expected near-bed ejection, the contribution of the sand and gravels on SSC and deposition will be spatially limited to within metres to tens of metres, i.e. close to or within the cable trench. This is primarily due to the sediments which are liquidised rapidly falling out of suspension and settling back to the seabed. A proportion will settle into the trench, burying the cable with a deposition height in the order of tens of centimetres to a few metres.

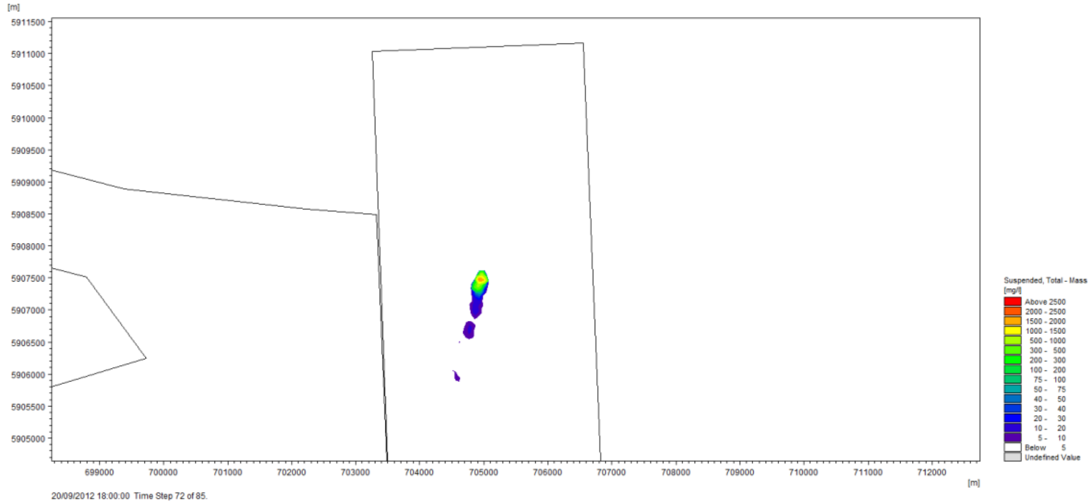

Figure 25 SSC concentrations immediately following the cessation of inter-array cable installation (0 hours after the cessation of activities on a spring tide, fine fraction only)

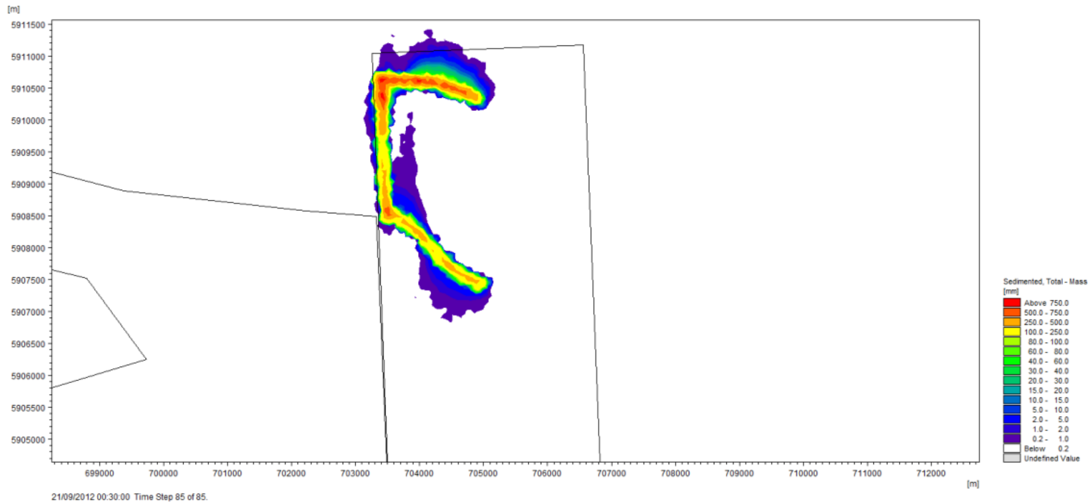

Figure 26 Maximum depth of sediment deposition following completion of inter-array cable installation on a spring tide (fine fraction only)

1.14.29 Based on the evidence above and expert judgement, the magnitude of the potential change to SSC and seabed height, from the installation of the IAC, is determined in Table 10 based on the methodology outlined Section 1.5.

Table 10 Determination of magnitude for increases in SSC and deposition of disturbed sediments to the seabed from the installation of inter-array cables

	Maximum design option	Alternative design option
Extent	All of the model scenarios predicted high concentrations at the point of release reduced to between circa 500 mg/l and 1500 mg/l following cessation of the MFE, with concentrations falling to background levels (5 mg/l) within a few hundred metres (see Figure 25). Linear depositional features are predicted between approximately 0.1 m to 0.75 m, although areas with a wider footprint are anticipated to have a lower depositional height (see Figure 26). Coarse sediments are expected to be spatially limited to within tens of metres of the trench, although depositional thickness may be up to a few metres. The temporary impacts of increased SSC and the impact of deposition will therefore be restricted to the near-field and adjacent areas of the far-field.	The temporary impact of increased SSC from the installation of IAC will be restricted to the near-field and the adjacent areas of the far-field (within one tidal cycle/ mean spring tidal excursion). The impact of deposition of disturbed sediments from the installation of IAC will be restricted to the near-field and the adjacent areas of the far-field.
Duration	The effect is anticipated to be temporary (i.e. lasting less than a day) following the completion of cable installation activities.	The effect is anticipated to be temporary (i.e. lasting less than a day) following the completion of cable installation activities.
Frequency	The inter-array cables (IAC) will be potentially installed as a series of sequential segments, during the construction phase. The installation of the IAC will be in a single campaign lasting up to six months.	The (IAC will be potentially installed as a series of sequential segments, during the construction phase. The installation of the IAC will be in a single campaign lasting up to six months.

	Maximum design option	Alternative design option
Probability	The predicted impacts can reasonably be expected to occur, although the magnitude will be less than the modelled scenarios, as these scenarios have been provided for the use of MFE for cable trenching. MFE is instead to be used as a backfill methodology. Further details are provided in the Physical Processes Modelling and Design Options Comparison Report.	The predicted impacts can reasonably be expected to occur, although the magnitude will be less than the modelled scenarios, as these scenarios have been provided for the use of MFE for cable trenching. MFE is instead to be used as a backfill methodology. Further details are provided in the Physical Processes Modelling and Design Options Comparison Report.
Consequence	Noticeable but brief changes in SSC concentrations occurring during the construction phase within the near-field and the adjacent areas of the far-field. Noticeable (linear features) to barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field.	Noticeable but brief changes in SSC concentrations occurring during the construction phase within the near-field and the adjacent areas of the far-field. Noticeable (linear features) to barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field.
Overall magnitude	*The potential magnitude of the predicted changes is rated as Low.*	*The potential magnitude of the predicted changes is rated as Low.*

Pathway 4: Increases in SSC and deposition of disturbed sediment to the seabed due to export cable installation

1.14.30 As noted above for the installation of IAC (Pathway 3), the exact nature of this disturbance will be determined by the soil conditions within the Dublin Array export cable route, the length of the installed cables, the burial depth, burial method and metocean conditions at the time of installation. The MDO for the purposes of assessment for the export cable installation is for the use of ploughing to excavate a cable trench, in addition to the use of MFE in order to backfill the trench (as outlined in Paragraph 1.14.24). This pathway has been informed by sediment plume modelling using the DAPPMS (see the Physical Processes Modelling Report for further information of the scenarios modelled).

1.14.31 As outlined in Paragraph 1.12.6, the scenarios modelled using DAPPMS are not all consistent with the MDO identified in Table 6. However, the MDO will not give rise to an effect that is more significant than those of the modelled scenarios, and therefore the results of sediment plume modelling are considered to be appropriate evidence for the assessment provided below. A full comparison of the modelled scenarios and MDO is presented in the Physical Processes Modelling and Design Options Comparison Report.

1.14.32 Three sites within the ZoI were modelled to account for the variation in environmental conditions, including water depth and sediment grain size within the study areas. The two sections modelled that are of relevance to the assessment are located approximately 5 km north of an export cable route which was associated with the now obsolete Poolbeg ECC route (Section 1; representing the now obsolete Poolbeg-associated ECC route); and along the proposed offshore ECC route associated with landfall (Section 3). Whilst Section 1 is not within the EIA project boundary, it is within the ZoI (as defined in Paragraph 1.4.3), and is therefore representative of locations at similar distances offshore.

1.14.33 The fate of the displaced sediment consisting of fine fractions, as modelled in the DAPPMS, can be summarised as follows:

- Now obsolete Poolbeg-associated ECC route (Section 1 – see Figure 2):
  - Duration – For both spring and neap tide modelled scenarios the sediment fully disperses within, approximately, 60 minutes of the completion of sediment release;
  - Concentrations - Model simulations on both spring and neap tides show high SSC at the release point (circa 300 mg/l) (see Figures C-42 to C-43 of the Physical Processes Modelling Report); and
  - Spatial Extent - Concentrations return to ambient conditions (circa 5mg/l) within 400 m from trenching.
- The proposed offshore ECC route, associated with the proposed landfall (Section 3 – see Figure 2):
  - Duration – For both spring and neap tide modelled scenarios the sediment fully disperses within, approximately, 30 minutes of the completion of sediment release;
  - Concentrations - Model simulations on both spring and neap tides show high SSC at the point of release (circa 500 mg/l) (see Figures C-46 to C-47 of the Physical Processes Modelling Report); and
  - Spatial Extent – The plume is predicted to be approximately 250 m^2 with a concentration of, approximately, 50 mg/l, before dissipating to ambient conditions.

1.14.34 The coarse fractions from all locations in the offshore ECC are expected to behave as follows:

- Duration – The coarse fractions will only be in suspension during the active cable installation process. Coarse grained sediments (e.g. gravels to medium sands) will typically fall out of suspension relatively quickly (in the order of minutes) without opportunity to be advected substantially away from the location of release;
- Concentrations - The level of SSC caused by all sediment types together is realistically expected to be locally high (in the order of tens to hundreds of thousands) at the location of release, noting that this will be highly localised; and

- Spatial extent – Any sediment larger than fine sand is expected to rapidly fall out of suspension with a proportion falling back into the trench to bury the cable as the MFE progresses.

1.14.35 The landfall zone modelled simulations had the largest depositional footprint and changes to seabed height, this is primarily attributed to the larger volumes modelled and the lower energy environment. Sediment deposition as a result of export cable installation from the project specific modelling predicts the following:

- The now obsolete Poolbeg- ECC route (Section 1 – see Figure 2): Sediments are deposited in linear features following the modelled cable route (see Figure 29). Sediment deposition is expected up to 500 m from the trench, however, all the fine fractions are predicted to be deposited in the near-field (see Figures C-48 to C-49 of the Physical Processes Modelling Report). The maximum deposition depth is predicted to be 0.08 m in the area being actively trenched, though it should be noted that the model itself does not resolve the trench itself so these sediments are anticipated to infill the trench in practice; and

- Proposed offshore ECC route, associated with the landfall (Section 3 – see Figure 2): Sediments are generally deposited in linear features following the modelled cable route (see Figure 30). A wider footprint of deposition is experienced in this section of the offshore ECC than Section 1, depositing sediment up to 2 km from the trench on both spring and neap tides. The maximum deposition depth is predicted to be between 0.1 m and 0.5 m in the area being actively trenched. As noted above, in practice this sediment would infill the trench itself to bury the cable.

1.14.36 The coarse fractions from all locations in the offshore ECC are expected to be deposited within metres to tens of metres, i.e. close to or within the cable trench. This is primarily as the sediments which are liquidised will rapidly fall out of the suspension (in the order of seconds to minutes) and a notable proportion will subsequently fall back into the trench burying the cable, with a deposition height in the order of tens of centimetres to a few metres outside of the trench depending on the specific sediment present (e.g. medium sands may be laterally transported a few metres).

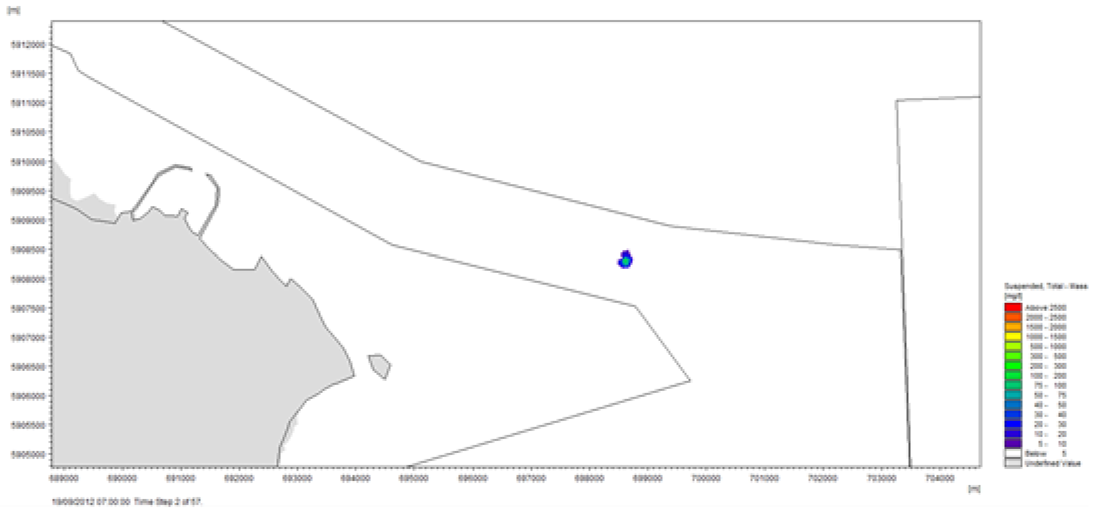

Figure 27 SSC plumes associated with the installation of export cables at Section 1 (one hour after initial release on a spring tide, fine fraction only)

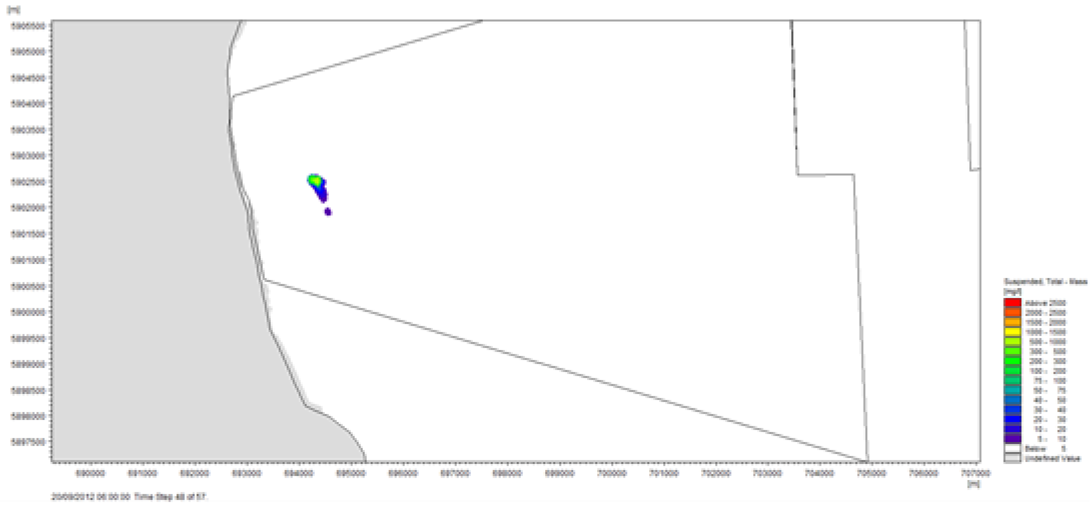

Figure 28 SSC plumes associated with the installation of export cables at Section 3 (immediately following the release of all sediment on a spring tide, fine fraction only)

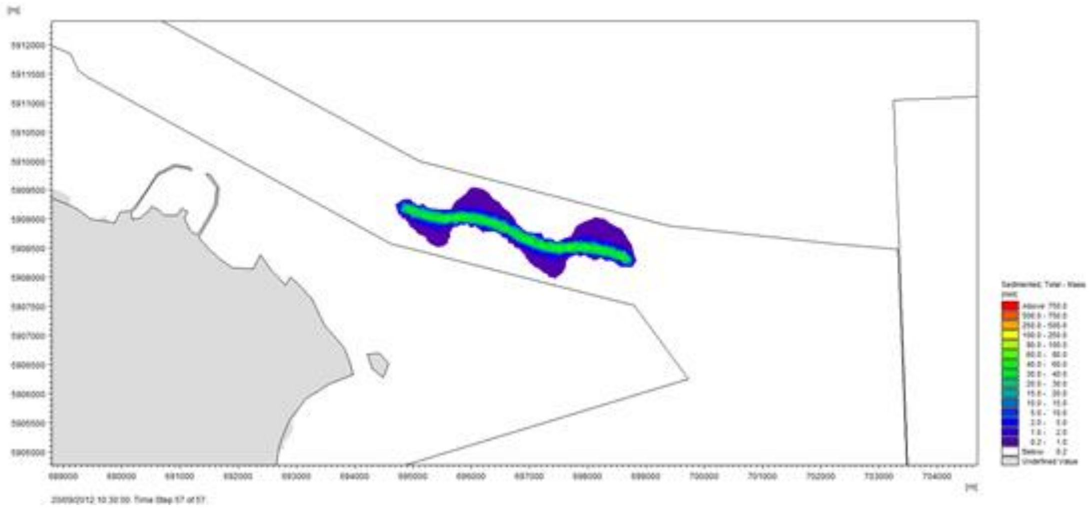

Figure 29 Maximum deposition thickness for export cable installation at Section 1 (spring tide, fine fraction only)

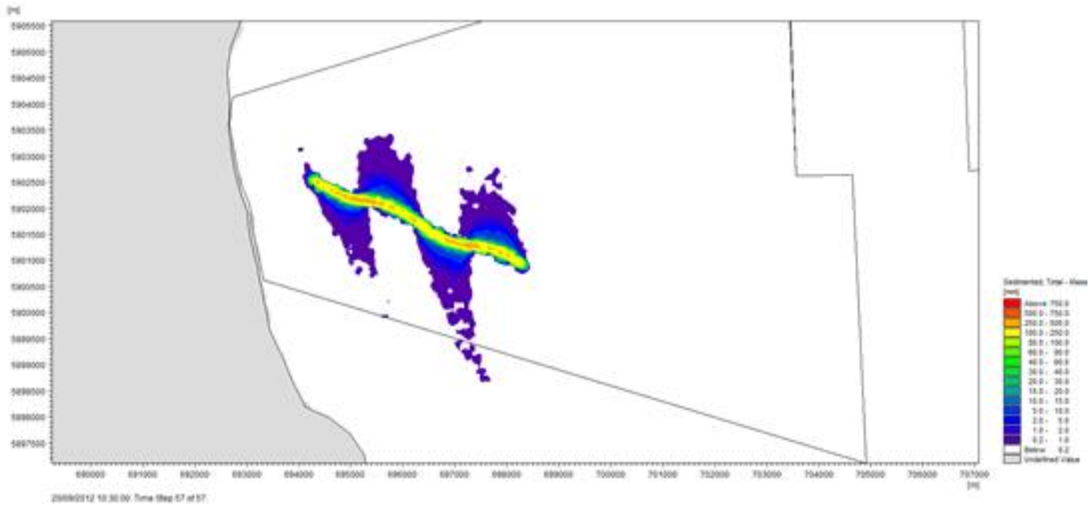

Figure 30 Maximum deposition thickness for export cable installation at Section 3 (spring tide, fine fraction only)

1.14.37 Based on the evidence above and expert judgement, the magnitude of the potential change to SSC and seabed height, from the installation of the export cables, is assessed in Table 11 based on the methodology outlined Section 1.5.

Table 11 Determination of magnitude for increases in SSC and deposition of disturbed sediments to the seabed from the installation of export cables

	Maximum design option	Alternative design options
Extent	All of the model simulations predicted high concentrations at the point of release (in the order of thousands mg/l), with concentrations falling to background levels (5 mg/l) within approximately 2 km. Sediment deposition is expected up to 2 km away from the trench, with maximum depths of deposition between 0.1 m and 0.5 m. Coarse sediments are expected to be spatially limited to within a few metres of the trench, although depositional thickness may be up to a few metres.	The temporary impact of increased SSC from the installation of export cables will be restricted to the near-field and the adjacent areas of the far-field (within one tidal cycle/ mean spring tidal excursion). The impact of deposition of disturbed sediments from the installation of export cables will be restricted to the near-field and the adjacent areas of the far-field.
Duration	The elevated SSCs and associated deposition of sediment is anticipated to be brief (i.e. lasting less than a day) following the completion of cable installation activities.	The elevated SSCs and associated deposition of sediment is anticipated to be brief (i.e. lasting less than a day) following the completion of cable installation activities.
Frequency	The export cables will be installed once, potentially in segments, during the construction phase.	The export cables will be installed once, potentially in segments, during the construction phase.
Probability	The predicted impacts can reasonably be expected to occur although the magnitude will be less as the modelled scenarios are provided for the use of MFE for trenching, which is to be used as a backfill methodology. Further details are provided in the Physical Processes Modelling and Design Options Comparison Report.	The predicted impacts can reasonably be expected to occur, although the magnitude will be less as the modelled scenarios are provided for the use of MFE for trenching, which is to be used as a backfill methodology. Further details are provided in the Physical Processes Modelling and Design Options Comparison Report.

	Maximum design option	Alternative design options
Consequence	Noticeable, but brief, changes in SSC concentrations occurring during the construction phase within the near-field and the adjacent areas of the far-field. Noticeable (linear features) to barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field.	Noticeable, but brief, changes in SSC concentrations occurring during the construction phase within the near-field and the adjacent areas of the far-field. Noticeable (linear features) to barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field.
Overall magnitude	*The potential magnitude of the predicted changes is rated as Low.*	*The potential magnitude of the predicted changes is rated as Low.*

Pathway 5: Increases in SSC and deposition of disturbed sediment to the seabed due to release of drilling mud

1.14.38 Bentonite (specifically sodium bentonite) is a non-toxic, inert, natural clay mineral (<63 µm particle diameter) that can be diluted with water and is commonly used as a drilling mud, lubricating the drill annulus and forming an impermeable filter cake that acts to control fluid loss. Used extensively in the marine environment, it has been most commonly used for trenchless installation techniques (such as Horizontal Directional Drilling (HDD) works and Direct Pipe operations) in the renewables industry and also in the Oil and Gas industry during drilling operations.

1.14.39 The requirement for drilling mud, such as bentonite (or another inert mud), during the drilling could result in the release of drilling mud within the shallow subtidal area at the Drilling Punch Out point. The bentonite may then be dispersed and transported by tidal currents. The principal issues relating to bentonite release comprises of the potential for an increase in SSC within an area and/or subsequent deposition, leading to a risk of smothering of benthic organisms should the material settle on the seabed, for example during low tidal flow states. The significance of such potential impacts relates to the degree to which SSC are elevated and the depth and temporal extent of any seabed deposition.

1.14.40 The greatest volume of drilling mud that may be released at the seabed is less than 20 m^3. As the bentonite is a fine-grained clay suspension, it is expected that it will take hours if not days to settle out of suspension, however, elevated SSC will be rapidly dispersed in ambient current conditions. The effects of the plume, following Drilling Punch Out will therefore be of very short duration and temporary at any given location. It can be expected that within one tidal cycle, the contribution of the bentonite to the local background levels of SSC will be negligible.

1.14.41 In terms of spatial extent, if the Drilling Punch Out location occurs in the subtidal zone then the currents advecting the plume are aligned parallel to the coast and so it is reasonable to assume that the plume will largely remain a similar distance from the coast. If the plume experiences sufficient lateral diffusion to reach the adjacent shoreline, then the corresponding SSC would be very low (within the range of naturally occurring values).

1.14.42 The majority, if not all, of the bentonite released will be held in suspension for days before settling. In this time, the individual grains will become dispersed widely over very large areas and so will not result in any measurable thickness of bentonite accumulation or change in seabed sediment type or texture.

1.14.43 During Drilling Punch Out of the second drill, it is anticipated that any bentonite released from a previous Drilling Punch Out will be sufficiently dissipated during the intervening time period so that there will be no measurable overlap.

1.14.44 Based on the evidence above and expert judgment, the magnitude of the potential change to SSC and seabed height, from release of bentonite, is assessed in Table 12 based on the methodology outlined in Section 1.5. No alternative options have been considered for the use of trenchless techniques (i.e. HDD or Direct Pipe), as this is considered the most appropriate option.

Table 12 Determination of magnitude for increases in SSC and deposition of bentonite[25]

	Maximum design option
Extent	The plume (per drill) is expected to be measurable within tens of metres from the area of release. No measurable thickness of bentonite deposition is expected.
Duration	The effect is anticipated to be brief (i.e. lasting less than a day) per drill.
Frequency	The impact described will occur up to twice during the construction phase, i.e. once per export cable.
Probability	The predicted impacts can reasonably be expected to occur.
Consequence	Noticeable but extremely brief changes in SSC concentrations occurring during the construction phase within the near-field and the adjacent areas of the far-field.
Overall magnitude	*The potential magnitude of the predicted changes is rated as Negligible.*

Pathway 6: Increases in SSC and deposition of disturbed sediment to the seabed due to sandwave clearance

1.14.45 To ensure effective burial below the level of the stable seabed, it may (in places) be necessary to first remove sections of sandwaves through the use of a TSHD, before trenching into the underlying seabed sediments. The total volume that could be dredged during sandwave clearance activities will be up to 10,800,000 m^3 for the IAC and 4,110,400 m^3 for the export cables (as shown in Table 6).

[25] No ADO presented as no alternative options have been considered for this operation, as the methodology described as the maximum design option is considered the most appropriate option.

1.14.46 In order to inform the assessment of potential changes to SSC and bed levels arising from sandwave clearance in the array area and the offshore ECC, plume modelling has been undertaken using the DAPPMS. Full results and detailed information regarding of the modelling simulations are provided the Physical Processes Modelling Report and have been summarised below.

1.14.47 As outlined in Paragraph 1.12.6, the scenarios modelled using DAPPMS are not all consistent with the MDO identified in Table 6. However, the MDO will not give rise to an effect that is more significant than those of the modelled scenarios, and therefore the results of sediment plume modelling are considered to be appropriate evidence for the assessment provided below. A full comparison of the modelled scenarios and MDO is presented in the Physical Processes Modelling and Design Options Comparison Report.

Overspill

1.14.48 The fate of the overspill sediment can be summarised as follows:

- Fine fractions as predicted by the DAPPMS:
  - Duration – The plume will not be detectable after an hour from release, with the majority of suspended settling out of the water column within approximately 30 minutes of release;
  - Concentration - The maximum concentrations will occur at slack water when levels increase to between approximately 110 mg/l and 160 mg/l at the end of the release, with the highest concentrations predicted when released within the south of the array area; and
  - Spatial extent – Concentrations arising from the overspill are small, with SSC typically 15 mg/l on spring tides and 25 mg/l on neap tides, with plumes from the release location observed (above 5 mg/l) for a distance of approximately 1 km.
- Coarse fractions – see Pathway 1.

1.14.49 Sediment deposition as a result of overspill is characterised as follows:

- Fine Fractions: Overspill footprints are larger and elongated in the direction of the tidal stream. The footprints for the overspill plume are generally 2 km long for a spring tide release, and 1.5 km for a neap tide release, with depths of typically 0.001 m to 0.002 m, with a maximum depth less than 0.01 m. Typically, they cover an area of approximately 900 m by 200 m, with settled depths of circa 0.002 m to 0.006 m; and
- Coarse fractions - The sediment released during the overspill will comprise of fine fractions (see above).

Disposal

1.14.50 The fate of the disposed sediment can be summarised as follows:

- The DAPPMS predicted concentrations up to 600 mg/l before settling immediately to the bed. The activity was confined within one model cell. These detailed nearfield processes are only relatively coarsely resolved in the model (at a resolution of approximately 100 m). Similar to the disposal assessed in Pathway 1, the level of SSC caused by all sediment types/ grain sizes together is realistically expected to be locally very high at the location of active disposal. The effect is very localised. It can be reasonably considered that the sediment in suspension during disposal will fall out within the order of minutes when deposited near the seabed.

1.14.51 The spoil mound dimensions of the coarse-grained sediments were calculated using the STFATE model (see the Physical Processes Modelling Report). The deposition of fine and coarse sediment fractions should be considered as additive in order to represent the magnitude of the potential changes. The Physical Processes Modelling Report provides full details of the results. The bed level changes associated with dredged material for foundation preparation can be summarised as follows:

- Fine fractions as predicted in the DAPPMS: The footprint and depths for the worst-case location predict a footprint of, approximately, 250 m by 200 m with depositional depths of circa 0.01 m (see Figure 31). The footprint of dredge disposal covers a smaller area, typically 250 m by 250 m, with a maximum depth of approximately 0.04 to 0.06 m; and
- Coarse fractions based on the STFATE modelling: The maximum depth of deposition for one dredger load was predicted to be circa 1.2 m when deposited on a slack tide at low water in the northern extents of the array area (see the Physical Processes Modelling Report)[23]. The maximum spatial extent of deposited material, exceeding a height of 0.3 m, was predicted to be approximately 9,523 m^2 for a single dredger load when deposited in the southern extent of the array. The maximum spatial extent of deposited material, exceeding a height of 0.05 m, was predicted to be approximately 23,226 m^2 for a single dredger load when deposited in the southern extent of the array.

1.14.52 The disposal of material may result in a slight change in the particle size composition of seabed sediments at the disposal location. For the purposes of assessment, all material will be disposed of within the array. Furthermore, the material generated from sandwave clearance being released and deposited is the same as that already present in the natural environment (and in the array area) and so will not affect seabed sediment character or be any more or less susceptible to remobilisation than the baseline environment, once initially deposited. Deposited sediments will be rapidly incorporated into the seabed and local accumulations will be subject to redistribution under the prevailing hydrodynamic conditions. The sediment transport system will disperse sediments where the particle size composition of deposited sediments is different to that of the local seabed, recovering towards a new equilibrium state over time.

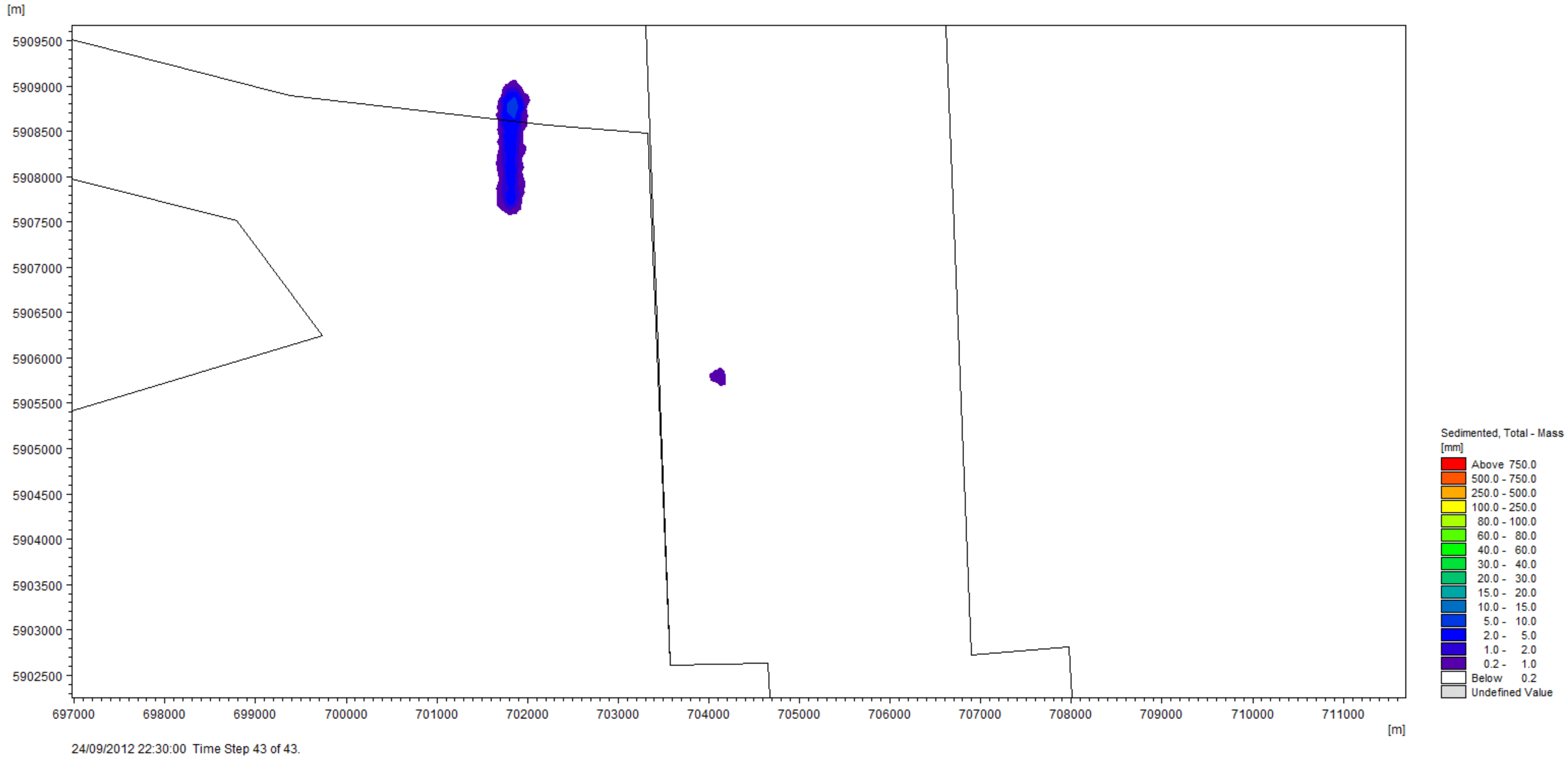

Figure 31 Maximum deposition thickness for sandwave clearance at Section 11 (on a neap tide, fine fraction only)

Magnitude

1.14.53 Based on the evidence above and expert judgement, the magnitude of the potential change to SSC and seabed height, from sandwave clearance, is assessed in Table 13 based on the methodology outlined Section 1.5.

Table 13 Determination of magnitude for increases in SSC and deposition of disturbed sediments to the seabed from the sandwave clearance

	Maximum design option	Alternative design option
Extent	The model predicted that the maximum extent of the detectable plume will be up to 1 km from the location of the overspill release. Disposal plume will be localised to disposal site. The maximum deposition footprint will be approximately 50,000 m^2 (250 m x 200 m).	The temporary impact of increased SSC and deposition from construction activities will be restricted to the near field and the adjacent areas of the far-field (within one tidal cycle/ mean spring tidal excursion).
Duration	The effect is anticipated to be momentary (seconds to minutes) to brief (i.e. lasting less than a day) following the completion of sandwave clearance activities.	The effect is anticipated to be momentary (seconds to minutes) to brief (i.e. lasting less than a day) following the completion of sandwave clearance activities.
Frequency	Sections of seabed will be identified for clearance and may be undertaken sequentially prior to cable installation. Sandwave clearance will be undertaken once per section identified for clearance during the construction phase.	Sections of seabed will be identified for clearance and may be undertaken sequentially prior to cable installation. Sandwave clearance will be undertaken once per section identified for clearance during the construction phase.
Probability	The predicted impacts can reasonably be expected to occur where sandwave clearance is required.	The predicted impacts can reasonably be expected to occur where sandwave clearance is required.
Consequence	Noticeable and barely discernible change in SSC concentrations frequently occurring during the construction phase within the near-field and the adjacent areas of the far-field respectively. Noticeable (mounds) and barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field respectively.	Noticeable and barely discernible change in SSC concentrations frequently occurring during the construction phase within the near-field and the adjacent areas of the far-field respectively. Noticeable (mounds) and barely discernible change (lateral footprint) in seabed height created during the construction phase within the near-field and the adjacent areas of the far-field respectively.
Overall magnitude	*The potential magnitude of the predicted changes is rated as Low.*	*The potential magnitude of the predicted changes is rated as Low.*

Pathway 7: Sandwave crest level preparation resulting in a change to local hydrodynamic, wave and sediment transport processes

1.14.54 The sandwave clearance process (as described in the Project Description Chapter) has the potential to change the local tidal and wave regimes, and so alter sediment transport processes. Detailed accounts of the local hydrodynamic and sedimentary processes are provided in the Physical Processes Technical Baseline. The naturally occurring processes governing the overall evolution of the sedimentary systems (the flow regime, water depths and sediment availability) are at a much larger scale than the area covered by Dublin Array, and so will not be affected by the proposed localised works (i.e. sandwave clearance).

1.14.55 Given the dynamic nature of sedimentary processes, the bedforms will recover/ reform providing that there is an adequate supply of sediment available within the system, with sediments typically being transported from the south through the proposed development (see the Physical Processes Technical Baseline for more details). 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 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). However, all such possible outcomes are consistent with the natural processes and bedform configurations that are already present in the study area and will not adversely affect the onward form and function of the individual bedform features.

1.14.56 Evidence for this recovery process is provided by monitoring data from the Race Bank wind farm off the east coast of the UK (DONG Energy, 2017). This includes pre-levelling, levelling, and post-levelling bathymetry data for 19 locations (over 12 monitoring sites), providing 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. The Race Bank OWF is located in an area of generally similar oceanographic and sedimentary conditions, with comparable water depths, predominantly sandy sediments and peak current speeds of between 1.0m/s to 1.2m/s (Centrica, 2009). Evidence from this location is therefore considered as an appropriate analogue for processes occurring at the Dublin Array area.

1.14.57 The Race Bank monitoring data (DONG Energy, 2017) indicates that locally levelled sandwaves continue to evolve in a manner that is consistent with recovery towards a new natural equilibrium state in the months to years post-levelling. There was evidence of partial to complete sandwave recovery at ten of the twelve monitoring sites within five months of levelling, consistent with the site being an active and dynamic sedimentary environment that is conducive to the development, maintenance and migration of sandwave bedforms.

1.14.58 This is further supported by evidence from Larsen *et al.* (2019), 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. This provides evidence 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 present) will not prevent continued evolution of the features through the same naturally occurring processes and the features will therefore recover towards a new equilibrium state over time.

1.14.59 The levelled areas are not considered likely to create a barrier to sediment movement and displaced material will not be removed from the sedimentary system. Evidence drawn from aggregate dredging activities indicates that if any changes occur to the flow conditions or wave regime, these are localised in close proximity to the dredge pocket (with width and lengths of several kilometres) (DONG Energy, 2017). The proposed works will be at much smaller scale and footprint, with trench widths of the order of 40 m. This means there is likely to be little to no influence on the flow or wave regime, which in turn means no change to the regional scale sediment transport processes across the array area and offshore ECC.

Table 14 Determination of magnitude change to local hydrodynamic, wave and sediment transport processes from sandwave crest levelling

	Maximum design option	Alternative design option
Extent	The maximum seabed footprint of sandwave clearance are as follows: ▪ Within the array area = approximately 2.8 km^2 ▪ Within the offshore ECC = approximately 1.0 km^2 All direct impacts will be limited to within the near-field.	The footprint of seabed footprint of sandwave clearance may range from: ▪ Within the array area = between approximately 1.6 km^2 and approximately 2.8 km^2 ▪ Within the offshore ECC = between approximately 0.4 km^2 and approximately 1.0 km^2 All direct impacts will be limited to within the near-field.
Duration	The impact is anticipated to be short-term (i.e. one to seven years).	The impact is anticipated to be short-term (i.e. one to seven years).
Frequency	Sandwave clearance will only be undertaken once during the construction phase of the proposed development.	Sandwave clearance will only be undertaken once during the construction phase of the proposed development.
Probability	The predicted impacts on sandbanks and sandwaves can reasonably be expected to occur.	The predicted impacts on sandbanks and sandwaves can reasonably be expected to occur.
Consequence	This sandwave clearance activity will necessarily result in localised and short-term changes to seabed topography.	This sandwave clearance activity will necessarily result in localised and short-term changes to seabed topography.
Overall magnitude	*The potential magnitude of the changes is judged to be Low.*	*The potential magnitude of the changes is judged to be Low.*

1.14.60 As detailed for Pathways 6 and 7, no changes have been identified to sediment transport or morphological features from the activities associated with the Dublin Array construction. Therefore, no infilling of navigation channels in the study, beyond that expected due to natural processes, are expected. Impact 1: Impacts to sandbank and sandwave receptors from construction activities

1.14.61 Sandbanks and sandwaves will be directly impacted by sandwave clearance operations, which could theoretically interrupt the supply of sediment within the system through alterations in the tidal and wave regimes (see Pathway 6 and 7). This assessment draws upon the conclusions presented in Pathway 6 and 7 above and is made with due regard to the identification of the sandbanks as having features consistent with those of Annex I habitat (Section 1.6.19). As such an assessment has been carried out to whether the project activities will affect the form and function of these seabed features.

1.14.62 As outlined in Table 7, the identification of the proposed offshore ECCs was carried out to avoid sandwave fields where possible. The volume of material to be cleared from individual sandwaves will vary according to the local dimensions of the sandwave (height, length and shape) and the level to which the sandwave must be reduced (also accounting for stable sediment slope angles).

1.14.63 The identified sandwave and sandbank receptors in the study area (see Figure 13) which may be impacted are:

- Sandbanks:
  - Kish Bank;
  - Bray Bank; and
  - Fraser Bank.
- Sandwaves:
  - In the northern and southern extents of the array;
  - On the landward side of the Kish Bank which extend into an export cable route which was associated with the now obsolete Poolbeg ECC route; and
  - Within the proposed offshore ECC route associated with landfall, approximately, 2.5 km offshore.

1.14.64 The total volume that could be dredged during sandwave clearance activities will be up to 10,800,000 m^3 for the IAC and 4,110,400 m^3 for the export cables, as outlined in Table 6. The sediments comprising the sandwave features will be predominantly sand, although a small proportion of fines and gravel may also be present. Individual sandwaves may require multiple dredging cycles to achieve the required width of corridor. All dredged material will remain within the array area and the plan is for it to be returned to the seabed in the vicinity of the dredged area in areas with a similar sediment type, and in areas with high currents speeds in order to allow for sediment to be redistributed into the sediment transport system.

1.14.65 The total volumes for the IAC include 1,200,000 m^3 to be dredged across the Kish and Bray Banks in order to facilitate IAC installation. This refers specifically to the IACs to be installed perpendicular to the Kish and Bray Banks, which require sandwave clearance up to a depth of 4 m in order to facilitate cable burial. A total of six IACs are to be installed over two locations, one located on the Kish Bank and one on the Bray Bank. At each location three IACs will be installed, with a target separation distance of between 400 m and 800 m between each trench. Whilst the trenches are open the sediment will be stored temporarily alongside the trench and utilised as backfill to ensure that the trench is closed after cable installation operations have taken place. Measures will be taken to ensure the potential for the loss of sediment prior to backfilling is minimised, including minimising the duration of time the material is stored and the distance the deposited material is located from the excavated trench.

1.14.66 These operations will result in the same potential impacts as those associated with more general sandwave clearance works along the offshore ECC and other IAC, including elevated SSC and associated deposition (Pathway 6), and modifications to local hydrodynamic, wave and sediment transport processes (Pathway 7). Assumptions regarding these operations for the purposes of assessment for EIA purposes are presented in Table 6.

1.14.67 The dredging of the trenches will be undertaken using a TSHD, with backfill operations expected to be carried out using the same methodology. The magnitude of the potential changes to SSC and associated sediment deposition is therefore consistent with that determined within Table 13 . Alternatively, backfill operations may be undertaken using MFE, in which case the magnitude of the potential change will be no greater than that outlined in Table 10 as part of Pathway 3.

1.14.68 The trenching operations have the potential to modify the local tidal and wave regimes, and so alter sediment transport processes, but will be no greater than those outlined in Pathway 7 (Paragraph 1.14.54 *et seq.*). As all trenches are to be backfilled after cable installation operations have taken place, the change to the seabed level across the sandbank will be temporary. Sediment will not be removed from the local sandbank system, with dredged sediment only temporarily displaced a short distance, therefore presenting minimal impacts to local sediment availability and budget. Trenches will only be present for timeframes in the order of weeks before being backfilled, with levelled areas and bedforms expected to recover given the dynamic nature of sedimentary processes on the sandbank. This is supported by the evidence provided in Pathway 7, and the magnitude of this potential change is consistent with that determined within Table 14 . Post-lay asset and integrity surveys will be carried out along all cable routes, including at the sandbank crossing locations, which will record the as-built seabed level and evidence that the seabed (including the sandbank), as far as is reasonably practicable, has been returned to a comparable condition to its pre-construction state.

1.14.69 Site specific mobility analysis has indicated that the sandbanks identified as receptors each have actively migrating sandwave bedforms on their flanks and crests. The larger Kish and Bray Banks are characterised by lateral crest movement of between 4 m/yr and 10 m/yr, in addition to the presence of sandwaves with an average migration rate between 2 m/yr to 10 m/yr (ABPmer, 2022). The presence of these bedforms is evidence of a dynamic seafloor with ongoing sediment mobility processes, which will continue throughout and after sandwave clearance operations have taken place. Once sediment is redeposited, disturbed sediment will immediately re-join the local and regional sedimentary system, with minimal potential to affect the form and function of the wider sandbank system.

1.14.70 The tidal current regime, with spring tidal current speeds between approximately 0.8 m/s and 1.4 m/s, is sufficiently strong to cause the mobility of sand. As demonstrated in Pathway 7, the volume of sediment available in each local system will be retained during the trenching operation and will not change in an overall net sense. The tidal current regime will not be measurably impacted as a result of the localised levelling of sandwaves and although the volume of sediment available in each local system will be locally redistributed by the levelling, there will be no net loss. As the controlling factors will also not change, the affected areas and sandwave features will have the potential to recover in time to a new, dynamically evolving natural state.

1.14.71 The magnitude of the potential impacts to sandbank and sandwave receptors (as defined in Table 6) is assessed in Table 15 based on the methodology outlined in Section 1.5. The sensitivities of the receptors to the potential impact are assessed in Table 16.

Table 15 Determination of magnitude for impacts to sandbank and sandwave receptors

	Maximum design option	Alternative design option
Extent	The maximum footprint which could be affected are as follows: ▪ Within the array area = approximately 2.8 km^2 ▪ Within the offshore ECC = approximately 1.0 km^2 All direct impacts will be limited to within the near-field.	The footprint of seabed which could be affected by sandwave clearance may range from: ▪ Within the array area = between approximately 1.6 km^2 and approximately 2.8 km^2 ▪ Within the offshore ECC = between approximately 0.4 km^2 and approximately 1.0 km^2 All direct impacts will be limited to within the near-field.
Duration	The impact is anticipated to be short-term (i.e. one to seven years).	The impact is anticipated to be short-term (i.e. one to seven years).
Frequency	Sandwave clearance and trenching works will only be planned to be undertaken once during the construction phase of the proposed development.	Sandwave clearance and trenching works will only be planned to be undertaken once during the construction phase of the proposed development.
Probability	The predicted impacts on sandbanks and sandwaves can reasonably be expected to occur.	The predicted impacts on sandbanks and sandwaves can reasonably be expected to occur.

	Maximum design option	Alternative design option
Consequence	This sandwave clearance activity will necessarily result in localised and short-term changes to seabed topography.	This sandwave clearance activity will necessarily result in localised and short-term changes to seabed topography.
Overall magnitude	*The potential magnitude on sandbank and sandwave receptors is judged to be Low.*	*The potential magnitude on sandbank and sandwave receptors is judged to be Low.*

Table 16 Determination of sensitivity for sandbanks and waves to potential changes to local hydrodynamic, wave and sediment transport

Sandbanks and sandwaves	Justification
Context	**Adaptability:** The predicted tidal and wave regimes, and therefore sedimentary transport processes, are consistent with the natural processes and bedform configurations that are already present in the study area. These changes therefore will not adversely affect the onward form and function of the individual bedform features. **Tolerance:** The environment has a moderate capacity to accommodate the proposed form of change. **Recoverability:** Given the dynamic nature of sedimentary processes the bedforms will recover/ reform providing that there is an adequate supply of sediment from the system. The proposed trenching works will not result in any net loss of sediment from the sandbank system. For trenching works, the seabed level will be returned to a comparable condition to its preconstruction state as far as is reasonably practical, thereby accelerating the recovery process.
Value	The sandbanks are of national importance[26]. The sandwaves are of local importance as they can help to reduce wave energy reaching the shoreline and have ecological value.
Overall sensitivity	*The potential sensitivity on sandbanks is rated as Medium.* *The potential sensitivity on sandwaves is rated as Low.*

1.14.72 The magnitude of the impact has been assessed as **Low**, with the maximum sensitivity of the sandbank receptors being **Medium**. Therefore, the significance of potential changes to local hydrodynamic, wave and sediment transport processes occurring as a result of sandwave crest preparation activities in the array area and ECC areas is **Slight adverse**, which is not significant in EIA terms.

[26] The sandbanks are not designated as a European site under S.I. No. 477/2011, as amended, but are nonetheless representative of the habitat type 'sandbanks which are slightly covered by seawater all of the time', and are therefore a natural habitat that is subject to conservation obligations under these regulations which transpose the Habitats and Birds Directives.

1.14.73 The magnitude of the impact has been assessed as **Low**, with the maximum sensitivity of the sandwaves receptors being **Low**. Therefore, the significance of potential changes to local hydrodynamic, wave and sediment transport processes occurring as a result of sandwave crest preparation activities in the array and ECC areas is **Slight adverse**, which is not significant in EIA terms.

1.14.74 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect

1.14.75 The significance of effect from changes to local hydrodynamic, wave and sediment transport processes is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 7 is considered necessary. Therefore, **no significant adverse residual effects** have been predicted in respect of local hydrodynamic, wave and sediment transport processes.

Impact 2: Impacts to coastlines from construction activities

1.14.76 The proposed activities and temporary infrastructure at landfall (i.e. the use of a trenchless technologies) will not directly interact with any coastal defences. In addition, no source-pathway-receptor-has been identified from the proposed development which would result in changes to coastal flooding as a result of landfall activities (or any other wind farm construction activities).

1.14.77 The use of trenchless techniques (i.e. HDD or Direct Pipe) is proposed as the methodology to make landfall. Depending upon the position of the exit pits and associated mounds in the subtidal, they may have the potential to modify the nearshore wave regime and therefore seabed morphology. In particular, localised changes in water depth over the pits and mounds could, in theory, allow a greater or differently distributed transmission of wave energy to the coast. This in turn may cause a localised morphological response. Such an impact is likely to be more pronounced the closer to shore or the shallower the waters in which the exit pits are located. The location of the exit pits will be designed post-consent following detailed engineering work as outlined in the Project Description Chapter.

1.14.78 The magnitude of the potential impacts to coastal features is assessed in Table 17 , based on the methodology outlined in Section 1.5, for the identified receptors. The sensitivities of the receptors to the potential impact are assessed in Table 18 No alternative options have been considered for the use of trenchless techniques (i.e. HDD or Direct Pipe), as this is considered the most appropriate option.

Table 17 Determination of magnitude for impacts from the use of trenchless installation techniques

	Maximum design option
Extent	The maximum footprints which could be affected are as follows: ▪ Drilling Punch Out dimensions: 5 m (wide) x 35 m (length) x 2.5 m depth All direct impacts will be limited to within the near-field.
Duration	The trenchless operations and cable installation period will last for up to three months. Following infill of the exit pits, no further impacts are anticipated to occur. Therefore, the impact is anticipated to be temporary (i.e. less than one year).
Frequency	Trenchless operations will only be undertaken once per export cable during the construction phase of the proposed development.
Probability	The predicted impacts on the physical processes can reasonably be expected to occur.
Consequence	The exit pits (and any associated spoil mounds) will be temporary features and it is anticipated that they would only be present for a short period (up to a few weeks) before the excavated material was used to backfill the pits. Accordingly, the potential for longer term morphological change arising from changes to the tidal and/or wave regime is considered to be very small.
Overall magnitude	*The potential magnitude on morphological changes at the coast is judged to be Low.*

Table 18 Determination of sensitivity of the coast to potential changes in local hydrodynamic, wave and sediment transport

Coastline	Justification
Context	**Adaptability:** All possible alterations to coastal processes are consistent with the natural processes and variability that are already present in the study area and will not adversely affect the onward form and function of the coastline features. **Tolerance:** The coast of County Dublin is susceptible to wave action, tidal and storm surges and is highly predisposed to geomorphological change from active erosion and deposition processes. The Shanganagh coastline is therefore potentially susceptible to the natural processes of coastal erosion, coastal flooding and/or sea level rise. **Recoverability:** No discernible change from baseline is predicted on the morphology of the coastline due to the use of trenchless techniques at landfall. Consequently, recoverability is not relevant here.
Value	The coastlines in the study, some of which are designated, are typically highly populated and have high socio-economic value.
Overall sensitivity	*The potential sensitivity of the coastline is rated as High.*

1.14.79 The magnitude of the impact has been assessed as **Low**, with the maximum sensitivity of the coastline being **High**. Therefore, the significance of potential changes to coastal processes occurring as a result of the use of trenchless techniques is **Moderate** which is not significant in EIA terms.

Residual effect

1.14.80 The significance of effect from changes to coastal processes is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 7 are considered necessary. Therefore, **no significant adverse residual effects** have been predicted in respect of local hydrodynamic, wave and sediment transport processes at the coast.

1.15 Environmental assessment: operational phase

Operation pathways

Pathway 8: Changes to the tidal regime

1.15.1 Each WTG and OSP foundation will present an obstacle to the passage of currents locally, causing a small modification to the height and/or phase of the water levels and a wake in the current flow. This latter process involves a deceleration of flow immediately upstream and downstream of each foundation and an acceleration of flow around the sides of each foundation. Current speeds return to baseline conditions with progression downstream of each foundation and generally do not interact with wakes from adjacent foundations due to the separation distances. There exists a close relationship between flow speed and bedform type (e.g. Belderson *et al*., 1982) and thus any changes to flows have the potential to alter seabed morphology over the lifetime of the project.

1.15.2 However, there is a strong scientific evidence base which demonstrates that the changes in the tidal regime due to the presence of foundation structures are both small in magnitude and localised in spatial extent. This is confirmed by existing guidance documents (ETSU 2000; ETSU 2002; COWRIE 2009).

1.15.3 As outlined in Paragraph 1.12.6, the scenarios modelled using DAPPMS are not all consistent with the MDO identified in Table 6. However, the MDO will not give rise to an effect that is more significant than those of the modelled scenarios, and therefore the results of hydrodynamic blockage modelling are considered to be appropriate evidence for the assessment provided below. A full comparison of the modelled scenarios and MDO is presented in the Physical Processes Modelling and Design Options Comparison Report.

1.15.4 DAPPMS predicted changes to water levels, on both mean spring and mean neap tides, with the proposed foundations installed in the array area to be very small. Predicted changes for all states of the tide are less than circa 0.1 cm (1 mm), with the exception of the peak flood and ebb stages of a mean spring tide, where changes of up to ± 0.2 cm (2 mm) are predicted. Such changes are, in reality, immeasurable (see Figure 32). This occurs along the southern most edge of the array area and at small, isolated locations within the array area. The maximum extent of this small change beyond the array area is up to, approximately, 2 km from the southern edge of this site. No measurable changes of tidal levels are predicted at the coastline[27]. A more detailed analysis is provided in the Physical Processes Modelling Report.

[27] Very small differences in water level at the nearshore (as seen at Dublin harbour) are not considered to be effects related to the OWF development but are an artefact of the model numerical flooding and drying scheme. Therefore, these changes in water level at the nearshore will are not anticipated to occur following the construction of the proposed development. See the Physical Processes Modelling Report for more details.

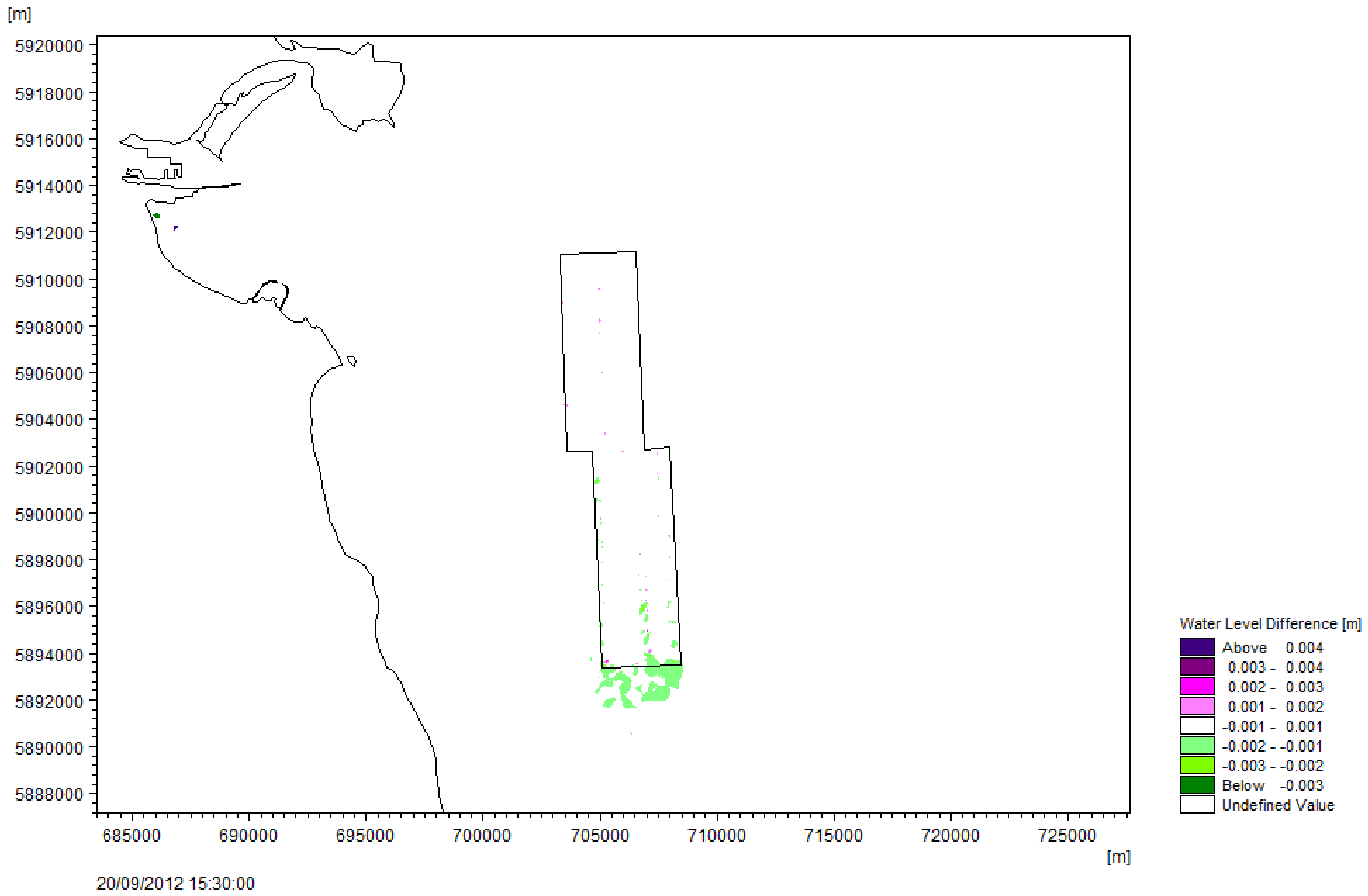

Figure 32 Difference in water levels during mean spring tide on a peak ebb

1.15.5 The predicted changes to current speeds due to the presence of offshore infrastructure for Dublin Array are very small. Changes of greater than ±0.01 m/s (0.019 knots) are shown to occur within the array area, and its immediate surroundings (see Figure 33). No measurable changes of current speed are predicted at the coastline. As a general pattern, flow speed changes of greater than ±0.01 m/s (0.019 knots) are seen to occur in a north to south axis, aligning with the direction of the tidal stream. The maximum modelled changes to current speed magnitudes are limited to ±0.04 m/s (0.078 knots), with the greatest scales of change observed on mean spring tides. During mean spring tides, the greatest changes to magnitude occur during the flooding and ebbing phase of the tide (see Figure 33). A more detailed analysis is provided in the Physical Processes Modelling Report.

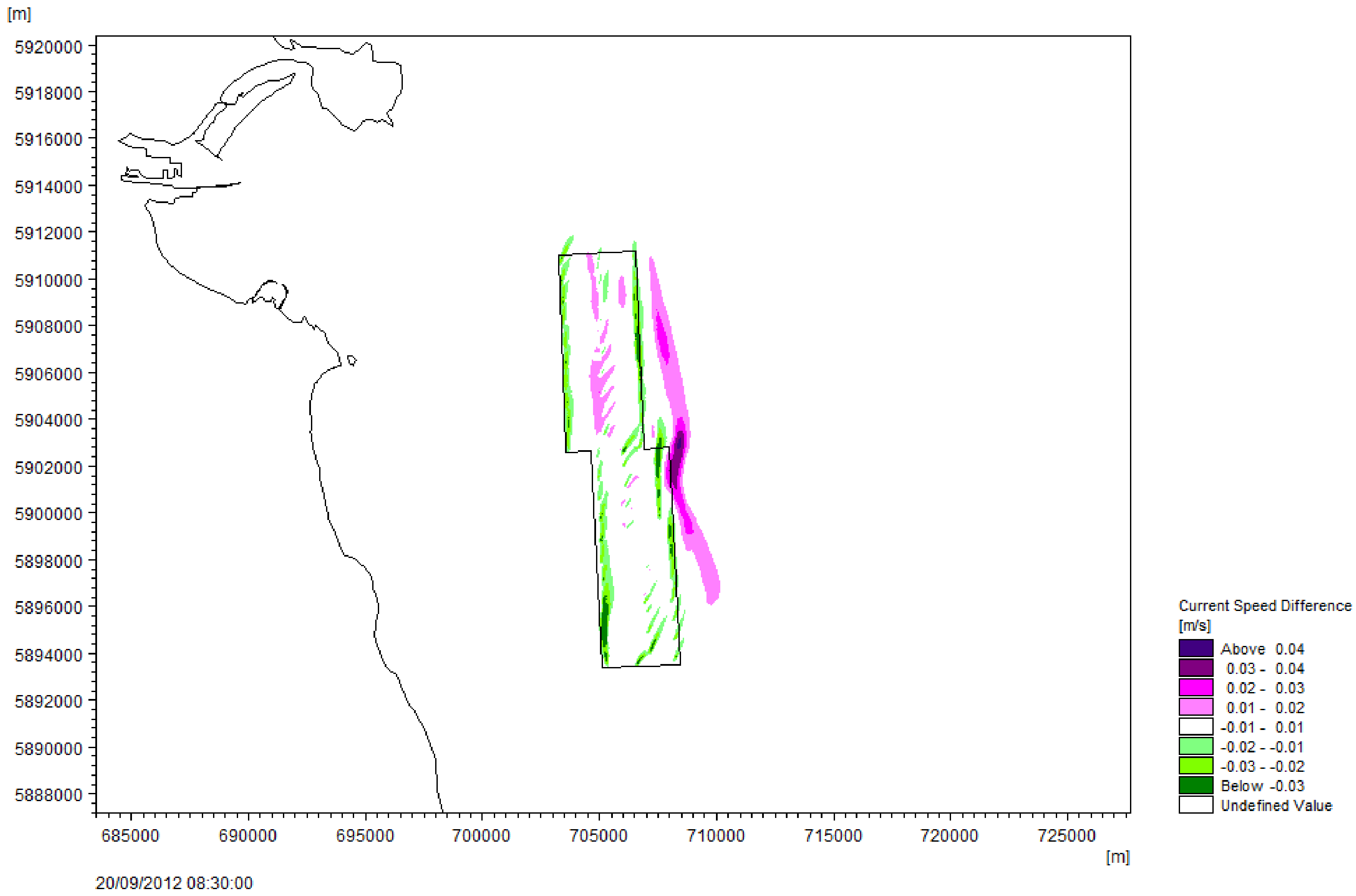

Figure 33 Difference in mean spring tide current speed at peak flood

1.15.6 Based on the evidence above and expert judgement, the magnitude of the potential change to the tidal regime, from the presence of structures, is assessed in Table 19 based on the methodology outlined in Section 1.5.

Table 19 Determination of magnitude for changes in the tidal regime

	Maximum design option	Alternative design options
Extent	The changes will be within the array area and its immediate surroundings. No changes are anticipated at the coast.	The changes will be within the array area and its immediate surroundings. No changes are anticipated at the coast.
Duration	The changes would be long-lasting, i.e. throughout the operational phase of the project.	The changes would be long-lasting, i.e. throughout the operational phase of the project.
Frequency	All changes will occur on each tide during the operational phase of the project.	All changes will occur on each tide during the operational phase of the project.
Probability	The predicted impacts can reasonably be expected to occur.	The predicted impacts can reasonably be expected to occur.
Consequence	No discernible change in the tidal regime, throughout the operation of Dublin Array, will be encountered within the near-field and the adjacent areas of the far-field.	No discernible change in the tidal regime, throughout the operation of Dublin Array, will be encountered within the near-field and the adjacent areas of the far-field.
Overall magnitude	*The potential magnitude of the predicted changes is rated as Negligible.*	*The potential magnitude of the predicted changes is rated as Negligible.*

Pathway 9: Changes to the wave regime

1.15.7 The presence of foundation structures within the array area will have the potential to alter the baseline wave regime, particularly in respect of wave heights and directions. Any changes in the wave regime may have the potential to contribute to changes in the seabed morphology due to alteration of sediment transport patterns or due to initiation of seabed scour.

1.15.8 Expert-based assessment suggests that each foundation will present an obstacle, or blockage, to the passage of waves locally, causing a small modification to the height and/or direction of the waves as they pass. Generally, this causes a small wave shadow effect to be created by each foundation. Wave heights return to baseline conditions with progression downstream of each foundation and generally do not interact with effects from adjacent foundations due to the separation distances. This is supported by evidence from Round 1, Round 2, and Round 3 windfarms in UK and European waters (Seagreen, 2011).

1.15.9 There is a strong evidence base from modelling studies and constructed windfarms which demonstrates that the changes in the wave regime due to the presence of foundation structures, even under a worst-case scenario of the largest surface area of structures in the water column, are both relatively small and localised in spatial extent. Typically, the foundation types with the largest surface area in the water column are gravity base foundations which are not included with the project design of Dublin Array (see the Project Description Chapter). This is confirmed by a review of modelling studies from around 30 wind farms in the UK and European waters (Seagreen, 2011), existing guidance documents (ETSU 2000; ETSU 2002; COWRIE 2009), published research (Ohl *et al*., 2001) and post-installation monitoring (Cefas, 2005).

1.15.10 The blockage effects on the wave climate due to the operational phase of the Dublin Array offshore infrastructure were modelled using the DAPPMS SW model. As outlined in Paragraph 1.12.6, the scenarios modelled using DAPPMS are not all consistent with the MDO identified in Table 6. However, the MDO will not give rise to an effect that is more significant than those of the modelled scenarios, and therefore the results of wave blockage modelling are considered to be appropriate evidence for the assessment provided below. A full comparison of the modelled scenarios and MDO is presented in the Physical Processes Modelling and Design Options Comparison Report.

1.15.11 The model predicted that the changes to significant wave heights[28] would be limited to within the array area and its immediate vicinity (up to 200 m from the array boundary) (further detail is presented in the Physical Processes Modelling Report). The model predicted some scattered and localised impacts in the wave regime at the nearshore (as seen at Dublin Port). However, these are not considered to be effects related to the OWF development but are instead an effect of the model's numerical solution along its' coastal boundary. These changes in waves at the nearshore will not be anticipated to occur in reality following the construction of the proposed development[29]. Based on the DAPPMS results, expert judgement, and evidence from existing offshore wind farms (Cefas, 2005), there are no changes in the wave regime anticipated at the coast.

1.15.12 For wave scenarios approaching from the north, east and south there is a predicted reduction in significant wave height due to the array structures modelled simulations. Within the array area, there are very localised areas where an increase in wave height is predicted for the north, east and west scenarios (see Figure 34). This generally occurs over a couple of the model cells equating to, approximately, 100 m distance from the turbines. The effect is most frequently predicted in the shallower parts of the array area and may be due to waves slowing and steepening locally due to the blocking effects of the OWF infrastructure. The changes to the wave regime will be small in both absolute and relative terms (Physical Processes Modelling Report). For example, a maximum of 0.04 m reduction in significant wave height at 200 m outside the array area (under a 1 in 100 year condition from east). Therefore, no source-pathway-receptors have been identified which would result in changes to coastal flooding as a result of the development.

[28] Average wave height of the highest 1/3 of waves in a timeseries.
[29] See the Physical Processes Modelling Report for more details.

1.15.13 Differences in wave height of this magnitude are small in both relative and absolute terms. Such small differences are not measurable in practice and would be indistinguishable from normal, short term natural variability in wave height (both for individual wave heights and in terms of the overall sea state). Accordingly, these changes are not predicted to have any indirect impact on coastal morphology through changes to sediment transport. Nor are these wave height changes expected to have any influence upon the form and function of the identified sandbanks which correspond with an Annex I habitat type, within the array area.

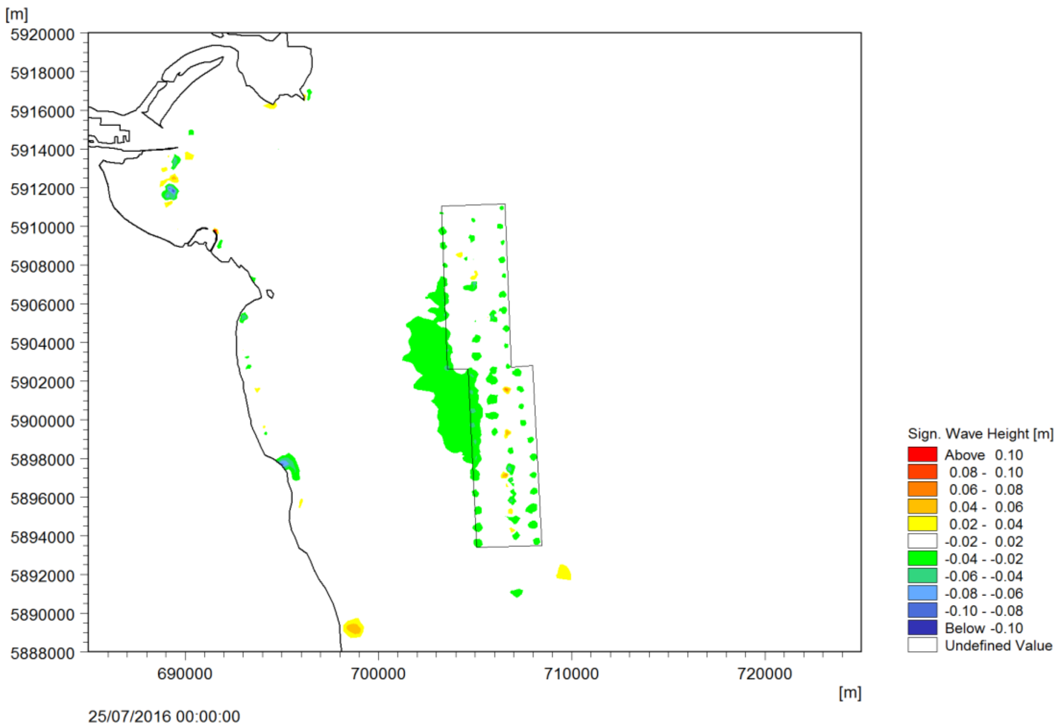

Figure 34 Absolute difference in significant wave heights for the 1 in 100-year scenario from east

1.15.14 Based on the evidence above and using expert judgement, the magnitude of the potential change to the wave regime, from the presence of structures, is assessed in Table 20 based on the methodology outlined in Section 1.5.

Table 20 Determination of magnitude for changes in the wave regime

	Maximum design option	Alternative design options
Extent	The changes will be within the array area and its immediate surroundings. No changes are anticipated at the coast.	The changes will be within the array area and its immediate surroundings. No changes are anticipated at the coast.
Duration	The changes would be long-lasting, i.e. throughout the operational phase of the project.	The changes would be long-lasting, i.e. throughout the operational phase of the project.
Frequency	The changes will occur throughout the operational phase of the project.	The changes will occur throughout the operational phase of the project.
Probability	The predicted impacts can reasonably be expected to occur.	The predicted impacts can reasonably be expected to occur.

	Maximum design option	Alternative design options
Consequence	No discernible change in the wave regime, throughout the operation of Dublin Array, will be encountered within the near-field and the adjacent areas of the far-field.	No discernible change in the wave regime, throughout the operation of Dublin Array, will be encountered within the near-field and the adjacent areas of the far-field.
Overall magnitude	*The potential magnitude of the predicted changes is rated as Negligible.*	*The potential magnitude of the predicted changes is rated as Negligible.*

Pathway 10: Changes to sediment transport and sediment transport pathways

1.15.15 Sandy sediments are transported in two modes: bedload and saltation. Saltation is the process by which sands are moved up into the water column. Bedload is the process by which sands move while still in contact with the seabed. The sediment on the seabed is transported when it is exposed to large enough forces, or bed shear stresses, by the water movements. These movements can be caused by the tidal currents, the wave orbital velocities or a combination of both.

1.15.16 Existing sediment transport pathways could be altered in response to changes in the wave and tidal regimes as a result of the presence of wind farm structures. As noted above, the magnitude of the changes for the tidal and wave regimes are small differences and not measurable in practice and would be indistinguishable from normal short-term natural variability. Accordingly, these changes are not predicted to have any measurable influence on longshore sediment transport. This is supported by the analysis of the changes in bed shear stress within the array area with the structures present. The analysis demonstrated that the differences in bed shear stress were very small, with the largest differences in the north of the array either side of the Kish Bank (modelled sites Ob_K_01 and Ob_K_03, see the Physical Processes Modelling Report for more details) occurring at peak flows. The absolute differences are very small (c.0.02 N/m^2) (see Figure 35) and indicate no meaningful change to the sediment regime will occur at these locations. For context, bed shear stress values of 0.12 N/m^2 are required to transport fine sand grains.

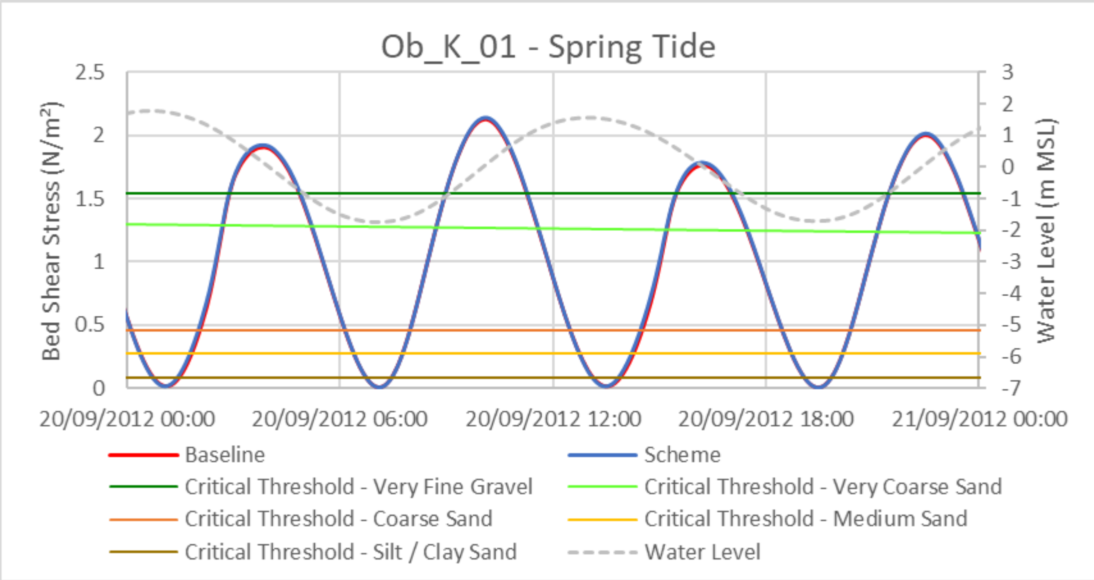

Figure 35 Comparison of baseline and with Dublin Array (scheme) bed shear stress and critical erosion thresholds for a mean spring tide at Ob_K_01

1.15.17 The presence of cable protection measures may also have the potential to cause a direct (albeit highly localised) blockage of sediment transport. Installation of cable protection could result in a local elevation of the seabed profile by up to 1 m (Table 6). Cable protection would be placed onto the seabed surface above the cable and therefore could directly trap sediment, locally impacting down-drift locations.

1.15.18 Following installation and under favourable conditions, an initial period of sediment accumulation would be expected to occur, creating a smooth slope against the cable protection. The process of wedge formation may take place over a period of a few weeks to months, depending on rates of sediment transport.

1.15.19 Suspended sediments would be expected to move relatively freely over the top of the cable protection although to begin with would regularly be deposited upon it, filling void spaces. 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 bed form migration) will remain unaffected. The process of void infilling is expected to occur relatively quickly (in the order of a few months). This is due to saltation as well as the anticipated high rates of transport in areas of mobile seabed (which is where much of the cable protection is anticipated).

1.15.20 Bedload will be temporarily affected until such time that the cable protection is covered by sand and the slope gradient either side has been reduced in response to the accumulation of a sediment wedge with stable slope angles (approximately 30 degrees). Following this, bedload will continue because the slope angle presented by sections of protected cable would be within the natural range of bed slope angles associated with bed forms mapped within the offshore ECC and array area.

1.15.21 Accordingly, for all areas in which cable protection is used (including where sandwaves are present), it is not expected that the presence of the cable protection will continuously affect patterns of sediment transport following the initial period of accumulation. It follows that any changes on seabed morphology away from the cable protection will also be very small. The extent of the cable protection measures does not constitute a continuous blockage along the export cable route corridors or in the array.

1.15.22 There is also the expectation that cable protection measures may result in scour development. Given the projected dimensions of any protection, including its extent along the cable route, it is anticipated that any such morphological response will be on a smaller scale than expected around the foundations.

1.15.23 A thorough Cable Burial Risk Assessment (CBRA) as outlined in the Project Description Chapter will be undertaken, and it is therefore considered unlikely that cables will become exposed throughout the lifetime of the project. If a section of cable (IAC or export cable) were to become exposed, it might locally influence physical processes and morphology at a scale proportional to the diameter of the cable (order of a few tens of centimetres) and the length of the exposed section. The cable may become naturally reburied or could require reburial using similar techniques to during construction. An assessment of resultant SSC and subsequent bed level changes associated with maintenance activities has been undertaken in Pathway 11. However, it is noted that it is unlikely that cables will become exposed as this will be mitigated against through a thorough cable burial risk assessment.

1.15.24 Although areas of mobile sediments are present along the cable routes, this will be taken into account pre-construction, and the appropriate plans implemented for these areas in order to ensure either sufficient burial depths are reached, or, alternatively, that additional cable protection is installed. Where maintenance activities are required, they would be undertaken using similar techniques to that set out in the assessment associated with cable installation activities. The lengths of exposed cable would be shorter, the potential impacts would likely be more localised and to occur over a shorter duration than those considered during the construction phase. Based on the evidence above and using expert judgement, the magnitude of the potential change to the sediment regime, from the presence of structures and cable protection, is assessed in Table 21 based on the methodology outlined in Section 1.5.

1.15.25 As detailed for Pathway 10, no changes have been identified to sediment transport or morphological features from the presence of offshore infrastructure associated with Dublin Array. Therefore, no infilling of navigation channels in the study, beyond that expected due to natural processes, are expected.

Table 21 Determination of magnitude for changes in the sediment transport system

	Maximum design option	Alternative design options
Extent	The changes will be within the array area, offshore ECC and its immediate surroundings. No changes are anticipated at the coast.	The changes will be within the array area, offshore ECC and its immediate surroundings. No changes are anticipated at the coast.
Duration	The changes would be long-lasting, i.e. throughout the operational phase of the project for those associated with the presence of foundation structures. The changes associated with cable protection material would be temporary.	The changes would be long-lasting, i.e. throughout the operational phase of the project for those associated with the presence of foundation structures. The changes associated with cable protection material would be temporary.
Frequency	The changes will occur throughout the operational phase of the project.	The changes will occur throughout the operational phase of the project.
Probability	The predicted impacts can reasonably be expected to occur.	The predicted impacts can reasonably be expected to occur.
Consequence	No discernible changes would occur to the sediment transport pathways as a result of the presence of structures in the array area and cable protection material.	No discernible changes would occur to the sediment transport pathways as a result of the presence of structures in the array area and cable protection material.
Overall magnitude	*The potential magnitude of the predicted changes is rated as Negligible.*	*The potential magnitude of the predicted changes is rated as Negligible.*

Pathway 11: Increases in SSC and deposition of disturbed sediment to the seabed during O&M

1.15.26 If a section of the cable (IAC or export cable) became exposed or damaged it would require reburial and/or replacement. Of note is that potential for this to occur will be reduced through the undertaking of a CBRA pre-installation. Further, monitoring of the export and IAC at Arklow Bank, located in a similar environmental setting, concluded that there was no evidence of scour, apart from local to the turbine foundations (Department of Energy and Climate Change (DECC), 2008). Reburial (or replacement) would be undertaken using similar techniques to that set out in the assessment of SSC and bed level changes associated with cable installation activities (see Pathways 3 and 4). The lengths of exposed cable would be shorter, the potential impacts would likely be more localised and to occur over a shorter duration than those considered during the construction phase. This is supported by BERR (2008) which noted that the impact of cable reburial operations mainly relates to a localised and temporary re-suspension and subsequent settling of sediments. Therefore, the magnitude of these potential impacts would be **Low**.

Pathway 12: Scour of seabed sediments

1.15.27 The term scour refers here to the development of pits, troughs or other depressions in the seabed sediments around the base of foundations. Scour may also develop in response to the placement of cable protection material. However, given the smaller requirements for cable protection in comparison to the number of WTG foundations proposed within the array area, it is considered that the extent of such scour will be considerably less. As such, scour resulting from the placement of WTG foundations is considered to represent the MDO for EIA purposes.

1.15.28 Scour is the result of net sediment removal over time due to the complex three-dimensional interaction between the foundation and ambient flows (currents and/or waves). Such interactions result in locally accelerated mean flow and locally elevated turbulence levels that also locally enhance sediment transport potential. The resulting dimensions of the scour features and their rate of development are, generally, dependent upon the characteristics of the:

- Obstacle (dimensions, shape and orientation);
- Ambient conditions such as the tidal flow and wave; and
- Seabed sediment properties.

1.15.29 As scour is a dynamic process, it's greatest extent (depth; footprint) will develop during high energy periods and will therefore be short-lived. Equilibrium principles are such that, once the energy reduces, the scour holes will begin to refill (DECC, 2008).

1.15.30 Following the development of scour pits, the seabed area may become modified from its natural state in several ways, including:

- A different (coarser) surface sediment grain size distribution may develop due to winnowing of finer material by the more energetic flow within the scour pit;
- A different surface character will be present if scour protection (e.g. rock protection) is used;
- Seabed slopes may be locally steeper in the scour pit; and
- Flow speed and turbulence may be locally elevated.

1.15.31 The magnitude of the change to the seabed is assessed in Table 22 based on the methodology outlined in Section 1.5. A quantified assessment of the scour potential around the array infrastructure is provided in the Physical Processes Modelling Report. Here it is shown that the greatest potential for scour occurs, in the absence of scour protection, for the Option B WTG monopile foundation option and is of the order of 95,567 m^2 which is equivalent to 0.16% of the total array area.

1.15.32 The underlying geology within the array, as determined from a series of boreholes, is indicative of scour resistant material. Bands of clay, gravel and sand are present in various combinations whilst bedrock is comprised of limestone. Further detail is provided in the Physical Processes Technical Baseline.

1.15.33 Of relevance to the current development are observations made of scour development at Arklow Bank, an offshore wind farm development in a comparable sandbank setting to that of Dublin Array. Post-construction monitoring indicated that the interval between foundation and scour protection installation was sufficient to allow scour to develop. However, once scour protection was installed, the secondary scour that developed was considered to be minimal (DECC, 2008). Of further note is that, following an assessment of the monitoring data collected at sites constructed following the UK Crown Estate first offshore wind farm leasing round, the spatial development of scour beyond holes i.e. to 'tails'/ wakes, was only observed at Scroby Sands (Lambkin *et al.*, 2009).

Table 22 Determination of magnitude for impacts to receptors from scour

	Maximum design option	Alternative design options
Extent	The maximum footprint, in the absence of scour protection, which could be affected by the development of scour pits is approximately 95,567 m^2.	The footprint, in the absence of scour protection, which could be affected by the development of scour pits will range from between approximately 42,529 m^2 and approximately 95,567 m^2.
Duration	The development is anticipated to be temporary (i.e. less than one year) to short term (i.e. one to seven years) until the scour pit reaches equilibrium. Following the pits development, they are anticipated to be present for as long as the infrastructure is present. Monitoring of scour development around monopile foundations in UK offshore wind farm sites suggest that the time-scale to achieve equilibrium conditions can be of the order of 60 days in mobile seabed environments (Harris *et al*., 2010).	The development is anticipated to be temporary (i.e. less than one year) to short term (i.e. one to seven years) until the scour pit reaches equilibrium. Following the pits development, they are anticipated to be present for as long as the infrastructure is present. Monitoring of scour development around monopile foundations in UK offshore wind farm sites suggest that the time-scale to achieve equilibrium conditions can be of the order of 60 days in mobile seabed environments (Harris *et al*., 2010).
Frequency	Scour pits would develop once (in the absence of scour protection) following the installation of structures until an equilibrium is met.	Scour pits would develop once (in the absence of scour protection) following the installation of structures until an equilibrium is met.
Probability	The predicted impacts on the seabed can reasonably be expected to occur.	The predicted impacts on the seabed can reasonably be expected to occur.
Consequence	The development of scour pits would result in numerous localised changes to seabed topography.	The development of scour pits would result in numerous localised changes to seabed topography.
Overall magnitude	*The potential magnitude of the change is judged to be Low.*	*The potential magnitude of the change is judged to be Low.*

Impact 3: Impacts to sandbank and sandwave receptors during the operational phase

1.15.34 Sandbanks and sandwaves could potentially be impacted by the interruption of the supply of sediment from the system via alterations in the tidal and wave regimes (see Pathways 7 to 10). This assessment of impacts to sandbank and sandwave receptors during the operational phase will draw upon the conclusions presented in Pathways 7 to 10 above. No specific project design features or other avoidance or preventative measures (see Table 7) have been defined which are relevant to the potential impacts to the identified sandbank and sandwave receptors.

1.15.35 Available evidence suggests that other offshore wind farm developments which have been installed upon sandbanks, for example Arklow Bank and Nysted, have had limited impact upon the form and function of the bathymetric features through alterations in the tidal and wave regimes (DECC, 2008). Evidence from the Scroby Sands OWF demonstrates that the overall sandbank form has not changed since the construction of the offshore wind farm, and that natural change dominates (Cefas, 2006). This natural change takes the form of natural variations in accretion and erosion relating to periodic fluctuations in the position of the bank along the longitudinal axis (Bakare *et al.*, 2010). 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 the Kish and Bray Banks (DECC, 2008).

1.15.36 Furthermore, surveys from the Race Bank OWF, located on a sandbank system located approximately 20 km offshore of Lincolnshire, in the UK, suggest that seabed change remains localised to the monopiles. This evidence supports the conclusion that potential flow speed reductions, 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 the Kish and Bray Banks. The scales associated with the evolution and behaviour of sandbanks are greater (spatially and temporally) than those associated with the presence of the Dublin Array offshore infrastructure and the distances associated with the potential impacts outlined above.

1.15.37 The magnitude of the potential changes to the tidal and wave regimes is deemed to be **Negligible**. Similarly, the potential changes to sediment transport following the construction of Dublin Array are considered to be **Negligible**.

1.15.38 The sensitivity of the receptors to the potential impacts for an interruption of the supply of sediment from the system via alterations in the tidal and wave regimes is assessed in Table 23.

Table 23 Determination of sensitivity for sandbanks and sandwaves to an interruption of the supply of sediment from the system

Sandbanks and sandwaves	Justification
Context	**Adaptability:** The potential for interruption of the sediment supply from the system and alterations on the sandbanks and sandwaves in the study area from the presence of structures within the water column, is predicted to be consistent with the natural processes that are already present in the study area and will not adversely affect the onward form and function of the individual bedform features. **Tolerance:** The environment has a moderate capacity to accommodate the proposed form of change. **Recoverability:** Given the dynamic nature of sedimentary processes the bedforms will be maintained providing that there is an adequate supply of sediment from the system. No changes to the supply of sediment is anticipated due to the presence of Dublin Array.
Value	The sandbanks are of national importance. The sandwaves are of local importance as they can help to reduce wave energy reaching the shoreline and have ecological value.
Overall sensitivity	*The potential sensitivity on sandbanks is rated as Medium.* *The potential sensitivity on sandwaves is rated as Low.*

1.15.39 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the sandbank receptors being **Medium**. Therefore, the significance of potential changes to sedimentary bedforms occurring as a result via alterations in the tidal and wave regimes in the array and ECC areas is **Not Significant**, which is not significant in EIA terms.

1.15.40 The magnitude of the impact has been assessed as **Negligible**, with the maximum sensitivity of the sandwaves receptors being **Low**. Therefore, the significance of potential changes to sedimentary bedforms occurring as a result via alterations in the tidal and wave regimes in the array and ECC areas is **Not Significant**, which is not significant in EIA terms.

1.15.41 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect

1.15.42 The significance of effect from changes to sandwaves and sandbanks is not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 7 are considered necessary. Therefore, **no significant adverse residual effects** have been predicted in respect of local hydrodynamic, wave and sediment transport processes resulting in changes to sandbanks and sandwaves.

Impact 4: Impacts to coastlines during the operational phase

1.15.43 The primary means by which the coast could be impacted by the operational presence of Dublin Array offshore infrastructure are:

- Modification of the tidal and wave regime due to the presence of foundations within the array area, causing associated changes in sedimentary transport processes and possible alterations to coastal behaviour;
- The presence of cable protection measures in shallow nearshore areas, locally modifying hydrodynamic, wave and sediment transport processes; and
- Exposure of buried export cables and associated infrastructure, locally modifying nearshore hydrodynamic, wave and sediment transport processes.

1.15.44 No O&M works are planned or are foreseeable at the landfall and as such have not been assessed. The presence of buried cables in the installed ducts and in the seabed are not anticipated to result in any significant effects to coastal processes. Although future sea level rise may result in coastal erosion and changes to coastal morphology (as outlined in Paragraph 1.6.34 *et seq.*), this will be taken into account in the design of the landfall works, and buried cables are therefore expected to remain buried throughout the lifetime of the project.

1.15.45 The magnitude of the potential modification of hydrodynamics, wave and sediment transport processes has been assessed as **Negligible** (see Pathway 10, Table 21) for the presence of foundations, cable protection and cable exposures. The sensitivity of the coastline receptors is considered to be **High** (see Impact 2, Table 18). Therefore, the significance of potential changes to coastal processes occurring as a result of the presence of infrastructure associated with Dublin Array is **Not Significant**, which is not significant in EIA terms.

1.15.46 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Residual effect

1.15.47 The significance of effect from changes on coastal processes are not significant in EIA terms. Therefore, no additional mitigation to that already identified in Table 7 are considered necessary. Therefore, **no significant adverse residual effects** have been predicted in respect of coastal receptors during the operational phase.

1.16 Environmental assessment: decommissioning phase

1.16.1 As referenced in the Project Description, the Decommissioning and Restoration Plan (Volume 7, Appendix 2), including the three rehabilitation schedules attached thereto, describes how the Applicant proposes to rehabilitate that part of the maritime area, and any other part of the maritime area, adversely affected by the permitted maritime usages that are the subject of the MACs (Reference Nos. 2022-MAC-003 and 004 / 20230012 and 240020).

1.16.2 It is based on the best scientific and technical knowledge available at the time of submission of this Planning Application. However, the lengthy passage of time between submission of the Planning Application and the carrying out of decommissioning works (expected to be in the approximately 35 years as defined in the MDO) gives rise to knowledge limitations and technical difficulties. Accordingly, the Decommissioning and Restoration Plan will be kept under review by the Applicant as the project progresses, and an alteration application will be submitted if necessary. In particular, it will be reviewed having regard to the following:

- The baseline environment at the time rehabilitation works are proposed to be carried out,
- What, if any, adverse effects have occurred that require rehabilitation,
- Technological developments relating to the rehabilitation of marine environments,
- Changes in what is accepted as best practice relating to the rehabilitation of marine environments,
- Submissions or recommendations made to the Applicant by interested parties, organisations and other bodies concerned with the rehabilitation of marine environments, and/or
- Any new relevant regulatory requirements.

1.16.3 The Decommissioning and Restoration Plan outlines the process for decommissioning of the WTG, foundations, scour protection, OSP, inter array cables and Offshore ECC. The plan outlines the assumption that the most practicable environmental option is to leave certain structures in situ (e.g. inter array cables, scour protection), however the general principle for decommissioning and of particular relevance to physical processes is for all surface structures to be removed and it is assumed that the wind turbine generators (WTG's) will be dismantled and completely removed to shore. Piled foundations will be cut at a level below the seabed, buried cables and scour and cable protection left in situ.

1.16.4 For the purposes of the assessment of decommissioning, all activities outlined within the Decommissioning and Restoration Plan relevant to physical processes have been considered.

Decommissioning pathways

Pathway 13: Increases in SSC and deposition of disturbed sediment to the seabed within the array area and the offshore ECC

1.16.5 The impacts during decommissioning are considered to be similar or less than those previously considered for construction (see Section 1.14). The working areas identified for removal will be restricted to the area used for installation; accordingly, any impacts would be no greater in magnitude than for the construction phase. Therefore, no significant adverse residual effects have been predicted in respect of increases in SSC or deposition of disturbed sediment following decommissioning activities.

Impact 5: Impacts to sandbank and sandwave receptors from decommissioning activities

1.16.6 Structures above the seabed are to be decommissioned in reverse of the construction process (see Section 1.14). As such, it is anticipated that the working areas for removal will also be restricted to the area used for installation; accordingly, any impacts would be no greater in magnitude than for the construction phase. Therefore, no significant adverse residual effects have been predicted in respect of local hydrodynamic, wave and sediment transport processes following the removal of structures.

1.16.7 Cables are proposed to be left *in situ*. If the cables are left in the seabed at the end of the project lifespan, impacts will be the same as those described previously for the operational phase. Therefore, no significant adverse residual effects have been predicted in respect of local hydrodynamic, wave and sediment transport processes following the decommissioning of subsea cables. If cables are removed the impacts during decommissioning are considered to be similar or less than those previously considered for construction (see Section 1.14). The working areas identified for removal will be restricted to the area used for installation; accordingly, any impacts would be no greater in magnitude than for the construction phase. Therefore, no significant adverse residual effects have been predicted in respect of sandbank and sandwave receptors or resulting local hydrodynamic, wave and sediment transport processes following decommissioning activities.

1.16.8 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

Impact 6: Impacts to coastlines from decommissioning activities

1.16.9 Landfall infrastructure will be left *in situ* where considered appropriate. Any requirements for decommissioning at the landfall will be agreed with statutory consultees. If the landfall infrastructure is left in place at the end of the project lifespan, impacts will be the same as those described previously for the operational phase. If cables were removed the working areas identified for removal will be restricted to the area used for installation; accordingly, any impacts would be no greater in magnitude than for the construction phase. Therefore, no significant adverse residual effects have been predicted in respect. Therefore, no significant adverse residual effects have been predicted in respect of coastal receptors following the decommissioning of the landfall zone.

1.16.10 The alternative design options (any other option within the range of parameters set out in the project description) will not give rise to an effect which is more significant than the maximum design option.

1.17 Environmental assessment: cumulative effects

Methodology

1.17.1 This section outlines the Cumulative Effect Assessment on physical processes and takes in account the impacts of the proposed development alone, together with other plans and projects. As outlined in Volume 2, Chapter 4: Cumulative Effects Assessment Methodology (hereafter referred to as the Cumulative Effects Assessment Methodology Chapter), the screening process involved determination of appropriate search areas for projects, plans and activities and Zones of Influence (ZoIs) for potential cumulative effects. These were then screened according to the level of detail publicly available and the potential for interactions with regard to the presence of an impact pathway as well as spatial/physical and temporal overlap.

1.17.2 The CEA long list of projects, plans and activities with which Dublin Array's offshore infrastructure has the potential to interact to produce a cumulative impact is presented within the Cumulative Effect Assessment Methodology chapter (Volume 2, Chapter 4, Annex A: Offshore Long-list). Each plan and project has been considered on case by case basis with the maximum suite of projects identified from a long list within a search area defined as the ICES Ecoregion subsection 7a. Division 7a of the Celtic Sea ICES Ecoregion[30] is considered appropriate for this exercise in relation to physical processes as it will fully encompass all projects and plans with the potential to have spatial overlap with the effects of the offshore works associated with the offshore infrastructure of Dublin Array.

1.17.3 The ZoI for physical process receptors for the purposes of this assessment has been defined as 17 km from Dublin Array, i.e. the maximum distance that a measurable sediment plume will travel from Dublin Array (equal to a single tidal ellipse in addition to a 1 km buffer). This has been considered suitable for the Cumulative Effect Assessment on the basis that these tidal ellipses will be regionally similar, and therefore sediment plumes from nearby projects and plans may travel a similar distance than those from Dublin Array. Due to the nature of tidal streams, any suspended sediment plumes will travel in the direction of the tidal transport, therefore, adjacent plumes will remain equidistant from one another as they are transported laterally. In addition, as presented in the Physical Processes Modelling Report, the plumes associated with the proposed activities for Dublin Array are typically constrained to the immediate far field and would be undetectable at the boundaries of the 17 km ZoI. Therefore, any marine operations that are located over 17 km from the Dublin Array offshore works area will not result in an additive cumulative effect. The potential spatial overlap will therefore be considered within 17 km from the offshore works area, which is consistent with the Physical Processes ZoI.

[30] Ecoregions are used to provide regional advice, steer regional integrated approaches and are the primary geographical units for ICES to develop science, new techniques and monitoring programmes. They provide the broad-scale spatial framework for the knowledge base to address management challenges and monitor the changing ecology of the North-East Atlantic. Division 7a is part of the Celtic Sea Ecoregion and broadly covers the Irish Sea

1.17.4 A spatial extent of 5 km has been defined as to be an appropriate distance for assessing cumulative blockage effects. As detailed in the Physical Processes Modelling Report and outlined in Pathway 8 (paragraph 1.15.4) and Pathway 9 (paragraph 1.15.11), measurable changes to the tidal and wave regimes from the Dublin Array proposed infrastructure are not expected to extend further than 2 km outside of the array area. A spatial extent of 5 km is therefore considered to provide a conservative extent for the purposes of cumulative assessment.

1.17.5 Plans and projects screened in, together with their allocated tier as defined in the Cumulative Effect Assessment Methodology Chapter that reflects their current stage within a consent and development process are presented in Table 24. For the purposes of the cumulative impact assessment, a precautionary construction period has been assumed between the years 2029 to 2032, with offshore construction (excluding preparation works) lasting up 30 months as a continuous phase within this period (refer to the Project Description Chapter).

Projects scoped out

1.17.6 The following types of developments have been scoped out from this cumulative assessment on physical processes receptors based on a lack of spatial overlap (i.e. stage one):

- Aggregate production;
- Transboundary disposal sites (i.e. equivalent to Dumping at Sea licences outside of Irish waters);
- Oil and gas pipelines and infrastructure;
- Wave and tidal energy projects;
- Aquaculture; and
- Carbon Capture and Storage.

1.17.7 Marine surveys were screened out from a Cumulative Effects Assessment for physical processes receptors on the basis of a lack of pathway which could result in significant effects in EIA terms, on the basis that the potential magnitude of effect (such as use of boreholes etc.) would result in a negligible magnitude of effect upon physical processes receptors.

Projects for cumulative assessment

1.17.8 The specific projects scoped into this Cumulative Effect Assessment on Physical Processes receptors or pathways, and the tiers into which they have been allocated are presented in Table 24 below. The full list of plans and projects considered, including those screened out, are presented in Volume 1, Annex 3.1. The construction programme for Dublin Array is between 2029 to 2032, with offshore construction lasting up to 30 months, excluding preparation works. After construction, Dublin Array will be operational for approximately 35 years.

1.17.9 The MDO for each of the scoped in projects, as identified in Table 24 , is presented in Table 25 for the assessment of cumulative blockage effects on receptors and additive SSC plumes as Physical Processes pathways.

Table 24 Projects for cumulative assessment

Development type	Project Name	Current Status of Development	Data confidence assessment/ phase	Planned programme
Tier 1				
Jetty construction and dredging	Dublin Port Company MP2 Project Licence FS006893	Consented	High – Consented	2021 – 2036
Dredging	Dublin Port Company Licence FS007132	Consented	High – Consented	2022 – 2029
Dumping at sea	Dublin Port Company Permit: S0004-03	Consented	High – Consented	2022 – 2029
Dumping at sea	Dublin Port Company Permit: S0024-02	Consented	High – Consented	2022 – 2035
Subsea cable	HIBERNIA Atlantic	Operational	Low	Unknown O&M works as required
Subsea cable	ESAT 2	Operational	Low	Unknown O&M works as required
Subsea cable	CeltixConnect - Sea Fibre Networks	Operational	Low	Unknown O&M works as required
Subsea cable	HIBERNIA 'C'	Operational	Low	Unknown O&M works as required
Subsea cable	ZAYO Emerald Bridge One	Operational	Low	Unknown O&M works as required
Tier 2				
No screened projects classed at Tier 2				
Tier 3				
Terminal construction and dredging	Dublin port Company 3FM Project	Pre-consent	Medium – EIA available (submitted July 2024)	2026 – 2040
Subsea cable	Mares Connect	Pre-application[31]	Low	Unknown O&M works as required

[31] Construction is programmed to be complete in 2027.

Development type	Project Name	Current Status of Development	Data confidence assessment/ phase	Planned programme
Offshore Wind Farm	Codling Wind Park	Pre-consent	Medium – Phase 1 (MAC awarded). Scoping report and EIA available (EIA submitted Q2 2024). Initial foreshore licence granted in 2005, more recently in 2021.	Installation of up to 75 WTGs, three export cables and three OSPs. Commencement in 2027 with offshore construction lasting 2-3 years.

Table 25 Cumulative maximum design option assessed

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
Impact 7: Cumulative changes to the wave and tidal regimes as a result of the operational presence of other OWFs	Codling Wind Park	Project design features have been identified from the project's Project Description Chapter and modelling report (Codling Wind Park Limited, 2024). For the purposes of the current assessment, the maximum design characteristics have been represented as: ▪ An array consisting of 75 Wind Turbine Generators (WTGs); and ▪ Monopile foundations with a diameter of 9 m.	The largest structures proposed for installation at Codling Wind Park and Dublin Array, given the locations of the developments, may have limited potential to create modifications to the wave and tidal regime of a scale large enough to allow interaction between them.
Pathway 14: Cumulative increases in SSC and associated sediment deposition	Tier 1: ▪ Dublin Port Company MP2 Project ▪ Dublin Port Company (Licence FS007132) ▪ Dublin Port Company (DAS permit: S0004-03) ▪ Dublin Port Company (DAS permit: S0024-02)	**Dublin Port Company MP2 Project:** Capital dredging and disposal will cause temporary localised sediment plumes both at the loading and licensed disposal sites. Total volume to be dredged: 424,644 m^3 Dredging will consist of: ▪ Berth 53 10 m Chart Datum (CD) 159,595 m^3 ▪ Channel Widening 10 m CD 111,995 m^3 ▪ Oil Berth 3 13 m CD 83,414 m^3 ▪ Berth 50A 11 m CD 69,640 m^3 **Dublin Port Company (Licence FS007132):** ▪ 300,000 m^3 of material to be dredged per annum;	If these intermittent activities overlap temporally with offshore construction activities for Dublin Array, there is potential for spatial (and temporal) overlap of SSC plumes generated by the developments.

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
		▪ Disposal of material into a licenced Dumping at Sea (DAS) site (located approximately 5.5 km from the Dublin Array area); ▪ Mostly of silt and sand with elements of clay, gravel and cobbles; and ▪ Dredging will be carried out by a trailer suction hopper dredger and support vessels. **Dublin Port Company (DAS permit: S0004-03):** ▪ The activities involve the loading and dumping of a maximum of 3,960,000 tonnes (wet weight) of dredged material during the months of April to September from 2022 to 2029; ▪ A maximum quantity of 495,000 tonnes (wet weight) per annum; and ▪ Disposal of material into a licenced DAS site (located approximately 5.5 km from the Dublin Array area). **Dublin Port Company (DAS permit: S0024-02):** ▪ Material arising from the MP2 project; ▪ The activities involve the loading and dumping of a maximum of 1,102,723 tonnes (wet weight) of dredged material; and ▪ Disposal of material into a licenced DAS site (located approximately 5.5 km from the Dublin Array area).	
	Tier 1: ▪ HIBERNIA ATLANTIC ▪ ESAT 2 ▪ HIBERNIA 'C' ▪ ZAYO Emerald Bridge One ▪ CeltixConnect - Sea Fibre Networks	▪ Routine planned and unplanned cable maintenance over the lifetime of the cables. Exact details and programmes are unknown and so there is a high uncertainty.	SSC plumes may be generated through cable installation, reburial and repair operations which have the potential to overlap with those associated with Dublin Array.
	Tier 3:	**Construction and/or maintenance of the proposed Mares Connect power cable:**	SSC plumes may be generated through cable installation, reburial and repair

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
	▪ Mares Connect	▪ Two High Voltage Direct Current (HVDC) subsea cables; ▪ Construction between 2026 to 2029; ▪ Landfall in the Greater Dublin area; ▪ Installation methodologies and exact route is unknown at the time of writing; and ▪ Routine planned and unplanned cable maintenance over the lifetime of the cables.	operations which have the potential to overlap with those associated with Dublin Array.
	Tier 3: ▪ Dublin Port Company 3FM Project	**Dublin Port Company 3FM Project:** Capital dredging and disposal will cause temporary localised sediment plumes both at the loading and licensed disposal sites. Total dredge volume suitable for disposal at sea: 1,189,000 m^3 Dredging will consist of: ▪ Maritime Village – Capital Dredging 3 m Chart Datum (CD) 197,000 m^3 ▪ Area K – Ro-Ro Terminal Scour Protection 12.5 m CD 13,000 m^3 ▪ Turning Circle – Capital Dredging 10 m CD 444,000 m^3 ▪ Area N – Lo-Lo Terminal – Capital Dredging 13 m CD 533,000 m^3 ▪ Area N – Lo-Lo Terminal – Capital Dredging 3 m CD 72,000 m^3 ▪ Total dredge volume: 1,259,000 m3 (70,000 m3 of which not suitable for disposal at sea)	If these intermittent activities overlap temporally with offshore construction activities for Dublin Array, there is potential for spatial (and temporal) overlap of SSC plumes generated by the developments.

Impact	Projects to be assessed	Maximum design option assessed	Justification for scoping in
	Tier 3: ▪ Codling Wind Park Offshore Wind Farm	**Codling Wind Park:** Installation of the Codling Wind Park's three export cables into Dublin Bay making landfall at Poolbeg. The export cables may be installed using jetting, ploughing, or mechanical trenching methods. Jet trenching methods were simulated in the project-specific numerical modelling (Codling Wind Park Limited, 2024).	If these intermittent activities overlap temporally with offshore construction activities for Dublin Array, there is potential for SSC plumes, and any potential associated deposition, to overlap.

Effect 7: Cumulative changes to the wave and tidal regimes as a result of the operational presence of other OWFs

1.17.10 The potential for significant cumulative effects, as a result in the presence of other OWFs on the tidal and wave regimes, is presented in Table 26 .

Table 26 Determination of potential for cumulative changes to the wave and tidal regimes as a result of the operational presence of other OWFs

	Justification
Step 1: Drivers	Changes in the tidal and wave regimes through the presence of structures in the marine environment could potentially change coastal processes.
Step 2: Pressures	Interaction between separate wind farms, on the tidal regime, only has the potential to occur if the extent of the turbulent wake features from one location overlaps with that from the other. The lateral extents of modification to tidal flows in the wake are likely to increase as the structure size increases. Li *et al*. (2014) found that the wake field has the potential to extend a distance of up to, approximately, 80 times the foundation diameter. Taking the maximum foundation widths for Dublin Array (24 m for the largest suction bucket multi-leg foundation), it follows that a likely extent of a measurable/ detectable wake is estimated to be in the order of 1.92 km (at times of peak flow) and along the axis of flows. This is very similar to the findings of DAPPMS, as presented in Pathway 8. The distances between Dublin Array and Codling Wind Park array are 2.9 km. The upwind path for southerly waves propagating through Codling Wind Park could theoretically extend to Dublin Array and have a similar level of reduction in wave energy for the “typical” wave from the south and southeast.
Step 3: States	The states which may be affected are hypothetically the coastlines within the study area.
Step 4: Impacts	The effects on the tidal and wave regimes from the project alone were deemed to be of Negligible magnitude in the far-field for Dublin Array (see Pathways 8 and 9) and that the influence on the regimes was highly localised. Codling Wind Park is predicted to have only a small effect on the prevailing hydrodynamic and wave regimes, with a negligible impact on the assessed wave parameters as well as the tidal regime away from the array site (Codling Wind Park Limited, 2024). Therefore, despite being potentially additive, it is not anticipated that the cumulative changes arising from the developments would be measurable at the coast or be significant in EIA terms when considered cumulatively.
Step 5: Responses	No additional mitigation to that already identified in Table 7 is considered necessary to prevent significant effects.
Conclusion	*Despite being potentially additive, it is not anticipated that the cumulative changes arising from the developments would be measurable at the identified receptors (including the coast) or be significant in EIA terms when considered cumulatively.*

Pathway 13: Cumulative temporary increases in SSC and seabed levels

1.17.11 The potential for significant cumulative effects, as a result of simultaneous sediment disturbance, is presented in Table 27 , Table 28 , Table 29 , Table 30 and Table 31.

1.17.12 Due regard has been afforded to the possibility of the works associated with the Dublin Port Company MP2 Project, Codling Wind Park Offshore Wind Farm and Dublin Array occurring within or close to (within a spring tidal ellipse of) Dublin Bay. However, given the project timelines are such that it is unlikely that the proposed construction programmes would overlap, as Dublin Array is scheduled to undergo construction works from 2029, whereas the two aforementioned projects are scheduled to have completed at this time. Furthermore, constraints due to equipment availability and space for the works to be safely undertaken also exist. However, in order to provide a conservative assessment of the potential impacts, this assessment has considered the possibility of the MP2 project, Dublin Array and Codling Wind Park undertaking activities at the same time.

Table 27 Consideration of potential for cumulative increases in SSC and deposition – Capital dredge

	Justification
Step 1: Drivers	Capital and maintenance dredging and disposal in Dublin Bay.
Step 2: Pressures	Temporary increases in SSC and associated sediment deposition.
Step 3: States	No receptors identified for physical processes.
Step 4: Impacts	The capital dredging and disposal, associated with the MP2 project, will cause temporary localised sediment plumes both at the loading location and licensed disposal sites. Plume modelling (undertaken on behalf of Dublin Port Company) demonstrated that all plumes generated from dredging were typically less than 10 mg/l within 750 m of the dredging activities. The deposition of sediments was generally confined to the area being dredged and were generally less than 8 g/m^2 beyond the immediate area of the dredging operation. The plumes associated with disposal of material, in the greater Dublin Bay area, results in a plume less than 200 mg/l and is confined to 750 m from the location of disposal. The potential increases in SSC, when considered cumulatively, are still anticipated to be within natural variation within Dublin Bay. Furthermore, it should be noted that given the potential construction programme durations of the two projects, it is unlikely that a temporal overlap would occur. Plumes generated from maintenance dredging are anticipated to dissipate quickly and be on a smaller geographical scale that the capital dredging associated with MP2. As demonstrated by the water quality monitoring undertaken for Dublin Port (Dublin Port Company, 2021), suspended sediment maxima resulting from seabed activities remain local to the works with background levels occurring elsewhere. Further and as previously stated, any increased SSC levels will immediately dissipate following the cessation of works removing the possibility for an additive process of these levels. Therefore, no additional potential impacts or receptors are identified than when considering Dublin Array in isolation. The magnitude (and so significance) of the effect on physical processes resulting from simultaneous cable installation activities would be no greater than those assessed in Impacts 1 and 2 (see Section 1.12).

	Justification
Step 5: Responses	No additional mitigation to that already identified in Table 7 is considered necessary to prevent significant effects.
Conclusion	*Therefore, no significant adverse residual effects have been predicted in respect of physical processes when considered cumulatively with Tier 1 plans and projects.*

Table 28 Consideration of potential for cumulative increases in SSC and deposition – Subsea cables

	Justification
Step 1: Drivers	Maintenance work of subsea cables.
Step 2: Pressures	Temporary increases in SSC and associated sediment deposition.
Step 3: States	No receptors identified for physical processes.
Step 4: Impacts	Cumulative effects may arise between the installation of the offshore components of Dublin Array and the planned and unplanned maintenance of operational subsea cables, and so could result in the potential for interaction of sediment plumes. Potential maintenance works could be both planned (routine) and unplanned works (where corrective action is needed) but at the time of writing it is unknown when these works could occur. However, there is the potential for a temporal overlap and so a potential interaction of sediment plumes and associated deposition. The lengths of cable to be replaced or reburied would be shorter, and the potential impacts will be more localised and occur over a shorter duration than those considered presented for the installation of the Dublin Array export cables. As increased SSC rapidly dissipate following the cessation of activities, it is not expected for there to be any measurable plume coalescence. The magnitude (and so significance) of the effect on physical processes resulting from these activities would be no greater than those assessed in Impacts 1 and 2 (see Section 1.14).
Step 5: Responses	No additional mitigation to that already identified in Table 7 are considered necessary to prevent significant effects.
Conclusion	*Therefore, no significant adverse residual effects have been predicted in respect of physical processes when considered cumulatively with Tier 2 plans and projects.*

Table 29 Consideration of potential for cumulative increases in SSC and deposition – Tier 3: MaresConnect

	Justification
Step 1: Drivers	Installation of the MaresConnect cable and landfall activities.
Step 2: Pressures	Temporary increases in SSC and associated sediment deposition.
Step 3: States	No receptors identified for physical processes.

	Justification
Step 4: Impacts	Whilst there is the potential for the offshore components and Mares Connect to be constructed the project timelines are such that it is highly unlikely that the proposed construction programmes would be proposed to overlap. Furthermore, if Mares Connect is installed in close proximity to Dublin Array then there will be additional construction constraints due to space for the works to be safely undertaken in practice. Therefore, on this basis of these constraints is not considered feasible for Dublin Array and MaresConnect to install cables or make landfall at the same time. However, the projects could undertake these activities sequentially to one another. As predicted in the Dublin Array modelling, the SSC plumes are anticipated to rapidly dissipate following the cessation of activities, and so it is not expected for there to be any measurable plume coalescence. The magnitude (and so significance) of the effect on physical processes resulting from these activities would be no greater than those assessed in Impacts 1 and 2 (see Section 1.14).
Step 5: Responses	No additional mitigation to that already identified in Table 7 are considered necessary to prevent significant effects.
Conclusion	*Therefore, no significant adverse residual effects have been predicted in respect of physical processes when considered cumulatively with MaresConnect.*

Table 30 Consideration of potential for cumulative increases in SSC and deposition – Dublin Port Company 3FM Project

	Justification
Step 1: Drivers	Capital dredging and disposal as part of the Dublin Port Company 3FM Project.
Step 2: Pressures	Temporary increases in SSC and associated sediment deposition.
Step 3: States	No receptors identified for physical processes.
Step 4: Impacts	The capital dredging and disposal associated with the 3FM Project will cause temporary localised sediment plumes both at the loading location and licensed disposal sites. Modelling and monitoring data analysed from earlier works in Dublin Bay has shown that plumes from proposed dredging operations are confined to the immediate area of operation and do not impact the wider environment. Plumes associated with the disposal of material in the greater Dublin Bay area have been shown to settle rapidly and within 750 m from the location of disposal (Dublin Port Company, 2024). As predicted in the Dublin Array modelling, the SSC plumes are anticipated to rapidly dissipate following the cessation of activities, and so it is not expected for there to be any measurable plume coalescence. The magnitude (and so significance) of the effect on physical processes resulting from these activities would be no greater than those assessed in Impacts 1 and 2 (see Section 1.14).

	Justification
Step 5: Responses	No additional mitigation to that already identified in Table 7 are considered necessary to prevent significant effects.
Conclusion	*Therefore, no significant adverse residual effects have been predicted in respect of physical processes when considered cumulatively with the Dublin Port Company 3FM Project.*

Table 31 Consideration of potential for cumulative increases in SSC and deposition – Tier 3: Codling Wind Park

	Justification
Step 1: Drivers	Simultaneous export cable laying in the greater Dublin area.
Step 2: Pressures	Temporary increases in SSC and associated sediment deposition.
Step 3: States	No receptors identified for physical processes.
Step 4: Impacts	Should the programmes change such that they are scheduled for the same period, the greatest likelihood is for the two project's installation periods to be sequenced to allow for the availability of installation equipment. As predicted in the Dublin Array modelling, the SSC plumes are anticipated to rapidly dissipate following the cessation of activities, and so it is not expected for there to be any measurable plume coalescence. The magnitude (and so significance) of the effect on physical processes resulting from these activities would be no greater than those assessed in Impacts 1 and 2 (see Section 1.14).
Step 5: Responses	No additional mitigation to that already identified in Table 7 are considered necessary to prevent significant effects.
Conclusion	*Therefore, no significant adverse residual effects have been predicted in respect of physical processes when considered cumulatively with Codling Wind Park.*

1.18 Interactions of environmental factors

1.18.1 A matrix illustrating the likely interactions of the foregoing arising from Dublin Array on physical processes is provided in Volume 8, Chapter 1: Interactions of the Environmental Factors.

1.18.2 Interactions of the foregoing environmental factors are considered to be the effects and associated effects of different aspects of the proposal on the same receptor and include:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, operation and decommissioning); to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project stages (e.g. suspended sediment effects from piling, remedial cable burial works and decommissioning); and

- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on benthic ecology such as direct habitat loss or disturbance, sediment plumes, scour, jack up vessel use etc., may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short-term, temporary or transient effects, or incorporate longer term effects.

1.18.3 As indicated in the interactions matrix (Volume 8, Chapter 1) there are linkages between the topic-specific chapters presented within this EIAR, whereby the effects assessed in one chapter have either the potential to result in secondary effects on another receptor (e.g. effects on fish and shellfish ecology have the potential to result in secondary effects on marine mammals via prey resources).

1.18.4 The different physical processes studied are already inter-related; in particular, sediment transport is dependent on currents and waves and therefore these linked processes have been considered within the assessment. The potential effects on physical processes during construction, operational and maintenance and decommissioning phases of the Project have been assessed in sections 1.14, 1.15 and 1.16 above. In turn, this assessment of changes to physical processes has been used to inform other EIA aspects.

1.18.5 As effects on the sediment regime (i.e. from increases in SSC and sediment deposition above background levels or changes to sediment transport pathways) also have the potential to have secondary effects on other receptors which have been fully assessed in the topic-specific chapters. These receptors are:

- Volume 3, Chapter 2: Marine Water and Sediment Quality (MW&SQ);
- Volume 3, Chapter 3: Benthic, Subtidal and Intertidal Ecology;
- Volume 3, Chapter 4: Fish and Shellfish Ecology;
- Volume 3, Chapter 5: Marine Mammals;
- Volume 3, Chapter 8: Nature Conservation;
- Volume 3, Chapter 11: Infrastructure and Other Users; and
- Volume 3, Chapter 13: Marine Archaeology.
- Part 4: Habitats Directive Assessment, Volume 3 Supporting Information Screening for Appropriate Assessment; and
- Part 4: Habitats Directive Assessments, Volume 4: NIS.

1.18.6 Marine Physical Processes are not in themselves receptors but are instead ‘pathways’. However, changes to Physical Processes have the potential to indirectly effect other environmental receptors. The following potential effects have been considered within the interactions assessment:

- Impacts to sandbank and sandwave receptors; and

- Impacts to coastlines.

Project lifetime effects

1.18.7 Project lifetime effects consider impacts from the construction, operation or decommissioning of Dublin Array on the same receptor (or group). The potential inter-related effects that could arise in relation to benthic and intertidal ecology are presented in Table 32 .

Table 32 Project lifetime effects assessment for potential inter-related effects on physical processes.

Impact Type	Effects (Assessment Alone)			Interaction Assessment
	C	O&M	D	Project lifetime effects
Impacts to sandbank and sandwave receptors	Slight adverse (sandbanks and sandwaves)	Not significant (sandbanks and sandwaves)	Not significant (sandbanks and sandwaves)	The majority of disturbance effects to sandbanks and sandwaves will occur during the construction phase, but will represent a long-term and continuous impact throughout the lifetime of the project where the physical processes in the area will be altered during all phases of the Project. However, only a relatively small proportion of sandbanks and sandwaves will be affected in the context of wider marine features in the area. The interaction of these impacts across the stages of the proposed development lifecycle is not predicted to result in an effect of any greater significance than those assessed in the individual project phases.
Impacts to coastlines	Moderate adverse (landfall)	Not significant	Not significant	Effects on coastlines will only arise during the construction phase, with the main source of effect relating to the construction required at landfall to accommodate the offshore ECC. Furthermore, with the project design features incorporated for this development (i.e. use of trenchless techniques), no significant effects on the coastline are predicted for the

Impact Type	Effects (Assessment Alone)			Interaction Assessment
	C	O&M	D	Project lifetime effects
				construction, operation and maintenance, and decommissioning phases of the project. Therefore, across the project lifetime, the effects on physical processes are not anticipated to interact in such a way as to result in combined effects of greater significance than the assessments presented for each individual phase.

Receptor led effects

1.18.8 The evaluation of SSC and associated deposition examined construction phase activities separately and there is a potential that that more than one activity may occur at a given time. For example, seabed preparation may be undertaken at one part of the site whilst inter-array cables are installed in another part. In terms of elevated suspended sediment levels, it should be noted that plumes would not travel towards each other as they are carried in the same direction by the tide. It is also unlikely that two activities would occur in close proximity simultaneously as the processes in each part of the site are consecutive, for example the site must be prepared prior to foundation installation.

1.18.9 In terms of coastal processes receptors, it is only at landfall that impacts from the offshore export cabling activity may occur and would not experience interactive effects should other construction activities occur further offshore at the Array area at the same time.

1.18.10 There are potential interactions between increased SSC and associated deposition and changes to tidal currents, wave climate, seabed morphology and sediment transport. However, any effects due to changes in the Physical Processes are likely to be limited, both in extent (i.e. largely within the array area and offshore ECC and Temporary Occupation Area) and also in magnitude, with receptors having low sensitivity to the scale of the changes predicted. As such, these interactions are predicted to be no greater than the individual effects assessed in isolation.

1.18.11 Overall, the interactions of the foregoing assessment does not identify any significant inter-related effects that were not already covered by the topic-specific assessment set out in the preceding sections. However, certain individual effects were identified that did interact with each other whilst not leading to any greater significance of effect.

1.19 Transboundary statement

1.19.1 No transboundary effects have been identified. This is because the predicted changes to the key physical process pathways (i.e. tides, waves, and sediment transport) occur within the ZoI and as such are not considered to be sufficient to influence identified receptors beyond the Irish maritime jurisdiction.

1.20 Summary of effects

1.20.1 A summary of the effects presented within this EIAR chapter are presented in Table 33 . Of relevance to the information presented within the table are the following definitions:

- Project design features and other avoidance or preventive measures: Features and measures that have been identified and adopted as part of the evolution of the project design (and therefore incorporated into the project design). Those that are relevant to physical processes are listed in Table 7;
- Additional mitigation: Where additional mitigation is identified as being required to reduce the significance of the residual effect in EIA terms. These are presented in Sections 1.12 and 1.15; and
- All committed mitigation measures, including project design features, avoidance and preventative measures and additional measures, are secured in Volume 8, Chapter 2: Schedule of Commitments.

Table 33 Summary of effects assessed for physical processes

Description of impact	Impact	Additional mitigation measures	Residual impact
Construction			
Impact 1	Impact to sandbank and sandwave receptors as a result of construction activities	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 2	Impact to coastal features as a result of construction activities	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Operation and maintenance			
Impact 3	Impact to sandbank and sandwave receptors as a result of changes in tidal and wave regimes	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 4	Impacts to coastal features from changes in the tidal and wave regimes	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Decommissioning			
Impact 5	Impact to sandbank and sandwave receptors as a result of decommissioning activities	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Impact 6	Impact to coastal features as a result of decommissioning activities	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Cumulative effects			
Impact 7	Cumulative changes to the wave and tidal regimes as a result of the operational presence of other OWFs	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Transboundary			
No transboundary effects have been identified.			

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Annex A: Marine Geology, Oceanography and Physical Processes Policy

Legislation, Policy and Guidance

Policy/ Legislation	Key provisions	Section where provision is addressed
Legislation		
European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011)	"Physical and chemical features: ▪ Topography and bathymetry of the seabed, features ▪ Annual and seasonal temperature regime and ice cover, current velocity, upwelling, wave exposure, mixing characteristics, turbidity, residence time, ▪ Spatial and temporal distribution of salinity"	Consideration of all physical features which will be impacted by the proposed development have been considered in sections 1.14 to 1.16. Consideration of all relevant chemical characteristics are provided in Volume 3, Chapter 2: Marine Water and Sediment Quality (referred to as the MW&SQ Chapter).
European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249 of 2011)	Pressures and Impacts: ▪ Physical Loss Smothering (including smothering by man-made structures, disposal of dredge spoil), ▪ Interference with hydrological processes ○ Significant changes in thermal regime (e.g. by outfalls from power stations), significant changes in salinity regime (e.g. by constructions impeding water movements, water abstraction).	The pressures and impacts outlined in Schedule 1, Table 2 of the Regulations were considered in the development of the scope of this assessment. The deposition of sediment on the seabed from various proposed activities is presented in sections 1.14 to 1.16. An assessment of the potential smothering of benthos was informed by the findings of these assessments. No source-receptor-pathways were identified for the potential change of the thermal of saline regimes as a result of the proposed development.

Policy/ Legislation	Key provisions	Section where provision is addressed
Water Framework Directive (WFD) (2000/60/EC)	The Water Framework Directive (WFD) (2000/60/EC) requires good ecological and good chemical status in inland and coastal waters by 2015. The WFD relates to water bodies up to 1nm from the baseline; with the exception of chemical status which also includes territorial waters i.e. to 12nm.	A full assessment of the proposed development on the chemical and ecological status of relevant WFD water bodies is provided in Volume 4, Appendix 4.3.2-1: Water Framework Directive and Marine Strategy Framework Directive Summary (hereafter referred to as the WFD Assessment). The information from this chapter has been used to inform the conclusions of the WFD assessment.
Guidelines and technical standards		
EIA Guidelines Para 6.12.	The Directive requires that the EIAR describes the cumulation of effects[32]. Cumulative effects may arise from: ▪ The interaction between the various impacts within a single project; ▪ The interaction between all of the different existing and/or approved projects in the same area as the proposed project.	The interactions between various environmental aspects within the proposed developments are presented in Volume 8, Chapter 1: Interactions of the Environmental Factors of this EIAR. A summary is provided in Section 1.17 of this chapter. The interactions between Dublin Array and other plans and projects, for physical processes, ae presented in Section 1.17 of this EIAR chapter.
DCCAE Guidance, 2017 Table 3	"Environmental protection by assessment of likely significant effects of projects to promote sustainable development"	The scope of this assessment is presented in Section 1.11. All effects which have been assessed were identified, in the Dublin Array Scoping Report, with the potential to arise in significant effects in EIA terms.

[32] Annex IV, point 5(e) of the Directive. See also Schedule 6(2)(e)(i)(V) to the Regulations.

Policy/ Legislation	Key provisions	Section where provision is addressed
DCCAE Guidance, 2017 Table 4	"developers and competent authorities should have regard to when planning/assessing a project – ▪ Protected sites and species "	An assessment of the potential changes in the physical processes on protected sites and species is presented in the Natura Impact Statement (NIS) (Part 4: Habitats Directive Assessments, Volume 4: NIS).
DCCAE Guidance, 2017 Table 4	"developers and competent authorities should have regard to when planning/assessing a project – Coastal erosion"	An assessment of the potential changes to coastal erosion and the associated implications are presented Sections 1.14 to 1.16.
DCCAE Guidance, 2017 Table 4	"developers and competent authorities should have regard to when planning/assessing a project – ▪ Sedimentation processes"	An assessment of the potential changes to coastal erosion and the associated implications are presented Sections 1.14 to 1.16.
DCCAE Guidance, 2017 Table 4	"developers and competent authorities should have regard to when planning/assessing a project – Seabed geology and morphology "	An assessment of the potential changes to the seabed geology and morphology and the associated implications are presented Sections 1.14 to 1.16.
DCCAE Guidance, 2017 Table 4	"developers and competent authorities should have regard to when planning/assessing a project – Bathymetry and hydrography "	An assessment of the potential changes to water depth and hydrography and the associated implications are presented Sections 1.14 to 1.16.
DCCAE Guidance, 2017 Table 4	"developers and competent authorities should have regard to when planning/assessing a project – Sediments "	An assessment of the potential changes to marine sediment composition and suspended concentrations are presented Sections 1.14 to 1.16.
DCCAE Guidance, 2017 Section 3.2	"All phases of the development should be considered in the assessment process. Each of these phases will have its own specific effects on the environment and will differ in duration. Considering all phases of the development will address full *lifecycle* effects of a proposed development."	All phases of the development have been considered within this physical process EIA assessment.

Policy/ Legislation	Key provisions	Section where provision is addressed
		The assessment of effects in the construction phase are presented in Section 1.14. The assessment of effects in the operational phase (including maintenance) are presented in Section 1.15. The assessment of effects in the decommissioning phase are presented in Section 1.16.
DCCAE Guidance, 2017 Section 4.5.3	"The zones of influence may differ depending upon the topic under consideration (e.g. the visual zone will differ from the biodiversity zone). In establishing the zones of influence, the following should be identified: ▪ the physical footprint of the project; ▪ the measures required to determine the overall zones of influence of a project (i.e. the area impacted by the development with reference to the of likely significant effects); and ▪ the study area (i.e. that selected for the review). Specific modelling techniques, typically simulating water mixing processes to predict temporal and spatial variations, can be used to assist in the exercise. The zones of influence relate primarily to ecological and visual impacts of the development."	The Zone of Influence (ZoI) for Dublin Array on the physical marine environment was developed through use of project specific modelling. Further details of the ZoI and the development of the study area is presented in Section 1.4.
DCCAE Guidance, 2017 Section 4.5.3	"A source – pathway – target risk assessment methodology may be of benefit in establishing the potential zones of influence."	A source-pathway-receptor assessment methodology was used to scope the receptors within the ZoI for this assessment - see Section 1.11 for those receptors scoped in for assessment.
DCCAE Guidance, 2017	"A description of the existing environment is required to allow for a prediction of significant likely effects of a development. "	A full characterisation of the receiving environment is presented in the Physical Processes Technical Baseline. The findings

Policy/ Legislation	Key provisions	Section where provision is addressed
Section 4.6.3		of this characterisation have been summarised in this chapter for the ease of the reader.
DCCAE Guidance, 2017 Section 4.6.3	"The *condition* of the receiving environment should be used to inform whether or not an effect is significant and to understand its vulnerability and sensitivity."	The assessment criteria for assessing the sensitivity of receptor to a potential effect is outlines in Section 1.5. The criterion including a consideration of its context (its adaptability, tolerance and recoverability) and value.
DCCAE Guidance, 2017 Table 9	Indicative list of impacts – ▪ Coastal processes Coastal erosion Coastal protection Estuarine and coastal flooding ▪ Sedimentation processes ▪ Seabed geology/morphology ▪ Water quality	Coastal processes, sedimentation processes and seabed geology and morphology have all been characterised and considered for assessment within this chapter. Water quality is considered in the MW&SQ Chapter.
DCCAE Guidance, 2017 Section 4.6.5	Mitigation measures are usually required where likely significant effects on the environment are identified. Mitigation measures may be proposed in order to *avoid, prevent, reduce, rectify,* or sometimes *compensate* any major adverse effects. The impact of residual effects should then be assessed.	The project design features and avoidance or preventative measuresrelevant to this physical processes assessment is presented in Table 7. Where significant adverse effects arose (with these measures in place) then additional mitigation measures have been proposed and the effects have been reassessed with the mitigation measures in place to determine the residual effect – see Sections 1.14 and 1.16.

Policy/ Legislation	Key provisions	Section where provision is addressed
DCCAE Guidance, 2017 Section 4.6.6	"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."	An assessment of sedimentation, wave impacts and coastal erosion are presented within Sections 1.14 and 1.16. Full details of the survey data used to inform the characterisation of the receiving environment is provided in the Physical Processes Technical Baseline. These data included tidal current, levels, waves and geophysical data within the study area. A hydrodynamic modelling system (Dublin Array Physical Process Modelling System (DAPPMS)) has been constructed to characterise and quantify the tidal currents, water levels, waves and transport within the study area. These simulations have been used to inform this EIA assessment.
Coastal Process Modelling for Offshore Wind Farm Environmental Impact Assessment: Best Practice Guidance	The report provided an update to existing best practice guidance on the application and use of numerical models to predict the potential impact from offshore wind farms on coastal processes.	This report and principles outlined within were adopted in the construction of the DAPPMS's during its application. This guidance was adopted to support this Planning Application as it is considered by the technical authors as the most comprehensive and detailed available guidance of numerical modelling to inform coastal modelling. In addition, it has been

Policy/ Legislation	Key provisions	Section where provision is addressed
(ABPmer and HR Wallingford, 2009)		widely adopted for similar EIA assessments of OWFs in jurisdictions/countries with established offshore renewable energy sectors where comprehensive guidance has been developed.
Potential Effects of Offshore Wind Developments on Coastal Processes (ABPmer and Metoc Plc, 2002)	This study sought to identify, review and assess the potential effects on coastal processes relation to the development of offshore wind farms around the UK.	This study was considered during the development of potential impacts, as outlined in Section 1.11.

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Annex B: Physical Processes Design Options

Physical Processes Design Options

1.21.1 The following tables provide a detailed breakdown of the parameters that inform the maximum and alternative design options as presented in Table 6 of Volume 3, Chapter 1: Marine Geology, Oceanography and Physical Processes (hereafter referred to as the Physical Processes Chapter). The maximum design option leads to the greatest potential for impact associated with each individual impact or pathway and informs the subsequent detailed assessment. The alternative design options within the range of parameters set out in the project description will not give rise to an effect which is more significant than the MDO.

1.21.2 During construction, sediment will be disturbed and released into the water column, giving rise to suspended sediment plumes and localised changes in bed levels as material settles out of suspension. As defined in the Physical Processes Chapter, Construction Pathway 1 describes increases in Suspended Sediment Concentrations (SSCs) and resulting sediment deposition due to dredging for seabed preparation prior to foundation installation. A detailed breakdown of the maximum seabed preparation parameters for each of three Wind Turbine Generator (WTG) options is provided in Table 34, Table 35 , and Table 36. Values are not provided for the Offshore Substation Platform (OSP), as the parameters for this activity are fixed. The greatest potential for impact results from the multileg (4-leg) with suction buckets WTG options (shown in Table 36). Although the affected seabed areas and spoil volumes disturbed per foundation are highest for the 39 (Option C) WTG layout option, the overall areas and volumes are greatest for the 45 (Option B) WTG layout option.

Table 34 Pathway 1 Assessment Design Option Comparison - Seabed Preparation prior to WTG Foundation Installation for Steel Monopile Foundations

Steel Monopile			
WTG Number and Option	50 (Option A)	45 (Option B)	39 (Option C)
Maximum percentage of locations at which seabed preparation will take place	100%	100%	100%
Assumed shape of prepared seabed area	Square	Square	Square
Maximum length of side (square prepared seabed areas) per foundation (m)	22.0	23.0	23.0
Maximum prepared seabed area per foundation (m^2)	484	529	529
Maximum total project seabed area (m^2)	**24,200**	23,805	20,631

Steel Monopile			
Maximum average soil thickness removed (m)	0.75	0.75	0.75
Maximum seabed volume disturbed per foundation (m^3)	363	397	397
Maximum percentage of excavated material that could become spoil	100%	100%	100%
Maximum spoil volume per foundation (m^3)	363	397	397
Maximum spoil volume for project (m^3)	**18,150**	17,854	15,473
Dredging time at each foundation (hr)	1.5	1.6	1.6

Table 35 Pathway 1 Assessment Design Option Comparison - Seabed Preparation prior to WTG Foundation Installation for 3-leg Multileg Foundations

	WTGs (Multileg (3-leg) with pin-piles)			WTGs (Multileg (3-leg) with suction buckets)		
WTG Number and Option	50 (Option A)	45 (Option B)	39 (Option C)	50 (Option A)	45 (Option B)	39 (Option C)
Maximum percentage of locations at which seabed preparation will take place	100%	100%	100%	100%	100%	100%
Assumed shape of prepared seabed area	Square	Square	Square	Square	Square	Square
Maximum length of side (square prepared seabed areas) per foundation (m)	49.3	54.2	54.7	60.3	66.6	**67.5**
Maximum prepared seabed area per foundation (m^2)	2,428	2,940	2,989	3,636	4,436	**4,556**

	WTGs (Multileg (3-leg) with pin-piles)			WTGs (Multileg (3-leg) with suction buckets)		
Maximum total project seabed area (m²)	121,401	132,316	116,585	181,805	**199,600**	177,694
Maximum average soil thickness removed (m)	0.75	0.75	0.75	0.75	0.75	0.75
Maximum seabed volume disturbed per foundation (m³)	1,821	2,205	2,242	2,727	3,327	**3,417**
Maximum percentage of excavated material that could become spoil	100%	100%	100%	100%	100%	100%
Maximum spoil volume per foundation (m³)	1,821	2,215	2,242	2,727	3,327	**3,417**
Maximum spoil volume for project (m³)	91,051	99,237	87,439	136,353	**149,700**	133,270
Dredging time at each foundation (hr)	7.3	8.8	9.0	10.9	13.3	13.7

Table 36 Pathway 1 Assessment Design Option Comparison - Seabed Preparation prior to WTG Foundation Installation for 4-leg Multileg Foundations

	WTGs (Multileg (4-leg) with pin-piles)			WTGs (Multileg (4-leg) with suction buckets)		
WTG Number and Option	50 (Option A)	45 (Option B)	39 (Option C)	50 (Option A)	45 (Option B)	39 (Option C)
Maximum percentage of locations at which seabed preparation will take place	100%	100%	100%	100%	100%	100%
Assumed shape of prepared seabed area	Square	Square	Square	Square	Square	Square
Maximum length of side (square prepared seabed	54.5	60.0	60.5	65.0	72.0	**73.0**

	WTGs (Multileg (4-leg) with pin-piles)			WTGs (Multileg (4-leg) with suction buckets)		
areas) per foundation (m)						
Maximum prepared seabed area per foundation (m^2)	2,970	3,600	3,660	4,225	5,184	**5,329**
Maximum total project seabed area (m^2)	148,513	162,000	142,750	211,250	**233,280**	207,831
Maximum average soil thickness removed (m)	0.75	0.75	0.75	0.75	0.75	0.75
Maximum seabed volume disturbed per foundation (m^3)	2,228	2,700	2,745	3,169	3,888	**3,997**
Maximum percentage of excavated material that could become spoil	100%	100%	100%	100%	100%	100%
Maximum spoil volume per foundation (m^3)	2,228	2,700	2,745	3,169	3,888	**3,997**
Maximum spoil volume for project (m^3)	111,384	121,500	107,062	158,438	**174,960**	155,873
Dredging time at each foundation (hr)	8.9	10.8	11.0	12.7	15.6	16.0

1.21.3 As defined in the Physical Processes Chapter, Construction Pathway 2 describes increases in SSCs and resulting sediment deposition due to the release of drill arisings during foundation installation. Monopile and pin-piled foundations may require drilling in some cases where the underlying geology presents an obstacle to piling. The drilling process will produce drill cuttings, which have the potential to result in high SSCs that advect from the discharge point. A detailed breakdown of design parameters that inform the maximum and alternative design options for this pathway are provided in Table 37for a range of WTG foundation options, and in Table 38 for a range of OSP foundation options. While WTG monopiles have a greater diameter, the pin-piles penetrate to a much greater depth and are therefore more likely to encounter bedrock which will require drilling. The combination of greater depth (with larger WTGs requiring greater penetration depths), a greater proportion of the foundations anticipated to require drilling, and a higher number of piles overall results in the multi-leg (4-leg) 39 (Option C) WTG option having the greatest potential volume of drill arisings. Similarly, for OSPs, as outlined in Table 38, whilst monopiles have a greater diameter, the pin-piles penetrate to a greater depth and there are more of them, resulting in the pin-piled OSP option having the greatest potential volume of drill arisings.

Table 37 Pathway 2 Assessment Design Option Comparison - Drill Arisings for WTGs

	Steel Monopile			Multileg (4-leg)			Multileg (3-leg)		
WTG Number and Option	50 (Option A)	45 (Option B)	39 (Option A)	50 (Option A)	45 (Option B)	39 (Option C)	50 (Option A)	45 (Option B)	39 (Option C)
Maximum penetration depth per pile (m)	60	60	60	70	70	70	70	70	**70**
Maximum number of piles per foundation	1	1	1	4	4	4	3	3	3
Maximum drill diameter (m)	13.0	**14.0**	**14.0**	5.50	6.00	6.50	5.75	6.25	6.75
Maximum drill volume arisings per	7,964	9,236	9,236	6,653	7,917	**9,291**	5,453	6,443	7,514

	Steel Monopile			Multileg (4-leg)			Multileg (3-leg)		
foundation (m^3)									
Maximum % of foundation locations using drilling	100%	100%	100%	100%	100%	100%	100%	100%	100%
Maximum volume of arisings per project (m^3)	398,190	**415,638**	360,219.6	332,616	356,257	362,359	272,655	289,922	293,038

Table 38 Pathway 2 Assessment Design Option Comparison - Drill Arisings for the OSP

Multileg (4-leg)	Monopile OSP Foundation	Jacket Pin-Piles OSP Foundation
Pile penetration depth (m)	55	**90**
Maximum drill diameter (m)	**12**	6
Maximum number of piles	1	**12**
Maximum drill volume arisings per foundation (m^3)	6,220	**30,536**
Maximum expected % of foundation locations using drilling	100%	100%
Maximum volume of arisings per project (m^3)	6,220	**30,536**

1.21.4 As defined in the Physical Processes Chapter, Construction Pathway 3 and 4 describe increases in SSCs and resulting sediment deposition due to the installation of inter-array cable (IAC) and export cables, respectively. A comparison of cable installation methodologies is provided in Table 39, which informs the maximum and alternative design options (installation methodologies) for these pathways. The information provided is derived from a combination of scientific literature, guidance documents, and expert judgement. These pathways specifically relate to the increase of SSC and deposition of the resulting disturbed sediments, therefore, the methodologies are assessed mainly in terms of their potential to disturb and elevate sediments into the water column. Other parameters, such as trench width, while presented for context, are not directly considered in terms of the MDO for these pathways. Although ploughing techniques have relatively low levels of sediment disturbance, the use of Mass Flow Excavators (MFE), which are identified as having the greatest potential for sediment disturbance, may be used as a backfill method once ploughing operations have taken place. The use of both ploughing and MFE (as a backfill methodology) has therefore been identified as the MDO for assessment purposes.

Table 39 Pathway 3 and 4 Assessment Design Option - Cable Installation Methodologies

Installation Methodology	Summary
Ploughing	Cable ploughing involves a towed plow that passively cuts a trench into the seabed, into which a cable is simultaneously inserted (Tetra Tech, 2021). Cable ploughs are generally used in sand, silt, clay and weak rock such as structureless chalk, although they may be used in harder rock with supplementary equipment. They are therefore appropriate for the majority of the Dublin Array site conditions. The controlled displacement of sediment, followed by natural backfilling of the trench, limits both soil disturbance and mixing between soil particles and the surrounding water, although fine sediments will still be suspended (BERR, 2008; NIRAS, 2015). The level of sediment disturbance is therefore lower using ploughing in comparison to jetting techniques, although trench widths are generally higher (OSPAR, 2012; Kraus and Carter, 2018; Clare *et al.*, 2023).
Mass Flow Excavator	Mass Flow Excavators (MFE), sometimes referred to as Controlled Flow Excavators (CFE), operate by directing water at the seabed via a ducted nozzle containing a propeller. Water flow rates and velocities can be high, resulting in potential turbidity, although the water flow can in some cases be controlled to achieve desired trench widths and depths without causing excessive turbidity. MFE is rarely deployed for long stretches of burial but may instead be used in discrete locations such as near structures, at cable joints and crossings, and for remedial burial operations (Tetra Tech, 2021). MFE is expected to develop both a wide trench and also have the greatest potential to fluidise and raise fine sediments into suspension and is therefore considered as the realistic worst-case option. This consideration is based on expert judgement and is in line with a comparative review of sediment disturbance from various burial tools provided in BERR (2008) as well as Natural England (2018), which identified MFE as resulting in greater impacts than those usually assessed for jetting.

Installation Methodology	Summary
Rock Cutting	Rock wheel cutters are often used to trench in hard clays and rock, forming a narrow slot into which the cable is lowered. The action of cutting the rock or hard clay causes the material to be broken down into its constituent components, such as sand for sandstone and silt for siltstone, limestone or chalk. This material may be elevated and suspended in the surrounding water (BERR, 2008).
Mechanical Chain Excavating	Mechanical chain excavators are often used to trench in hard clays and rock and are sometimes used in sands and gravels. In the former, this process is similar to that of rock cutting, whereas in sands and gravels the movement of the chain fluidizes the granular soil in the vicinity of the cutter, forming a low resistance 'slot' for the cable to be pushed through. Due to the lack of an open trench, the disturbed material can and does largely remain contained within the ground, limiting the amount of sediment dispersed (BERR, 2008).
Jetting (including Vertical Injection)	Jet trenchers act to fluidise or liquify the soil by pumping seawater at high pressure through a series of small diameter nozzles, with the mechanisms employed by jetting systems for developing a trench largely depending on the soil type (BERR, 2008; RPS, 2019). In cohesionless soils, trenches are formed through a process of erosion or scour, as the fluidised sediment is elevated into the water column. Due to the cohesionless nature of the soil, the trench walls will collapse and flow back into the trench, meaning that a lot of soil has to be removed in order to achieve a significant increase in trench depth. This may require multiple passes, resulting in a trench with gently sloping sides (BERR, 2008). Material may be suspended in the water column over prolonged periods (a number of hours) and have the capacity to be transported over long distances by waves and tidal flows, with the level of sediment disturbance considered to be higher than that of ploughing techniques (OSPAR, 2012; Clare *et al.* 2023). On the basis of expert judgement, jetting systems are also assumed to result in higher sediment disturbance than rock cutting due to the less focused nature of the activity and therefore the higher potential for sediment dispersion. Jet-trenching is considered to result in having the greatest potential for sediment disturbance impacts associated with cable installation with the exception of MFE.

The installation of WTG and offshore platform foundations, as well as the implementation of cable protection, scour protection, and cable crossings, have the potential to result in localised blockage of the wave, hydrodynamic, and sediment transport regimes, potentially resulting in impacts to sandbank and coastal features. These processes are described by Pathways 8, 9, and 10, and Impact 3 and 4, as defined in the Physical Processes Chapter. A detailed breakdown of design parameters that inform the maximum and alternative options for these pathways and impacts associated are presented in Table 40, Table 41, and Table 42 for WTG foundations (monopile, 4-leg multileg, and 3-leg multileg, respectively), and

1.21.5 Table 43 for OSP foundations. The highest areas and volumes of scour protection are required for the 4-leg multileg with suction buckets WTG foundation option for 45 (Option B) WTGs, and for the jacket with suction bucket foundation option for the OSP.

Table 40 Impact 3 and 4/Pathway 8, 9 and 10 Assessment Design Option - Scour Protection for WTG Monopile Foundations

Steel Monopile			
WTG Number and Option	50 (Option A)	45 (Option B)	39 (Option C)
Maximum scour protection depth (rock) (m)	2.0	2.0	2.0
Maximum diameter for top scour protection layer (m)	36.0	39.0	39.0
Maximum diameter for seabed scour protection layer (m)	51.0	54.0	54.0
Maximum scour protection surface area per foundation, including structure footprint (m²)	2,043	2,290	2,290
Maximum scour protection surface area per foundation, excluding structure footprint (m²)	1,930	2,157	2,157
Maximum scour protection area per project, including structure footprint (m²)	102,141	**103,060**	89,319
Maximum scour protection volume per foundation (m³)	2,948	3,352	3,352
Maximum scour protection volume for project (rock) (m³)	147,380	**150,844**	130,731
Maximum scour protection volume for project (rock) including addition 10% to account for slopes (m³)	162,118	**165,928**	143,804

Table 41 Impact 3 and 4/Pathway 8, 9, and 20 Assessment Design Option - Scour Protection for WTG 4-leg Multileg Foundations

	Multileg (4-leg) with Pin-piles			Multileg (4-leg) with Suction Buckets		
WTG Number and Option	50 (Option A)	45 (Option B)	39 (Option C)	50 (Option A)	45 (Option B)	39 (Option C)
Maximum scour protection depth (rock) (m)	2.0	2.0	2.0	2.0	2.0	2.0
Maximum diameter at top of scour protection per leg (m)	13.5	15.0	16.5	45.0	51.0	54.0

	Multileg (4-leg) with Pin-piles			Multileg (4-leg) with Suction Buckets		
Maximum scour protection diameter at seabed per leg (m)	28.5	30.0	31.5	60.0	66.0	69.0
Maximum scour protection surface area per foundation, including structure footprint (m^2)	2,552	2,827	3,117	11,310	13,685	**14,957**
Maximum scour protection surface area per foundation, excluding structure footprint (m^2)	2,488	2,749	3,022	--	--	--
Maximum scour protection area per project, including structure footprint (m^2)	127,588	127.235	121,573	565,487	**615,815**	583,328
Maximum scour protection volume per foundation (m^3)	3,061	3,456	3,878	16,965	20,948	**23,100**
Maximum scour protection for project (rock) (m^3)	168,338	171,060	166,345	933,053	**1,036,933**	990,996

Table 42 Impact 3 and 4/Pathway 8, 9, and 10 Assessment Design Option - Scour Protection for WTG 3-leg Multileg Foundations

	Multileg (3-leg) with Pin-piles			Multileg (3-leg) with Suction Buckets		
WTG Number and Option	50 (Option A)	45 (Option B)	39 (Option C)	50 (Option A)	45 (Option B)	39 (Option C)
Maximum scour protection depth (rock) (m)	2.0	2.0	2.0	2.0	2.0	2.0
Maximum diameter at top of scour protection per leg (m)	14.3	15.8	17.3	51.0	57.0	60.0
Maximum diameter for seabed scour protection layer (m)	29.3	30.8	32.3	66.0	72.0	75.0
Maximum scour protection surface area per foundation, including structure footprint (m^2)	2,016	2,228	2,451	10,264	12,215	**13,254**

	Multileg (3-leg) with Pin-piles			Multileg (3-leg) with Suction Buckets		
Maximum scour protection surface area per foundation, excluding structure footprint (m^2)	1,963	2,163	2,373	--	--	--
Maximum scour protection area per project, including structure footprint (m^2)	100,794	100,257	95,573	513,179	**549,653**	516,890
Maximum scour protection volume per foundation (m^3)	2,441	2,748	3,074	15,711	19,019	**20,793**
Maximum scour protection volume for project (rock) (m^3)	134,264	136,000	131,866	864,111	**941,451**	892,038

Table 43 Impact 3 and 4/Pathway 8, 9, and 10 Assessment Design Option - Scour Protection for OSP Foundations

	Monopile OSP Foundation	Jacket Pin-Piles OSP Foundation	Jacket Suction Bucket OSP Foundation
Maximum scour protection depth (rock) (m)	2.0	2.0	2.0
Maximum diameter for top scour protection layer (m)	33.0	33.0	45.0
Maximum diameter for seabed scour protection layer (m)	48.0	48.0	60.0
Maximum scour protection surface area per foundation, including structure footprint (m^2)	1,810	7,238	**11,310**
Maximum scour protection surface area per foundation, excluding structure footprint (m^2)	1,715	6,858	**10,603**

	Monopile OSP Foundation	Jacket Pin-Piles OSP Foundation	Jacket Suction Bucket OSP Foundation
Maximum scour protection area per project, including structure footprint (m^2)	1,715	6,858	**10,603**
Maximum scour protection volume per foundation (m^3)	2,570	10,279	16,965
Maximum scour protection volume for project (rock) (m^3)	2,570	10,279	**16,965**

1.21.6 The installation of WTG and offshore platform foundations may result in localised scour, which refers to the development of pits, troughs or other depressions in the seabed sediments at the base of foundations as a result of compensatory acceleration of flow. These processes are described by Pathway 12, as defined in the Physical Processes Chapter. A detailed breakdown of design parameters that inform the maximum and alternative options for this pathway is presented in Table 44 and Table 45 for WTG foundations, and in Table 46 for OSP foundations. The quantitative estimate of scour provided here assumes that the width of scour development, to the equilibrium scour depth, is equal to 4D, where D is the diameter of the pile. Only foundations including piles are considered due to design considerations, and this estimate is provided for the assessment of potential impacts on environmental receptors only, and is not intended for any engineering purposes. Further details are provided in Volume 4, Appendix 4.3.1-6: Physical Processes Modelling and Design Options Comparison Report.

Table 44 Pathway 12 Assessment Design Option – Scour for WTGs with monopile foundations

	Steel Monopile		
WTG Number and Option	50 (Option A)	45 (Option B)	39 (Option C)
Maximum diameter (m)	12.0	13.0	13.0
Maximum scour area per foundation (m^2)	1,809.6	2,123.7	2,123.7
Maximum total area of scour for array (m^2)	90,477.9	**95,567.2**	82,824.9

Table 45 Pathway 12 Assessment Design Option -Scour for WTGs with multi-leg foundations

	Multileg (3-leg) with Pin-piles			Multileg (4-leg) with Pin-piles		
WTG Number and Size	50 (Option A)	45 (Option B)	39 (Option C)	50 (Option A)	45 (Option B)	39 (Option C)
Maximum diameter (m)	4.75	5.25	**5.75**	4.5	5	5.5
Maximum scour area per pile (m^2)	283.5	346.4	**415.5**	254.5	314.2	380.1
Maximum number of piles/buckets per foundation	3	3	3	4	4	4
Maximum scour area per foundation (m^2)	850.6	1,039.1	1,246.4	1,017.9	1,256.6	**1,520.5**
Maximum total area of scour for array (m^2)	42,529.3	46,758.7	48,610.6	50,893.8	56,548.7	**59,300.7**

Table 46 Pathway 12 Assessment Design Option - Scour for OSP Foundations

	Monopile OSP Foundation	Jacket Pin-Piles OSP Foundation
Maximum diameter (m)	**11**	5
Maximum scour area per pile (m^2)	**1,520.5**	314.2
Maximum number of piles/buckets per foundation	1	**12**
Maximum scour area per foundation (m^2)	1,520.5	**3,769.9**
Maximum total area of scour for array (m^2)	1,520.5	**3,769.9**

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