Environmental Impact Assessment Report

NISA

North Irish Sea Array

Volume 9: Appendices (Offshore)

Appendix 10.3

Assessment of Spoil Mounds

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NORTH IRISH SEA ARRAY (NISA) OFFSHORE WIND FARM.

APPENDIX 10.3: ASSESSMENT OF SPOIL MOUNDS

MetOceanWorks / GoBe

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NORTH IRISH SEA ARRAY (NISA) OFFSHORE WIND FARM. APPENDIX 10.3: ASSESSMENT OF SPOIL MOUNDS

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Abbreviations

EIA	Environmental Impact Assessment
MDS	Maximum Design Scenario
MSL	Mean Sea Level
MW	Megawatt
NISA	North Irish Sea Array
OSP	Offshore Sub-station Platform
OWF	Offshore Wind Farm
STFATE	Short-term Fate
TSHD	Trailer Suction Hopper Dredger
USACE	United States Army Corps of Engineers
WTG	Wind Turbine Generator

1. Introduction

This technical appendix (Appendix 10.3) provides an assessment of spoil mounds which are expected to develop when a trailer suction-hopper dredger (TSHD) discharges sediment at various locations across the array area of North Irish Sea Array (NISA) Offshore Wind Farm (referred to as 'proposed development'). This sediment is produced from seabed levelling by TSHD at 50% of the jacket foundations associated with Project Option 2. This assessment complements the plume dispersion modelling of fine sediments released as overspill, as well as fine sediments advected away during the spoil discharge period.

1.1. Document structure

Section 1 explains the scope and purpose of the Technical Appendix.

Section 2 describes the method of assessment for spoil mounds.

Section 3 offers details of each spoil disposal scenario and presents the results.

Section 4 provides a summary of the assessment.

Section 5 lists the references related to this technical note.

1.2. Supporting documents

The assessment of spoil mounds has been established with consideration to the following project documents:

- Volume 2, Chapter 6: Description of the Project Development – Offshore
- Volume 2, Chapter 8: Construction Strategy – Offshore
- Fugro (2022). Geophysical Survey Results Report | Ireland, Irish Sea. Results Report – Fugro Mercator. F202831-REP-003. Issue 1. For North Irish Sea Array Windfarm Limited
- Natural Power (2022). NISA Benthic Ecology Baseline. Array Area Benthic Survey Report

2. Assessment of spoil mounds

2.1. Overview

Spoil mounds form on the seabed when a TSHD discharges a hopper load of sediments which fall to the seabed. Multiple phases of spoil disposal across a defined area may develop spatially overlapping spoil mounds which gradually modify the profile of the local seabed unless onward sediment transport can move the material away.

Initially, the mass of the spoil will fall relatively quickly to the seabed, developing a downward convective density flow with limited opportunity for wider dispersion over the relatively short release period. Most fine sediments (fine sand and silts) will be carried to the seabed within the convective flow (falling faster than associated particle settling velocities), but some will have the potential to be stripped out during this phase to become prone to tidal advection and dispersion further away. The subsequent dynamic collapse of the spoil across the seabed creates the highest potential for the occurrence of sediment plumes of fine sediments.

Finer sediments present across the surface of the spoil mound will be subject to the highest rates of sediment transport (compared to coarser sediments) during periods of peak flows and may be winnowed away over time to return to the ambient sediment transport regime. However, this process may be minimal in a deposition environment with relatively weak flows, such as those present across the proposed development.

2.2. Approach

The near-field STFATE (Short-Term Fate) model for split barge and hopper dredge disposal operations of dredged material disposal in open water (USACE, 1995) is applied to assess individual discharges of spoil disposal from a large-sized TSHD with a capacity of around 15,000 m^3.

STFATE considers the spoil disposal from an instantaneous discharge for the following stages:

- Convective descent of spoil released from hopper where gravity and momentum dominate
- Dynamic collapse where the discharge encounters the seabed and spreading dominates
- Diffusive phase with passive advective transport and sediment dispersion by currents in the short-term

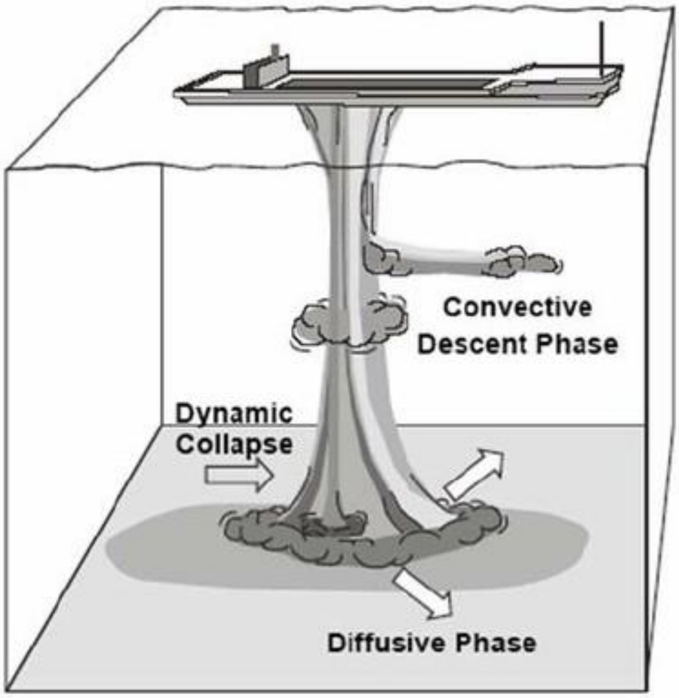

Figure 1. Phases of the spoil disposal process following release from dredger (PNNL, 2006)

Model inputs include the water depth and flow conditions at the spoil site (provided by the hydrodynamic model, MetOceanWorks, 2023), along with the volume of spoil which is described with up to four different particle sizes with associated values for specific gravity, fall velocity, and deposition voids ratio. The model also accounts for the basic dimensions and capacity of the TSHD. In the present case, the model is implemented with a 9.1 m (30 feet) grid in the horizontal to resolve the spoil mound on the seabed.

STFATE complements the far-field particle tracking model (MetOceanWorks, 2023), which is applied to assess the wider advection, dispersion, and subsequent deposition of fine sediment as sediment plumes.

2.3. Sediment parameters

STFATE allows the hopper volume of dredged material to be characterised into up to four sediment classes. Based on sediment gradings data obtained from the benthic survey grab samples (Natural Power, 2022) the following representative sediment types are adopted:

- Fine sand
- Very fine sand
- Coarse silt
- Medium silt

Coarse sediments are generally not present in surficial sediments across the array area of the proposed development.

Table 1 summarises the properties of the various sediment types defined in STFATE.

Table 1. STFATE representative sediment types, settling velocities, and deposition voids ratio

Sediment type	Representative size (mm)	Settling velocity (m/s)	Deposition void ratio
Fine sand	0.188	0.0227	0.7
Very fine sand	0.094	0.0057	1.0
Coarse silt	0.047	0.0014	3.0
Medium silt	0.023	0.0003	6.0

3. Disposal scenarios

3.1. Overview

STFATE has been applied to investigate spoil disposal from the anticipated TSHD dredging activities during the construction period, which are related to seabed levelling of around 50% of jacket foundations proposed for Project Option 2.

The disposal from a single hopper load is considered to determine a representative scale of the resulting spoil mound. In reality, seabed levelling will involve multiple disposals, which are expected to form spoil mounds independently of each other, across areas considered suitable for disposal.

3.2. TSHD dimensions

When the TSHD reaches the nominated area for spoil disposal the bottom hopper doors will open to discharge the cargo. The hopper is expected to be emptied within a short period of approximately six minutes.

Table 2 provides representative dimensions for the dredger (based on the Boskalis Oranje TSHD).

Table 2. Summary dimensions of representative TSHD (source: Boskalis)

Vessel Dimension	Value	Unit
Length	156	m
Breadth	28	m
Number of hopper doors	5	-
Hopper Capacity	15,961	m^3
Carry capacity	30,445	tonnes
Draught (empty)	4.63	m
Draught (full)	12.02	m
Max sailing speed (loaded)	16.2	knots

The number of spoil mounds and dimensions of each mound are closely related to the capacity of the dredger.

3.3. Seabed levelling – array area

3.3.1. Sediment volumes

The assessed option that presents the greatest magnitude of impact for seabed levelling (i.e., largest overall removed sediment volume) relates to the jacket foundation option for Project Option 2 that has 35 WTG, along with additional levelling for a single OSP. The in-situ volume of sediment to be removed from a single WTG location is estimated to be 5,945 m^3 and 6,082 m^3 for the OSP, however, seabed levelling is only anticipated at 50% of sites (equivalent to 18 locations) with a corresponding total levelling requirement of 113,086 m^3.

To estimate the number of hopper loads, a bulking factor of 1.25 has been assumed for present purposes which is mid-range of 1.1 to 1.4 for 'silts - consolidated' (Bray, Bates, & Land, 1996), which are common across the array area. In addition, the overspill loss is estimated to 42.6%. On this basis, seabed levelling around two WTG equates to around a single hopper load, with up to ten hopper loads expected for dredging all 18 locations, which lead to a corresponding number of spoil disposal events.

An area close to the northern array boundary, which coincides with the location identified to have the largest contribution of fine sediments (grab sample #5, (Volume 9, Appendix 12.1: Array Area Benthic Survey Report)), has been identified for undertaking this assessment as this represents the option considered to lead to the greatest magnitude of impact for seabed levelling. Table 3 summarises the anticipated proportion of each sediment type within a single hopper load after dredging this location.

Table 3. Contribution of sediment types from seabed levelling around WTG-T44 to -T43

Sediment type	Relative proportion (%)	Sediment volume (m^3)	Mass (tonnes)
Fine sand	5.6	660	739
Very fine sand	18.8	2,195	2,459
Coarse silt	18.6	2,181	2,443
Medium silt	56.9	6,660	7,459

N.b. For the purposes of the modelling described in this document the locations of WTGs within the array area for the proposed development have been numbered to aid identification in the model.

3.3.2. Environmental conditions

The environmental conditions at the representative spoil disposal site are established from a location close to WTG-T39, towards the northern array boundary, a site which remains within the same type of sediment classification. Water depths at this location are estimated to be around 45 m (relative to LAT). Given the draught of the loaded TSHD is around 12 m (Table 2) then the distance for spoil to fall from the open hopper doors to reach the local seabed depth is expected to be around a further 33 m.

Tidal currents have the potential to deflect the falling spoil which may slightly reduce the height and increase the spread and deposition area of the spoil mound compared to deposition during a period of slack water. The maximum depth-average current speed is estimated to be around 0.52 m/s on spring tides with a typical current speed of around 0.3 m/s.

When the dredger reaches the target disposal site then the vessel is expected to slow to discharge the loaded hopper. A minimum vessel speed will also serve to distribute the spoil over a slightly wider area, compared to a stationary vessel.

3.3.3. Representative spoil mound

STFATE predicts the immediate area of deposition and height of the spoil mound once all the material reaches the seabed, based on the prescribed inputs. Subsequent tidal winnowing of the spoil mound over the longer-term is not accounted for.

Figure 2 presents the deposition footprint of the spoil mound produced from seabed levelling at WTG-T44 to -T43.

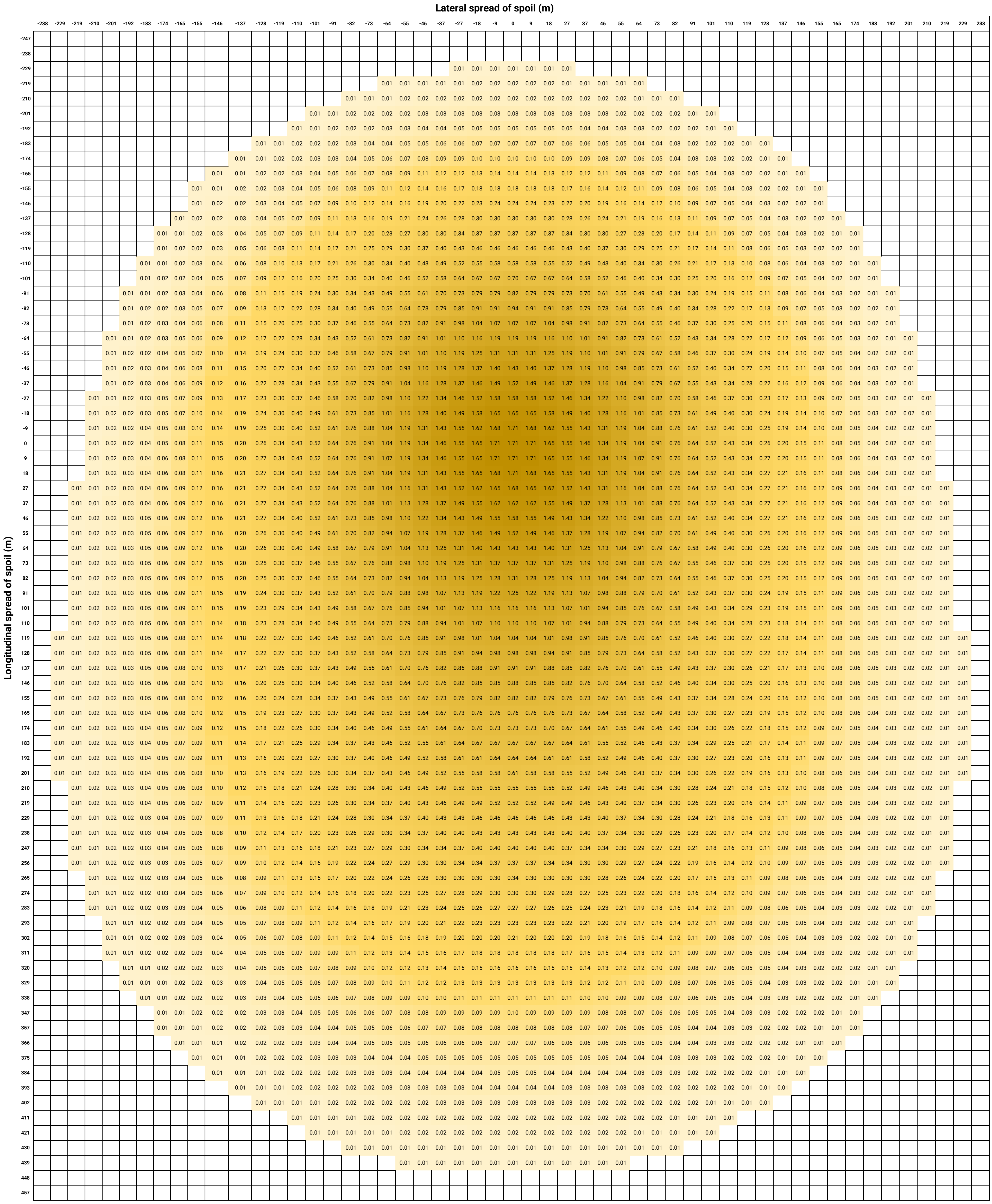

Figure 2. Predicted spoil mound height and extent from seabed levelling around WTG-T44 to T43

In this scenario, the dredger is moving from west to east with a nominal cross-flow from north to south. The southerly cross-flow leads to wider deposition of the fine sediments, notably the silts extend up to 439 m from the centre of the spoil mound, which is estimated to have a maximum height of 1.71 m and comprised mainly of fine sand and very fine sand.

Table 4 provides a summary of the area of coverage for the spoil mound for different heights above the seabed, including thresholds of 0.05 and 0.30 m which are regarded as conditions which would risk the smothering of benthic receptors at “light” and “heavy” levels (Tyler-Walter, Tillin, d'Avack, Perry, & Stamp, 2018). The wider areas covered with heights up to 0.01 m are considered to be formed mainly of the silt content.

Table 4. Area of coverage of spoil mound from seabed levelling around WTG23 and 24

Height of mound above seabed (m)	Area covered (km^2)
< 0.01 (periphery)	0.006
0.01 to 0.05	0.034
0.05 to 0.10	0.023
0.10 to 0.30	0.046
0.30 to 1.00	0.060
> 1.00 (centre)	0.022
Total	**0.191**

4. Summary

A representative spoil mound developing from the disposal of dredged arisings from seabed levelling around jacket foundations is investigated based on a large-sized TSHD with an assumed capacity of around 15,000 m^3. A larger or smaller capacity TSHD would expect to produce a proportionally different scale of spoil mound.

Apart from the dredger hopper capacity, the other main influences on the dimension of spoil mounds are the contributing sediment sizes, local water depth, and tidal flows.

There are expected to be up to ten disposal events to account for 50% of the 35 WTG (and one OSP) foundation locations, with each dredging event catering for two foundation locations. The separation of foundations means that spoil mounds are unlikely to overlap when the disposal events are nearby to the individual locations of seabed levelling, meaning that the total seabed footprint of all mounds can be considered as additive, i.e., ten separate mounds covering around 1.91 km^2, or less, noting the conservatism of the site assessed. The total area with deposition levels over 0.05 m is estimated as 1.51 km^2 and for levels over 0.3 m the area is estimated as 1.28 km^2.

5. References

Bray, R. N., Bates, A. D., & Land, J. M. (1996). *Dredging: A Handbook for Engineers 2nd Edition.*

Enviros. (2022). *Outer Dowsing Offshore Wind Farm Geophysical UHRS and Light Geotechnical Survey, East Anglia, Offshore UK. ENV21-21042-GTR4-02_Rev.01.*

MetOceanWorks. (2023). *North Irish Sea Array. Appendix 10.2: Marine Physical Processes Numerical Modelling. GoBe_C00002_R01.*

Miedema, D. S. (2013). *Dredging Processes. The loading process of a Trailing Suction Hopper Dredge.* TUDelft.

Natural Power. (2022). *NISA Benthic Ecology Baseline. Array Area Benthic Survey Report.*

PNNL. (2006). *Preliminary Assessment of Potential Impacts to Dungeness Crabs from Disposal of Dredged Materials from the Columbia River. Contract DE-AC05-76RL01830.*

Tyler-Walter, H., Tillin, H. M., d'Avack, E. A., Perry, F., & Stamp, T. (2018). *Marine Evidence-based Sensitivity Assessment (MarESA) – A Guide. Marine Life Information Network (MarLIN). Marine Biological Association of the UK, Plymouth, pp. 91.*

USACE. (1995). *Development and verification of numerical models for predicting the initial fate of dredged material disposed in open water. Report 2. Theoretical developments and verification results. Final Report. Dredging Research Program. Technical Report DRP-93-1.*

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