Arklow Bank Wind Park 2

Environmental Impact Assessment Report

Volume III, Appendix 6.1: Marine Physical Processes Numerical Modelling

sse Renewables

Arklow Bank Wind Park 2:

Marine Physical Processes Numerical Modelling

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Commercial in Confidence

Andrew Watson MSc CSci CMarSci MIMarEST

Senior Metocean Consultant & Director

andrew.watson@metoceanworks.com

Contact +44 (0)7763 896635

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1	14/05/2024	Final (External)	MetOcean Works	GoBe Consultants	Sure Partners Limited

Statement of Authority

Name	Qualifications	Experience
Andrew Watson	BSc MSc MIMarEST CSci CMarSci	Andrew has worked as a professional oceanographer for over 20 years. This includes a career with Fugro GEOS Ltd. for almost 6 years, where he managed a team of oceanographers. Andrew is managing director at MetOceanWorks Ltd. Andrew's key skills include: • Numerical modelling of waves and tides • Metocean analysis • Programming for statistical analysis of field and modelled datasets
Jamie Hernon	BSc MSc MIMarEST CSci CMarSci	Jamie has more than 17 years' experience in the application of numerical modelling to complex oceanographic projects and regularly has a lead role in studies. In addition to modelling tides, waves and sediment transport processes, he has developed expertise in metocean analysis, weather downtime analysis and coastal flood risk issues. Jamie's key skills include: • Numerical modelling of waves, tides and sediments • Metocean analysis • Programming for statistical analysis of field and modelled datasets • Application of GIS in the coastal and offshore environment

Disclaimer

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1 Definitions

1.1 Units and Conventions

The following list describes the units and conventions used in this report. Units have been expressed using the International System of Units (SI) convention.

- Wave direction is expressed in compass points or degrees, relative to true North [°T], and describes the direction **from** which the waves are propagating.
- Wave heights are expressed in metres [m].
- Wave periods are expressed in seconds [s].
- Current direction is expressed in compass points or degrees, relative to true North [°T], and describes the direction **towards** which the currents are flowing.
- Current speeds are expressed in metres per second [m/s].
- Water levels are expressed in metres [m].
- Positions are quoted relative to WGS 84 except where stated.
- All times are quoted in Coordinated Universal Time [UTC].

1.2 Glossary of commonly used terms

The following list describes common metocean terms used throughout this report.

Waves	Description
Hm0	Significant wave height. Approximately the average height of the highest one third of the waves in a defined period, estimated from the wave spectrum as $4\sqrt{m_0}$.
m_0, m_1, m_2	The zeroth, first and second moments of the wave spectrum respectively.
Tp	The spectral peak wave period. The wave period at which most energy is present in the wave spectrum.
Tm02	The mean zero-crossing wave period. Estimated from the wave spectrum as $\sqrt{m_0/m_2}$.
Levels	**Description**
LAT	Lowest Astronomical Tide. Minimum level of sea surface due to tidal forcing alone.
MSL	Mean Sea Level. Mean sea surface elevation over a prolonged period of time.
Currents	**Description**
Current speed	Magnitude of local current flow.
Offshore Construction	**Description**
Array Area	The Array Area is the area within which the Wind Turbine Generators (WTGs), the Offshore Substation Platforms (OSPs), and associated cables (export, inter- array and interconnector cabling) and foundations will be installed.
Cable Corridor and Working Area	The Cable Corridor and Working Area is the area within which export, inter-array and interconnector cabling will be installed This area will also facilitate vessel jacking operations associated with installation of WTG structures and associated foundations within the Array Area.

TSHD	Trailing suction hopper dredger. Self-propelled vessel able to vacuum sediments from the seafloor to a hopper in the hull, for subsequent discharge elsewhere.
WTG	Wind Turbine Generator.
OSPs	Offshore Substation Platforms.
HDD	Horizontal Directional Drilling. Method of installing underground cables using a drill.

2 Introduction

2.1 Background

GoBe Consultants Ltd contracted MetOceanWorks to provide marine processes modelling services, for the Arklow Bank Wind Park 2 (ABWP2). The ABWP2 site is being developed by Sure Partners Limited (SPL).

ABWP2 is situated on a long narrow sandbank approximately 10 km off the Wicklow Coast, near the town of Arklow (see Figure 6.1.1). The site area is approximately 27 km x 2.5 km and water depths within the Array Area range from approximately 2 m to more than 40 m below LAT [1]. A subsea cable will link the wind farm with the power delivery network at the adjacent coast. Figure 6.1.1 shows the proposed Array Area and the proposed Cable Corridor and Working Area. Numerical modelling has been carried out to assess the likely impact of the construction and operation of the wind farm and its associated infrastructure, on the marine environment.

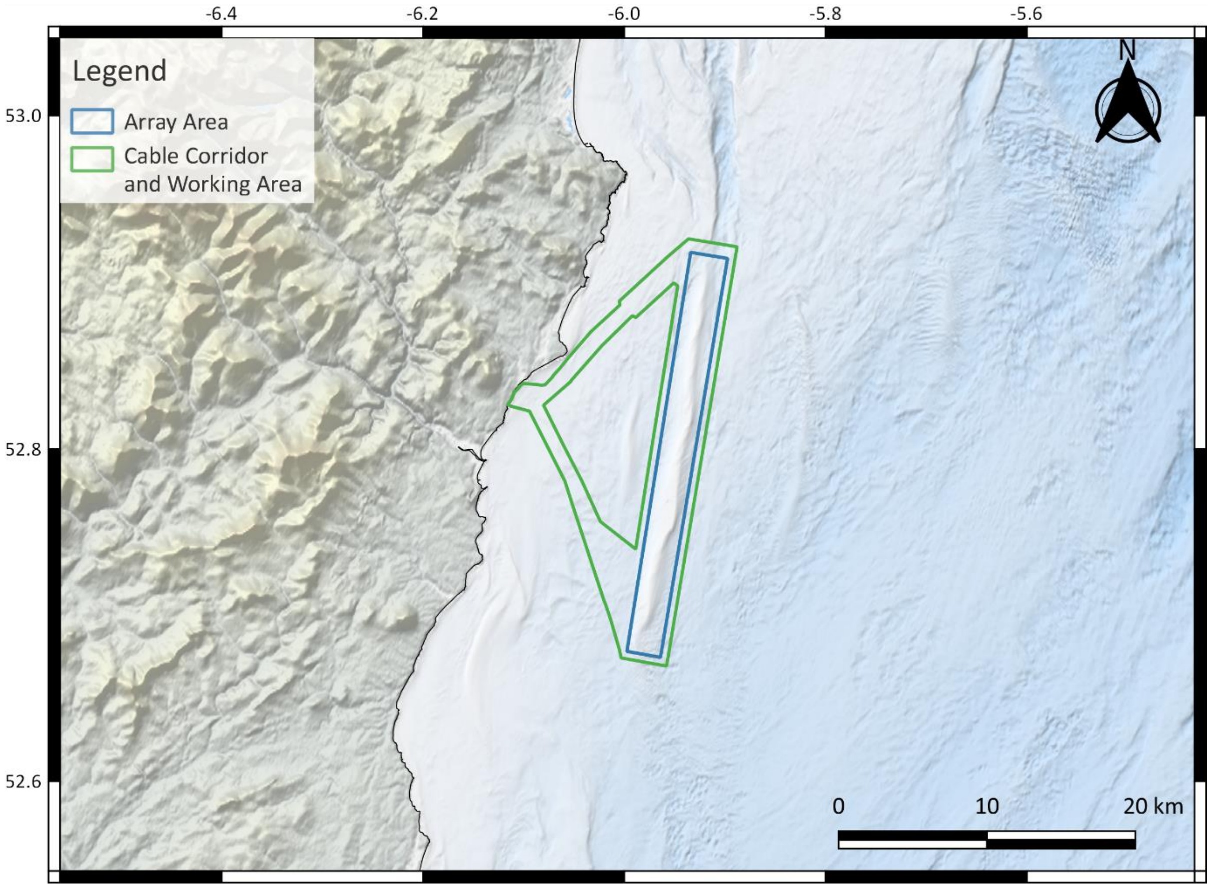


Figure 6.1.1: Overview of ABWP2 area including the Array Area and Cable Corridor and Working Area.

2.2 Report Structure

This document describes the various data sources, marine process models and analysis methods used throughout the study.

Modelling details are discussed in Sections 3 to 6, initially introducing common model inputs (Section 3) before moving onto the models themselves. By way of introduction to the overall approach:

- **Hydrodynamics** were modelled using the MIKE21FM 2D flexible mesh modelling package. Modelled currents and water levels have been validated against measurements from several locations. See Section 4 for details. The validated hydrodynamic model was then used to drive the particle tracking module, and to simulate blockages to flows caused by the presence of the built structures.
- The **Particle Tracking** module was used to simulate the extent and fate of sediments disturbed during construction activities (Section 6).
- **Waves** were modelled with a bespoke SWAN (Simulating Waves Nearshore) model with high resolution regional nests. The model has been extensively validated against measured datasets in the region. See Section 5 for details. The model was then used to simulate blockages to waves caused by the presence of the built structures.

Thereafter, Section 7 provides a description of the results. The document concludes with a list of the references used throughout.

3 Common Modelling Inputs

3.1 Bathymetry

A representative bathymetry dataset was required as input to the wave and hydrodynamic models. This was achieved by merging four different datasets which originated from:

- European Marine Observation and Data Network (EMODnet)
- Oceanwise
- SeaDataNet
- SPL-supplied survey data from 2019

Far-field bathymetry data for the models were sourced from the EMODnet Bathymetry Data Portal [2]. EMODnet provides a service for viewing and downloading a harmonised Digital Terrain Model (DTM) for the European sea regions that is generated by an ever-increasing number of bathymetric survey data sets provided by national hydrographic institutions, research bodies and academia. As of 2018, these data are available at a resolution of approximately 130 m.

These data were then merged with Oceanwise raster charts which have a resolution of 1 arc-second (or approximately 25 m, depending on latitude), whereby physical features such as trenches, ridges, sand banks and sand waves are well represented. Figure 6.1.2 shows the available coverage of Oceanwise data with the tiles procured highlighted in green.

To provide the highest possible resolution input data for the Western Irish Sea, surrounding Arklow Bank, individual survey datasets were procured from SeaDataNet. Merged available survey datasets in the region of the project are shown in Figure 6.1.3 and have various resolutions between approximately 4 m and 11 m. Overlapping or duplicated datasets were removed, leaving 22 individual survey datasets which were merged, and any small gaps were filled using interpolation.

The SPL-supplied survey data from 2019 are also highlighted in this figure, using a different colour scale. These data have a spatial resolution of 1 m and cover the entire wind farm lease area.

A critical aspect of the bathymetry development for the numerical modelling purposes was to ensure no vertical discontinuities at the boundaries between the SeaDataNet and 2019 survey data. Therefore, the two datasets were merged using a tapering method to avoid sudden vertical shifts at dataset edges.

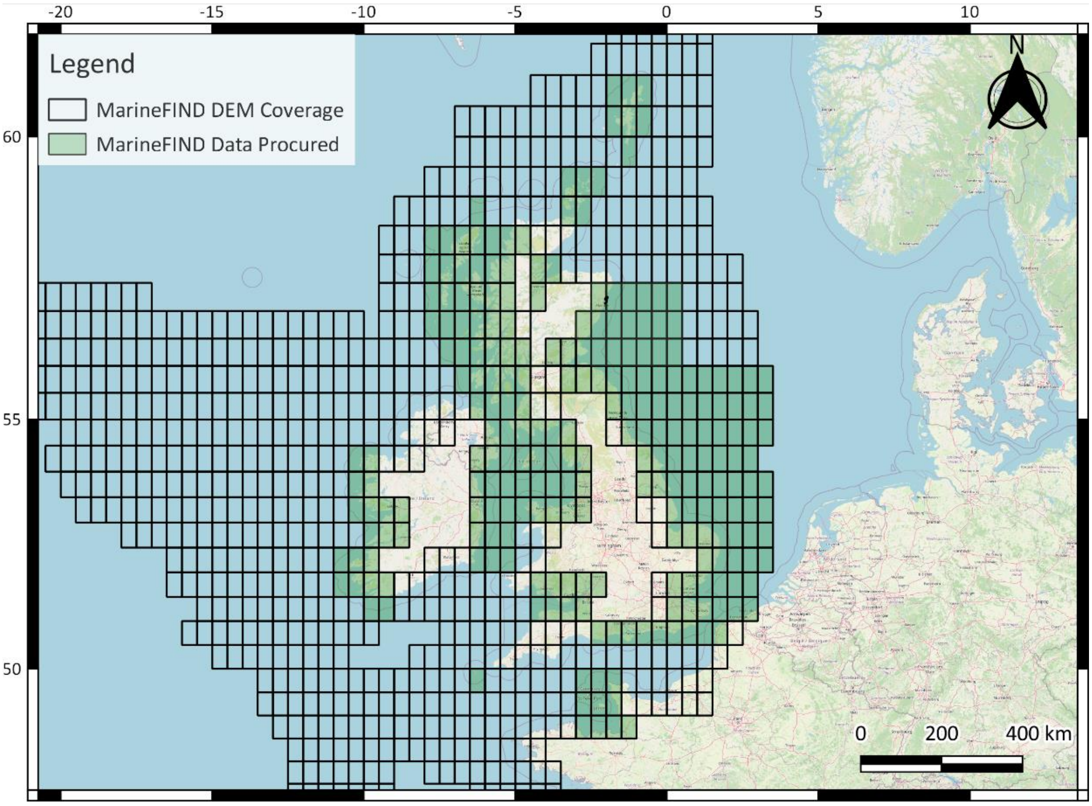


Figure 6.1.2: Coverage of OceanWise data, and DTM tiles procured shown in green.

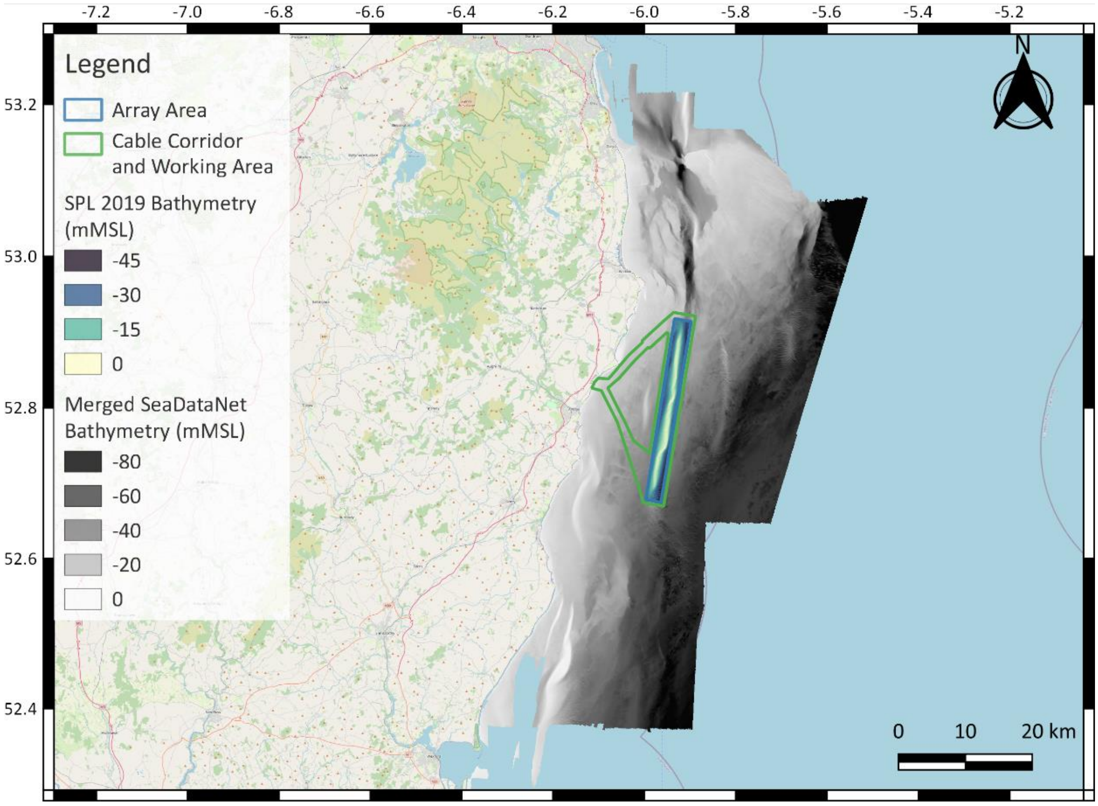


Figure 6.1.3: Merged available bathymetry surveys from SeaDataNet and SPL 2019 bathymetry overlain.

Finally, the bathymetry data were converted from LAT to MSL datum prior to use, as required by both the SWAN and MIKE21 modelling software. These datum differences were calculated from the Finite Element Solution FES2014 dataset, a 35-constituent, global tidal database available from AVISO [3].

3.2 Coastline

The coastlines of England, Scotland and Wales were discretised using the Boundary-Line™ mean high water mark vector product, from the Ordnance Survey, which describes the position of Mean High-Water Springs (broadly analogous to the High Water Mark). For continental Europe, the island of Ireland, and the Isle of Man, the coastline layer from OpenStreetMap was used. These data were used in conjunction with satellite imagery to provide the most accurate and appropriate coastline description for the models. Furthermore, they were found to have a better representation of coastal features than data available from the Ordnance Survey Ireland.

3.3 Wind

European Centre for Medium-Range Weather Forecasts (ECMWF) ReAnalysis 5 (ERA5) wind data was used to drive the hydrodynamic and regional-scale wave models. ERA5 is the fifth and latest major global reanalysis produced by ECMWF. Hourly wind speeds are available for the period 1979 to near-present at various levels (including at 10 m above sea level, as used to drive the wave and hydrodynamic models) are available on a 0.25° by 0.25° resolution grid via the Copernicus Climate Change Service (C3S) Climate Data Store (CDS). Prior to use, the raw ERA5 data is calibrated using a bespoke adjustment developed by MetOceanWorks which improves performance in driving models. These data have been extensively validated against on-site measured LiDAR data. These validations are described and presented in the project metocean report [4].

4 Hydrodynamics

Current and water level parameters were produced using a European, basin-scale flexible mesh hydrodynamic model. Depth-averaged currents and water levels were produced to drive the particle tracking model (described in Section 6), and to predict the blocking effect of the built structures.

Prior to use in the assessments, the performance of the model in representing currents and water levels was ascertained by comparison against several measured data sources. These are described in Section 4.1.

4.1 Measured Hydrodynamic Data

To support calibration and validation of the hydrodynamic model, measured data from acoustic waves and current recording devices (AWACs) were acquired from Sure Partners Limited. These deployments were commissioned by Sure Partners Limited for the purposes of site characterisation, and to support validation of numerical models of the site. An overview of the measured datasets can be found in Table 6.1.1 and Figure 6.1.4.

Table 6.1.1: Measured datasets used for hydrodynamic model validation.

Dataset	Location	Time Period	Water Depth [mMSL]
AWAC A	52.9087 °N, 5.9167 °W	6-Nov-2019 to 7-Mar-2021	27.4†
AWAC C	52.8218 °N, 6.0206 °W	24-Nov-2019 to 19-May-2020	26.3
AWAC E	52.6906 °N, 5.9940 °W	24-Nov-2019 to 8-Mar-2021	39.6.7

† No valid data was recorded was at AWAC A after 5th August 2020.

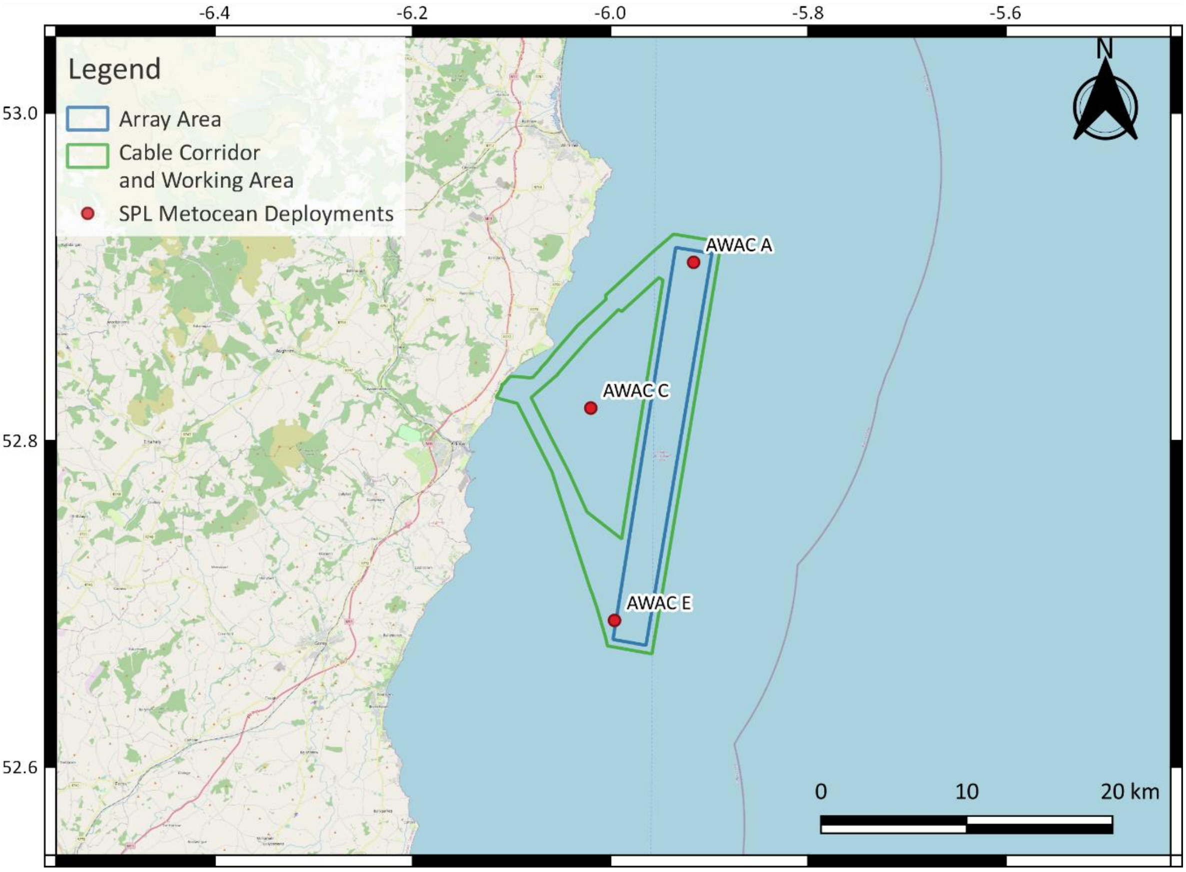


Figure 6.1.4: Measured datasets used for hydrodynamic model validation.

4.2 Modelling Software

The hydrodynamic model has been developed using the MIKE21FM (Flexible Mesh) 2D modelling package [5] [6], a comprehensive modelling system for two-dimensional water modelling developed by DHI.

4.3 Model Boundary Conditions and Spatial Extent

The model setup used in the project metocean study is described extensively in the project metocean overview report [4]. The model used comprised two constituent parts – a European basin-scale model, which then fed boundary conditions to a local model of the Arklow area and surrounds. Because in the present project there was a possibility that materials arising from construction activities could advect outside of the local model extents, a modified version of the setup used in the project metocean study was employed. The European basin-scale model and the local model were merged into a single model which had the spatial extents of the European basin-scale model, together with all the embedded resolution local to Arklow of the local model. Whilst this setup is more computationally expensive (and therefore time-consuming), it delivers the same or better model performance, with the added advantage of ensuring that no materials arising from construction activities could leave the model domain.

Tidal boundary conditions to the model originate from the Finite Element Solution FES2014 dataset. This 35-constituent, global data-set has been produced using numerical modelling which assimilates satellite observations of water level and has, in our opinion, the best performance of any publicly-available global tide model. The dataset includes tide elevations (amplitude and phase) and tide currents on a 0.0625-degree (approximately 7 km) grid. The model was driven using water levels varying along three open boundaries, as shown in Figure 6.1.5.

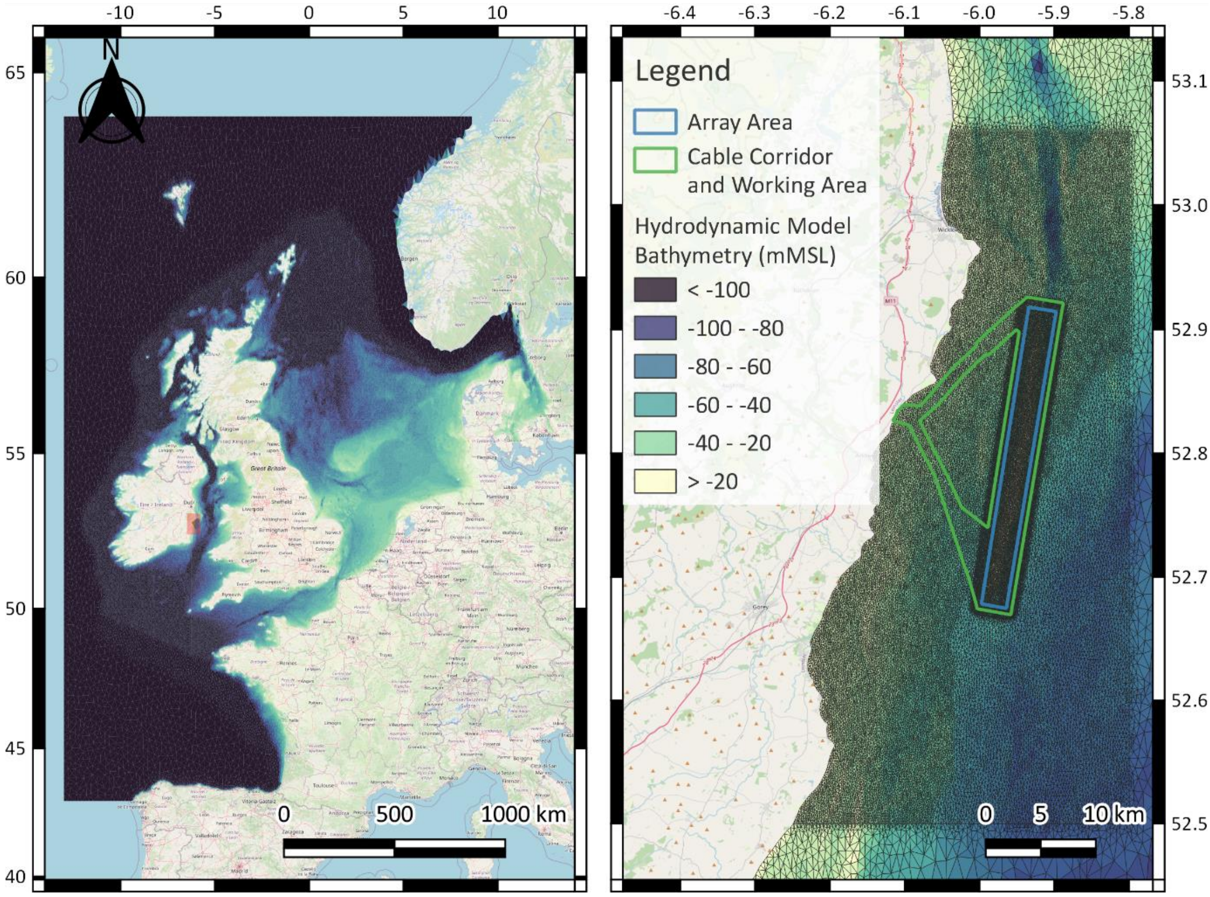


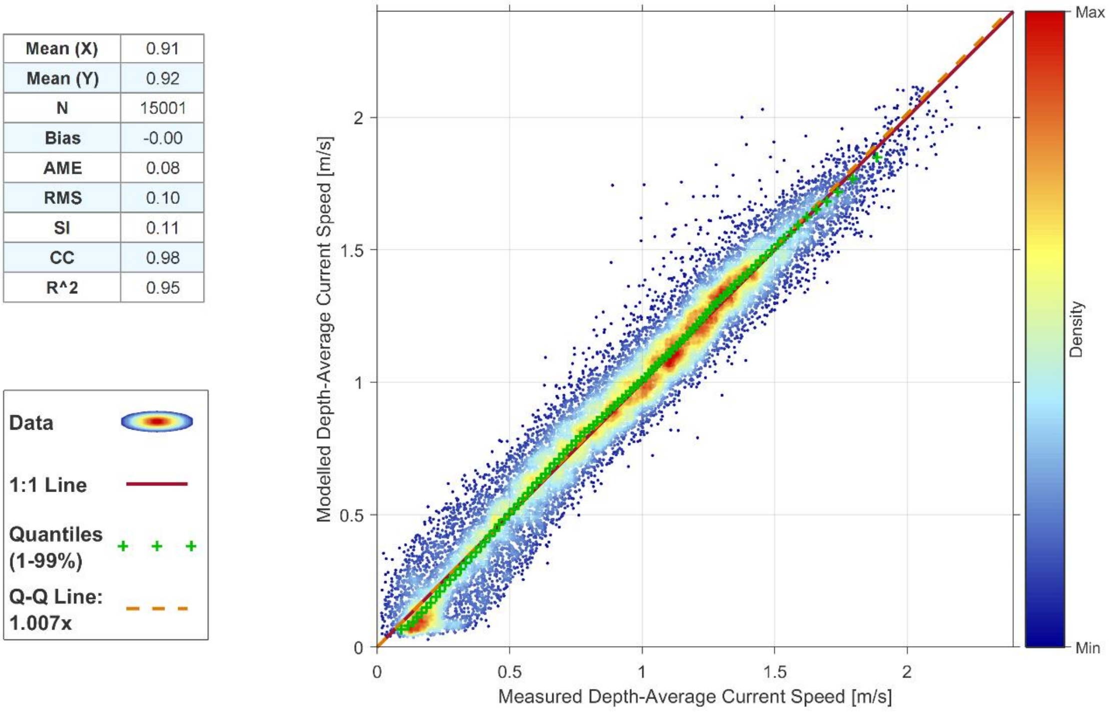
Figure 6.1.5: Regional European MIKE21 flexible model mesh. Bathymetry in m MSL.

The model had a spatial resolution of 75 m within the wind park Array Area boundary including a 2 km buffer surrounding it. Beyond this buffer, the model had a resolution of approximately 150 m in depths shallower than 40 m and a resolution of 225 m further offshore in the Irish Sea.

Atmospheric forcing for the hydrodynamic model originated from the ECMWF ERA5 dataset and was applied to ensure that atmospheric surge effects were properly represented in the model. This comprised of MetOceanWorks adjusted wind speeds, unadjusted wind directions, and unadjusted pressure fields.

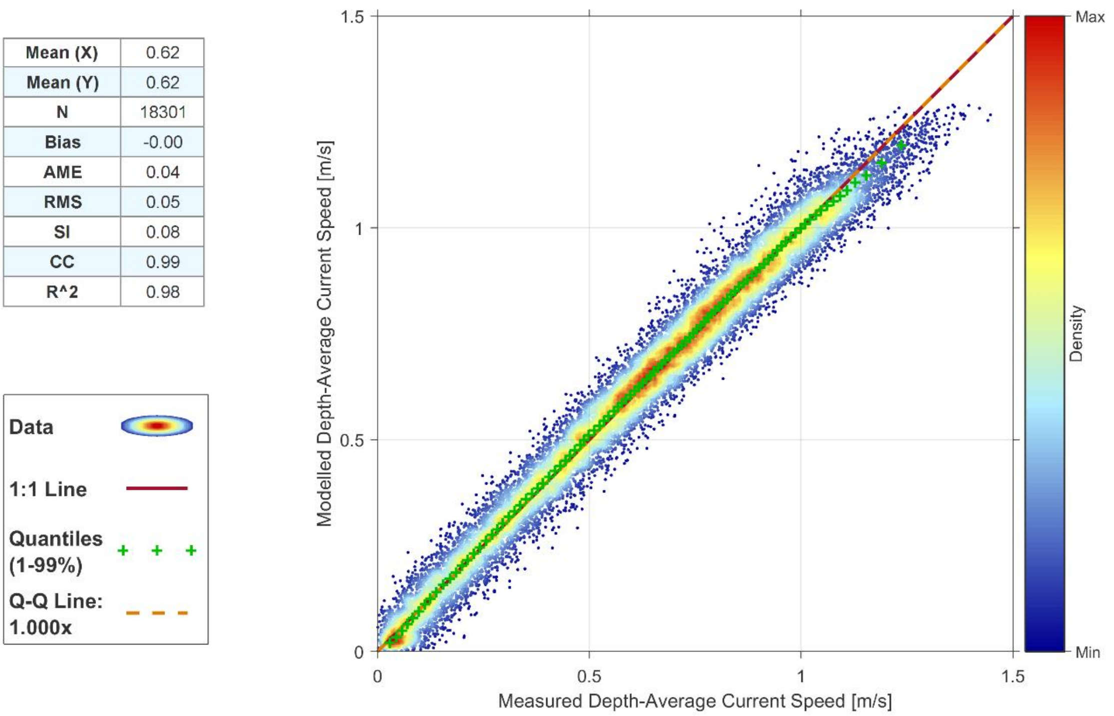
4.4 Model Validation

Validation of the hydrodynamic model used in this study was extensively reported in the project metocean overview report [4]. To ensure that the slightly different model setup used in this study had a similar or better level of performance, validations were carried out for currents for the three AWAC locations (see Figure 6.1.4) from the project metocean survey [1]. These additional validations are shown in Figure 6.1.6 to Figure 6.1.8.



Mean (X)	0.91
Mean (Y)	0.92
N	15001
Bias	-0.00
AME	0.08
RMS	0.10
SI	0.11
CC	0.98
R^2	0.95

Figure 6.1.6: Validation plot of currents at AWAC A.



Mean (X)	0.62
Mean (Y)	0.62
N	18301
Bias	-0.00
AME	0.04
RMS	0.05
SI	0.08
CC	0.99
R^2	0.98

Figure 6.1.7: Validation plot of currents at AWAC C.

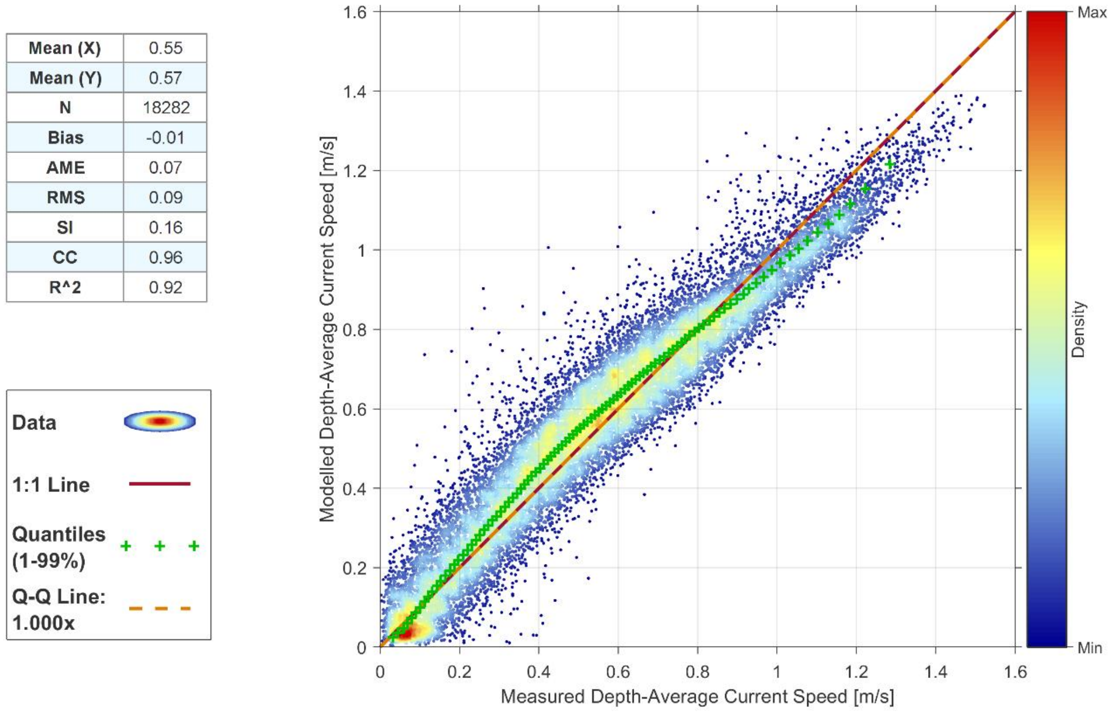


Figure 6.1.8: Validation plot of currents at AWAC E.

These plots demonstrate that the model has a slightly improved level of performance compared to the version of the model used in the project metocean study [4] (improvements of between 1 and 7% across all metrics). Performance can be classed as excellent at all locations.

4.5 Selection of Tidal Events

Four tidal events were selected for modelling of hydrodynamic blockage and for particle tracking modelling to encompass the largest (spring) and smallest (neap) likely tidal advection pathways on both flood (northerly) and ebb (southerly) phases of the tide. These are shown in Table 6.1.2:

Table 6.1.2: Events selected for hydrodynamic modelling.

Event Name	Description
Peak Spring flood	Flood (northerly) current speed that would be exceeded approximately seven times per year (therefore in the top 1% of peak flood current speeds)
Peak Neap flood	Flood (northerly) current speed that would not be exceeded approximately seven times per year (therefore in the bottom 1% of peak flood current speeds)
Peak Spring ebb	Ebb (southerly) current speed that would be exceeded approximately seven times per year (therefore in the top 1% of peak ebb current speeds)
Peak Neap ebb	Ebb (southerly) current speed that would not be exceeded approximately seven times per year (therefore in the bottom 1% of peak ebb current speeds)

In each construction scenario (i.e., the particle tracking modelling described in Section 6), the sediment releases were timed such that the period of greatest sediment release coincided with the period of maximum flow from Table 6.1.2 . After the release is finished, the model is then allowed to run for at least a further 48 hours to allow the far-field fate of the material to be ascertained. This time period allows all material to settle out from suspension.

4.6 Hydrodynamic Blockage Modelling

To assess the array-scale effect of the presence of the built wind farm on flows and water levels, blockage modelling was used. Blockage modelling uses a sub-grid scale parameterisation of each foundation structure to represent the blockage to flows caused by the wind farm. Three different structure types were modelled: the ABWP2 wind turbine generators (WTGs), the Offshore Substation Platforms (OSPs), and the Arklow Bank Wind Park 1 (ABWP1) WTGs. The ABWP1 WTGs were included in both the baseline and scheme models. The MIKE21 FMHD software allows the user to provide a description of the geometry of the structure in terms of its geographical position, plan shape, height and width, over any number of vertical sections. The model then uses a simple drag law to capture the increasing resistance imposed by the structures as the flow speed increases.

The model was run for the four tidal events described in Table 6.1.2 to establish a baseline condition. The model was then re-run for the same conditions, but this time including the representation of the ABWP2 structures in the model. The difference between these two results was calculated for each of the tidal events, providing the predicted difference in flow speeds and water levels caused by the presence of the wind farm.

5 Waves

For validation, waves were modelled using an Irish Sea SWAN model in conjunction with a higher resolution nested model of Arklow. SWAN cycle III version 40.91ABC [7] was used.

Model parameters should be considered as representative of a three-hour sea-state.

5.1 Modelling Software

A bespoke SWAN wave model was deployed, with a high-resolution regional nest. SWAN is a third-generation wave model, developed at Delft University of Technology, which computes random, short-crested wind-generated waves in coastal regions and inland waters. SWAN accounts for the following physics:

- Wave propagation in time and space, shoaling, refraction due to current and depth, frequency shifting due to currents and non-stationary depth;
- Wave generation by wind;
- Three- and four-wave interactions;
- White-capping, bottom friction and depth-induced breaking;
- Wave-induced set-up;
- Transmission through and reflection (specular and diffuse) against obstacles, and;
- Diffraction approximation.

The large-scale model used a spatial resolution of 5.5 km whilst the highest resolution nested model had a horizontal resolution of 110 m, which is considered sufficiently high resolution to be able to assess the array-scale effects of blockage by the structures, using a sub grid-scale technique. The wave model extents and resolutions are shown in Figure 6.1.9 below.

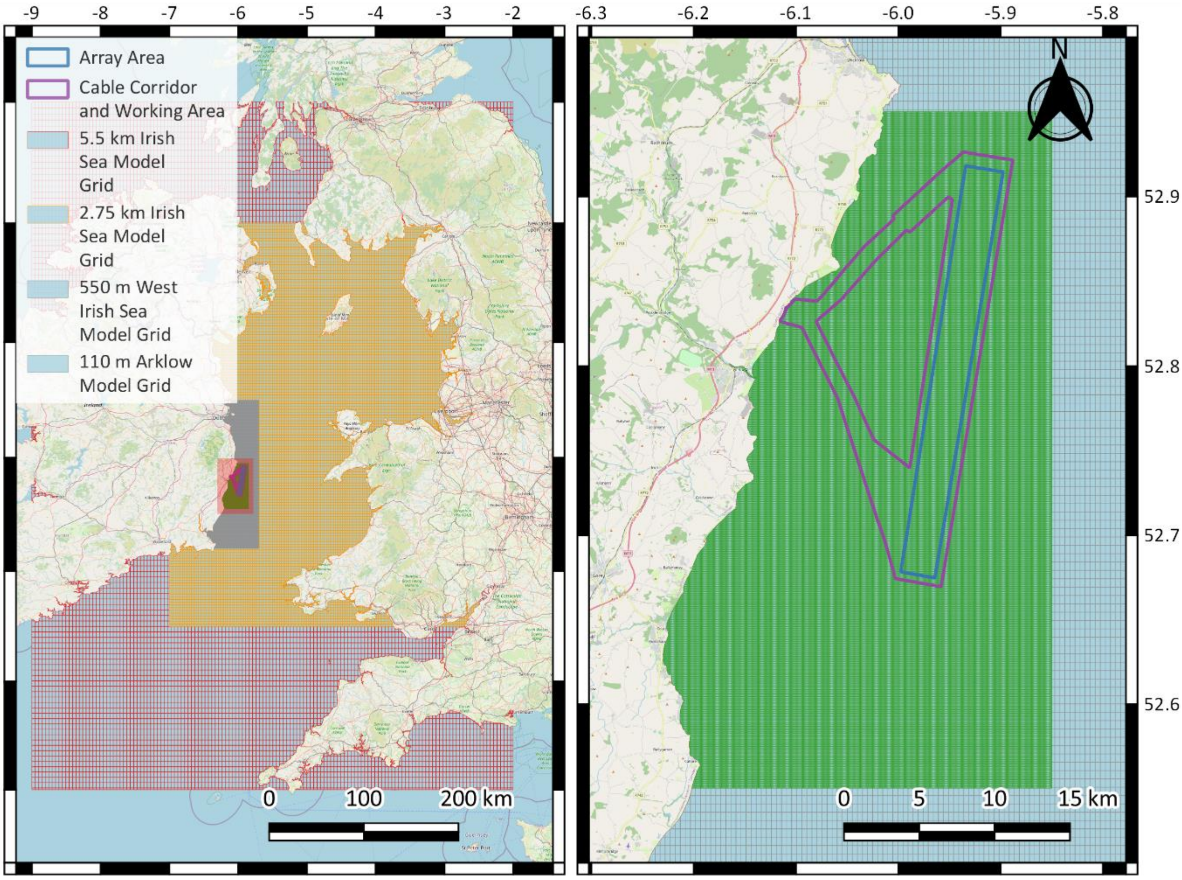


Figure 6.1.9: Wave model domains.

5.2 Model Boundary Conditions

For this study, the local-scale Arklow model was driven at its external boundaries by wave parameter values (Hm0, Tp, mean wave direction, wave spreading), along with 10 m wind speeds and directions applied across the whole domain. These values were adjusted to achieve the desired wave conditions at the analysis location (see Section 5.4). The water surface elevation in the model was set to MLWS.

5.3 Model Validation

The model used herein is the same model as was used for the project metocean study. Validation of the wave model is discussed extensively in the project metocean overview report [4].

5.4 Selection of Wave Events

The high-resolution Arklow model boundary conditions (input wind speed and wave parameter boundaries) were adjusted such that conditions in the model matched the following conditions as defined in ABWP2 metocean design criteria report [8] at the E4 location.

Table 6.1.3: Wave conditions modelled.

Event Name	Direction [°N from]	Hm0 [m]	Tm02 [s]
1 in 1 year	195	4.45	6.91
1 in 50 year	195	5.84	7.84
1 in 50 year	105	5.11	7.47
1 in 50 year	15	4.36	7.01

5.5 Wave Blockage Modelling

To assess the array-scale effect of the wind farm foundations on waves, blockage modelling was used. Blockage modelling uses a sub-grid scale parameterisation of each foundation structure to represent the blockage effects to waves caused by the wind farm. Three different structure types are modelled: the ABWP2 WTGs, the OSPs, and the ABWP1 WTGs. The SWAN software allows the user to provide a description of the structure as a coefficient of transmission through specified model grid cells (in this case, the cells containing the WTGs or OSPs).

After a run of the model with only the ABWP1 structures present (baseline conditions), the model was then re-run for the same conditions, but this time including the representation of the ABWP2 foundation structures. The difference between these two results was calculated for each of the events, providing the predicted difference in wave conditions caused by the imposition of the ABWP2.

6 Particle Tracking

The Particle Tracking module of MIKE 21 Flow Model FM (Flexible Mesh) is used for modelling the transport and fate of suspended and sedimented substances discharged in estuaries and coastal areas or in the open sea. The material is considered as particles forming a sediment plume being advected with the surrounding water body and dispersed as a result of random (turbulent) processes in three dimensions. Multiple sediment classes can be simulated. The particles from each class settle with a constant settling velocity. A mass is attached to each particle. The following processes are attached to individual particle classes:

- Settling;
- Moving sources (if applicable); and
- Horizontal and vertical dispersion.

In this study, several representative sediment classes were used. These are detailed in Table 6.1.4.

The model calculates the path of each particle and outputs the instantaneous concentrations of individual classes in two dimensions, as well as the settled mass. The output concentration is based on the mass of particles present in the volume of water in a given model cell. The settled mass is converted to a deposition depth by dividing by the settled density of the material under consideration. For the purpose of the present assessment, re-erosion of settled material is conservatively not considered, to ensure the maximum depth of deposition is determined.

The hydrodynamic model (and therefore the output grid) has a spatial resolution featuring a triangular mesh with 75 m resolution in ABWP2 development area and surrounds. For the purposes of environmental assessment, a minimum material concentration of 1 mg/l above background was chosen to be resolved by the model. Given that some releases are modelled near to the shallow coastal waters (for instance, Bentonite release), the model was also required to resolve these minimum concentrations in areas of relatively shallow water. A cut-off water depth of 1.5 m was chosen for resolving the minimum required concentrations in the model. Assuming that the triangular mesh is composed of triangles tending toward an equilateral shape, and a water depth corresponding with mean sea level, the volume of water in an individual mesh element with water depth 1.5 m is 8,438 m^3. In order to resolve to 1 mg/l in this volume of water, each particle must have a maximum mass of 8.4 kg. Therefore, a sufficiently high number of particles was released in each run such that each particle was assigned a maximum mass of 8.4 kg in the model. Although each particle has a representative maximum mass 8.4 kg, it inherits the settling velocities of its class from Table 6.1.4.

Table 6.1.4: Details of the representative sediment types.

Sediment type	Size range (mm)	Settling velocity (m/s)
Coarse sand	0.500 to 1.0	0.0663
Medium sand	0.250 to 0.500	0.0287
Fine sand	0.125 to 0.250	0.018
Very fine sand	0.063 to 0.125	0. 0065
Coarse silt	0.031 to 0.063	0.0014
Medium silt	< 0.0031	0. 00001

Brief details of the model set-up for each of the scenarios follows. With the exception of the Array Drilling scenario (for which detail is provided in Volume II, Chapter 4: Description of Development) , for each scenario, four different current events were simulated, as described in Section 4.5. These are high and low current speeds, flowing northward (flood) and southward (ebb).

For the array drilling scenario, the drilling event is expected to continue for around 188 hours, much longer than the 48-hour model runs used for the other scenarios. Therefore, in this case, only two scenarios were run (spring and neap – since flood and ebb tidal cycles lose significance over such long time period), and these runs were allowed to continue for the full 188-hour drilling period, plus 48 hours after the end of drilling operations.

The geographical positions of each of the sediment release locations described below are shown in Figure 6.1.10. In all cases, the volumes, release rates and geographical positions (based on the Proposed Development Parameters provided by the Developer) of the releases were defined by GoBe, and approved by the Developer.

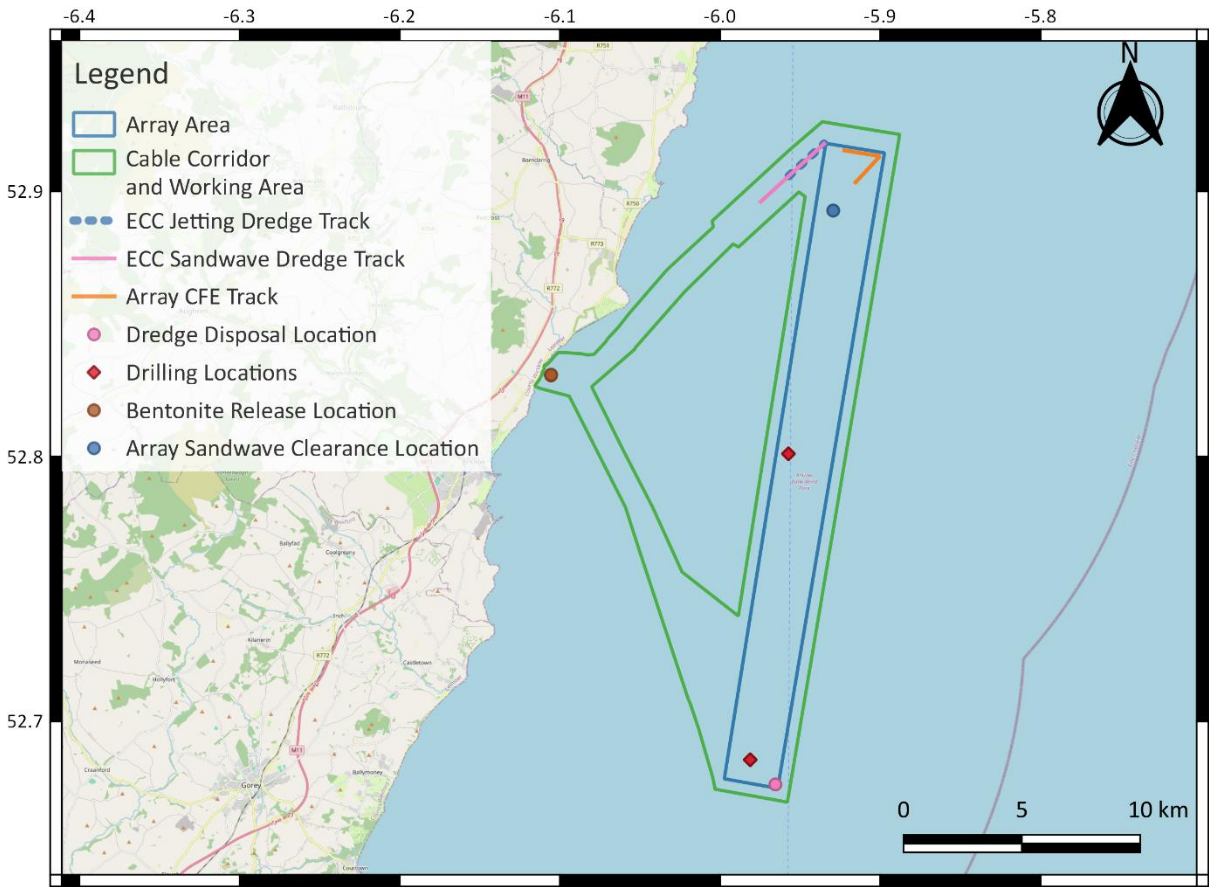


Figure 6.1.10: Locations used in particle tracking modelling.

6.1 Array Area

6.1.1 Foundation Installation – Drilling

Two locations are simulated as being drilled – WTG24 from the 47 WTGs layout, and the southern OSP. The release of drill arisings is simulated to persist for 88 hours (at WTG24), followed by a 12 hour pause, followed by another 88-hour period of drilling (at the southern OSP), with the current speed peak occurring six hours before the release ends at WTG24. Because the material is released in stages, a different representative settled bed density is used for each sediment type to calculate the sediment deposition thicknesses:

- For fine sand, 780 kg/m^3
- For very fine sand, 460 kg/m^3
- For coarse silt, 290 kg/m^3, and
- For medium silt, 200 kg/m^3

6.1.2 Foundation Installation – Dredging

A single Trailor Suction Hopper Dredger (TSHD) hopper load is simulated as being filled (including overspill discharges), and then discharged at an indicative dump site. The foundation site where overspill from the hopper commences is WTG11 from the 47 WTG Option layout, and the dump site is approximately 24.4 km to the south (in the south eastern corner of the array area). The overspill phase from the TSHD lasts 60 minutes at the WTG location. There is then a 50-minute break in discharge during demob and transit to the dump site, before a 10-minute dumping period at the dump site. The current speed peaks occur during the final ten minutes of the overspill phase. For the overspill phase the material is released into the model at the water surface, and for the dumping phase the material is released 9.8 m below the surface. To convert the settled mass from the model into a depth in mm, a settled density of 1,430 kg/m³ was used.

6.1.3 Cable Installation – Controlled Flow Excavation

A single Controlled Flow Excavator is simulated as moving from WTG03 to WTG02, before remobilising to move between WTG02 to WTG01. The excavation phase from WTG03 to WTG02 lasts 220 minutes, before a 24-hour pause for remobilisation, and then another 220-minute period of excavation between WTG02 and WTG01. The current speed peaks occur during the final ten minutes of the first excavation phase. The material is released into the model at 3 m above the bed. To convert the settled mass from the model into a depth in mm, a settled density of 1,009 kg/m³ was used.

6.2 Export Cable Route

6.2.1 HDD Punch-out - Bentonite Release

A single location for HDD punch-out and associated Bentonite release is simulated. The location is approximately 375 m from shore within the cable corridor. The release of Bentonite is simulated to last for 4.5 days (initial punch-out followed by a reaming phase), with the current speed peak occurring 20 minutes into the release period. To convert the settled mass from the model into a depth in mm, a settled density of 100 kg/m³ was used.

6.2.2 Cable Trenching (Jetting)

The jetting tool is simulated to be moving along a 2 km section of the cable route approximately 5.2 km offshore, at a rate of 50 m per hour, meaning that the trenching takes 40 hours. In each case, the current speed peak events occur half way along the excavation route. The material is released into the model at 2.5 m above the bed. To convert the settled mass from the model into a depth in mm, a settled density of 1,001.4 kg/m³ was used.

6.2.3 Sandwave Clearance using a Dredger

A single TSHD hopper load is simulated as being filled (including overspill discharges), and then discharged at a dump site. The dredger is simulated as moving along a 3.6 km line in the centre of the northern cable route for 60 minutes (thus travelling at a speed of 1 m/s), before transiting to the dump site approximately 25.8 km to the south (in the south eastern corner of the array area). The overspill phase from the TSHD lasts 60 minutes at the WTG location. There is then a 50-minute break in discharge during demob and transit to the dump site, before a 10-minute dumping period at the dump site. The current speed peaks occur during the final ten minutes of the overspill phase. For the overspill phase the material is released into the model at the water surface, and for the dumping phase the material is released 9.8 m below the surface. To convert the settled mass from the model into a depth in mm, a settled density of 1,212.2 kg/m³ was used.

7 Results

Model outputs were provided to GoBe in GIS format for interpretation in the relevant EIAR chapter(s). For the wave blockage modelling, raster GeoTIFFs are used, and for all other results, ESRI-format vector shapefiles were used. In the case of the vector shapefiles, all parts of the shapefile where the concentration of raised levels of suspended sediment or sediment deposition is zero, were removed.

- Two output parameters are provided for particle tracking scenarios:
  - Sedimented (showing the depth of sediment that has settled on the seabed after release). Note that re-suspension was switched off in the model.
  - Suspended (showing the depth-averaged concentration of sediment that is in suspension after release).
- For particle tracking scenarios, for each of the current events, and for each output parameter, the following were provided:
  - The situation at 0, 1, 2, 3, 4, 5, 10, 15 and 20 hours (and for the array drilling scenario, additionally 25, 50, 100, 150, 200 and 230 hours) after the beginning of dredge operations.
  - The maximum of sedimented and suspended. This represents the largest value that occurred in each model grid cell over the entire simulation period. It is not representative of any single instant in time, but does provide a useful indication of the maximal extent of the plume and associated sedimentation. Note that because re-suspension is switched off in the model, the maximum sedimentation is the same as the sedimentation situation at the final model time step.
- For particle tracking scenarios the units of 'suspended' are depth-averaged mg/l. The units of 'sedimented' are mm.
- For wave blockage scenarios, the following three output parameters are provided:
  - Hm0 = significant wave height. Units = metres.
  - Tm02 = mean zero-crossing wave period. Units = seconds.
  - mDir = mean wave direction. Units = degrees relative to north (or absolute degrees for the difference layer)

  for each of three output types:
  - BASELINE = ABWP1 turbines included in model, no ABWP2 turbines or OSPs included in model
  - SCHEMExxxRD = ABWP1 and ABWP2 turbines and OSPs included in the model, where xxx is the rotor diameter for that ABWP2 option
  - Diff = SCHEME minus BASELINE
- For the hydrodynamic blockage scenarios, the following three parameters are provided
  - Current speed and difference in current speed (units = depth averaged current speed m/s)
  - Current direction and difference in current direction (Units = depth averaged current direction °T, or absolute ° for the difference layer)
  - Surface elevation and difference in surface elevation (Units = m MSL or absolute m for the difference layer).

  for each of two output types:
  - Baseline = ABWP1 turbines included in model, no ABWP2 turbines or OSPs included in model
  - Difference = scheme results minus baseline results

References

[1] Fugro GB Marine, “Final Data Report, Arklow Offshore Wind Farm Metocean Survey, Ref: 181399-R-03(01), Draft,” 21 April 2021.

[2] The European Marine Observation and Data Network, “Bathymetry | European Marine Observation and Data Network (EMODnet),” The European Marine Observation and Data Network, 01 February 2023. [Online]. Available: http://www.emodnet-bathymetry.eu. [Accessed 01 February 2023].

[3] AVISIO, “GLOBAL TIDE - FES,” 01 February 2023. [Online]. Available: https://www.aviso.altimetry.fr/en/data/products/auxiliary-products/global-tide-fes.html. [Accessed 01 February 2023].

[4] MetOceanWorks, “Metocean Data Overview: Arklow Bank Offshore Wind Farm,” MetOceanWorks, 2021.

[5] DHI, “Mike 21 Flow Model FM: Hydrodynamic Module: User Guide,” DHI A/S, Denmark, 2021.

[6] DHI, “MIKE 21 Flow Model FM: Hydrodynamic and Transport Module; Scientific Documentation,” DHI A/S, Denmark, 2021.

[7] SWAN team, Delft University of Technology, “Swan cycle III version 40.91 ABC - Scientific and Technical Documentation,” 2013.

[8] MetOceanWorks, “Arklow Bank Wind Park Phase 2: Metocean Analysis for Site Assessment: Eastern Zone,” MetOceanWorks, 2021.