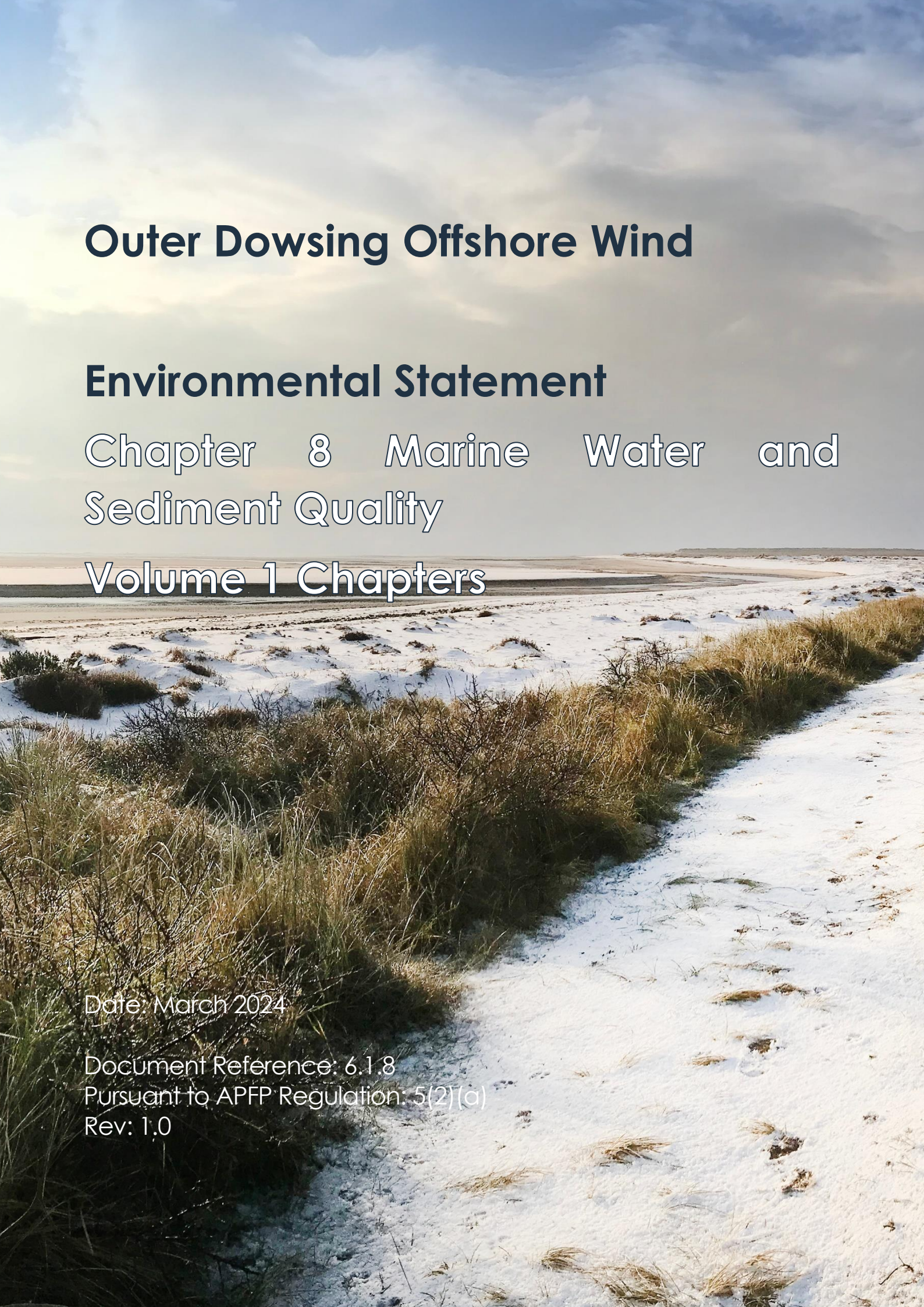

Outer Dowsing Offshore Wind

Environmental Statement

Chapter 8 Marine Water and Sediment Quality

Volume 1 Chapters

Date: March 2024

Document Reference: 6.1.8
Pursuant to APFP Regulation: 5(2)(a)
Rev: 1.0

Company:	**Outer Dowsing Offshore Wind**	Asset:	**Whole Asset**
Project:	**Whole Wind Farm**	Sub Project/Package:	Whole Asset
Document Title or Description:	Chapter 8- Marine Water and Sediment Quality		
Internal Document Number:	PP1-ODOW-DEV-CS-REP-0116	3rd Party Doc No (If applicable):	N/A

Rev No.	Date	Status / Reason for Issue	Author	Checked by	Reviewed by	Approved by
1.0	March 2024	DCO application	GoBe	GoBe	Shepherd and Wedderburn	Outer Dowsing

Table of Contents

Table of Tables

Table of Figures (Volume 2)

- Figure 8.3b Site Specific Survey Locations within he Project ECC and Array Area – Metals (document reference: 6.2.8.3b)
- Figure 8.4 Location of Cumulative Projects relating to the MW&SQ Study Area (document reference 6.2.8.4)

Table of Appendices (Volume 3)

- Water Framework Directive (document reference 6.3.8.1)

Acronyms & Terminology

Abbreviations / Acronyms

Acronym	Expanded name
AA	Annual Average
AfL	Agreement for Lease
AL1	Cefas Guideline Action Level 1
AL2	Cefas Guideline Action Level 2
ANS	Artificial Nesting Structure
BAC	Background Assessment Concentration
BEIS	Department for Business, Energy and Industrial Strategy (now the Department for Energy Security and Net Zero (DESNZ))
CBRA	Cable Burial Risk Assessment
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CMS	Construction Method Statement
DCO	Development Consent Order
DECC	Department for Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DESNZ	Department for Energy Security and Net Zero formerly Department of Business, Energy and Industrial Strategy (BEIS), which was previously Department of Energy & Climate Change (DECC)
dML	deemed Marine Licence
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
EPP	Evidence Plan Process
ERL	Effects Range Low
ERM	Effects Range Median
ES	Environmental Statement
ETG	Expert Topic Group
EU	European Union
GT R4 ltd	The Applicant. The special project vehicle created in partnership between Corio Generation (a wholly owned Green Investment Group portfolio company), Gulf Energy Development and TotalEnergies
HDD	Horizontal Directional Drilling
HMW	High Molecular Weight
IPC	Infrastructure Planning Commission
LMW	Low Molecular Weight
MAC	Maximum Allowable Concentration
MDS	Maximum Design Scenario
MFE	Mass Flow Excavator
MHWS	Mean High Water Springs
MMO	Marine Management Organisation
MPCP	Marine Pollution Contingency Plan
MSFD	Marine Strategy Framework Directive
MW&SQ	Marine Water and Sediment Quality
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project

Acronym	Expanded name
NVZ	Nitrate Vulnerable Zone
O&M	Operation and Maintenance
OCP	Organochlorine Pesticide
OFTO	Offshore Transmission Owner
ONS	Onshore Substation
ORCP	Offshore Reactive Compensation Platform
OSS	Offshore Substation
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbon
PBDE	Polybrominated Diphenyl Ether
PCB	Polychlorinated Biphenyl
PEL	Probable Effect Levels
PEIR	Preliminary Environmental Information Report
PEMP	Project Environment Management Plan
PLONOR	Pose Little or No Risk to the Environment
PSA	Particle Size Analysis
RBMP	River Basin Management Plan
rBWD	revised Bathing Water Directive
RWC	Realistic Worst Case
SoS	Secretary of State
SPM	Suspended Particulate Matter
SPMP	Scour Protection Management Plan
SSC	Suspended Sediment Concentration
TCE	The Crown Estate
TEL	Threshold Effect Levels
TSHD	Trailer Suction Hopper Dredger
UKMMAS	UK Marine Monitoring and Assessment Strategy
UNCLOS	The United Nations Convention on the Law of the Sea
USEPA	United States Environmental Protection Agency
UWWTD	Urban Waste Water Treatment Directive
WFD	Water Framework Directive
WTG	Wind Turbine Generator
ZoI	Zone of Influence

Terminology

Term	Definition
AfL array area	The area of the seabed awarded to GT R4 Ltd. through an Agreement for Lease (AfL) for the development of an offshore windfarm, as part of The Crown Estate's Offshore Wind Leasing Round 4.
Array area	The area offshore within which the generating station (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling will be positioned.
Baseline	The status of the environment at the time of assessment without the development in place.

Term	Definition
Cumulative effects	The combined effect of the Project acting additively with the effects of other developments, on the same single receptor/resource. The combined effect of the Project acting cumulatively with the effects of a number of different projects, on the same single receptor/resource. Cumulative impacts are those that result from changes caused by other past, present or reasonably foreseeable actions together with the Project.
Cumulative impact	Impacts that result from changes caused by other past, present or reasonably foreseeable actions together with the Project.
Deemed Marine Licence (dML)	A marine licence set out in a Schedule to the Development Consent Order and deemed to have been granted under Part 4 (marine licensing) of the Marine and Coastal Access Act 2009.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of an impact with the sensitivity of a receptor, in accordance with defined significance criteria.
EIA Directive	European Union 2011/92/EU of 13 December 2011 (as amended in 2014 by Directive 2014/52/EU).
EIA Regulations	Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Regulations, including the publication of an Environmental Statement (ES).
Environmental Statement (ES)	The suite of documents that detail the processes and results of the EIA.
Evidence Plan	A voluntary process of stakeholder consultation with appropriate Expert Topic Groups (ETGs) that discusses and, where possible, agrees the detailed approach to the Environmental Impact Assessment (EIA) and information to support Habitats Regulations Assessment (HRA) for those relevant topics included in the process, undertaken during the pre-application period.
Export cables	High voltage cables which transmit power from the Offshore Substations (OSS) to the Onshore Substation (OnSS) via an Offshore Reactive Compensation Platform (ORCP) if required, which may include one or more auxiliary cables (normally fibre optic cables).
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Inter-array cables	Cable which connects the wind turbines to each other and to the offshore substation(s) , which may include one or more auxiliary cables (normally fibre optic cables).

Term	Definition
Maximum Design Scenario	The project design parameters, or a combination of project design parameters that are likely to result in the greatest potential for change in relation to each impact assessed
Mitigation	Mitigation measures are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects. .
National Policy Statement (NPS)	A document setting out national policy against which proposals for Nationally Significant Infrastructure Projects (NSIPs) will be assessed and decided upon
Non-statutory consultee	Organisations that the Applicant may be required to (under Section 42 of the 2008 Act) or may otherwise choose to engage during the pre-application phases (if, for example, there are planning policy reasons to do so) who are not designated in law but are likely to have an interest in a proposed development.
Offshore Export Cable Corridor (ECC)	The Offshore Export Cable Corridor (Offshore ECC) is the area within the Order Limits within which the export cables running from the array to landfall will be situated.
Offshore Reactive Compensation Platform (ORCP)	A structure attached to the seabed by means of a foundation, with one or more decks and a helicopter platform (including bird deterrents) housing electrical reactors and switchgear for the purpose of the efficient transfer of power in the course of HVAC transmission by providing reactive compensation.
Offshore Substation (OSS)	A structure attached to the seabed by means of a foundation, with one or more decks and a helicopter platform (including bird deterrents), containing— (a) electrical equipment required to switch, transform, convert electricity generated at the wind turbine generators to a higher voltage and provide reactive power compensation; and (b) housing accommodation, storage, workshop auxiliary equipment, radar and facilities for operating, maintaining and controlling the substation or wind turbine generators
Outer Dowsing Offshore Wind	The Project.
Order Limits	The area subject to the application for development consent, The limits shown on the works plans within which the Project may be carried out.
Preliminary Environmental Information Report (PEIR)	The PEIR was written in the style of a draft Environmental Statement (ES) and provided information to support and inform the statutory consultation process during the pre-application phase.
Project Design envelope	A description of the range of possible elements that make up the Project's design options under consideration, as set out in detail in the project description. This envelope is used to define the Project for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters

Term	Definition
	are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses etc.
Statutory consultee	Organisations that are required to be consulted by the Applicant, the Local Planning Authorities and/or The Planning Inspectorate during the pre-application and/or examination phases, and who also have a statutory responsibility in some form that may be relevant to the Project and the DCO application. This includes those bodies and interests prescribed under Section 42 of the Planning Act 2008.
Subsea	Subsea comprises everything existing or occurring below the surface of the sea.
The Planning Inspectorate	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
The Project	Outer Dowsing Offshore Wind, an offshore wind generating station together with associated onshore and offshore infrastructure.
Transboundary impacts	Transboundary effects arise when impacts from the development within one European Economic Area (EEA) state affects the environment of another EEA state(s)
Trenched technique	Trenching is a construction excavation technique that involves digging a trench in the ground for the installation, maintenance, or inspection of pipelines, conduits, or cables.
Trenchless technique	Trenchless technology is an underground construction method of installing, repairing and renewing underground pipes, ducts and cables using techniques which minimize or eliminate the need for excavation. Trenchless technologies involve methods of new pipe installation with minimum surface and environmental disruptions. These techniques may include Horizontal Directional Drilling (HDD), thrust boring, auger boring, and pipe ramming, which allow ducts to be installed under an obstruction without breaking open the ground and digging a trench.
Wind turbine generator (WTG)	A structure comprising a tower, rotor with three blades connected at the hub, nacelle and ancillary electrical and other equipment which may include J-tube(s), transition piece, access and rest platforms, access ladders, boat access systems, corrosion protection systems, fenders and maintenance equipment, helicopter landing facilities and other associated equipment, fixed to a foundation.

Reference Documentation

Document Number	Title
6.1.3	Project Description
6.1.7	Marine Physical Processes
6.1.9	Benthic Subtidal and Intertidal Ecology
6.1.10	Fish and Shellfish Ecology
6.1.6	Technical Consultation
6.1.14	Commercial Fisheries
6.3.8.1	Water Framework Directive

8 Marine Water and Sediment Quality

8.1 Introduction

1. This chapter of the Environmental Statement (ES) presents the results of the Environmental Impact Assessment (EIA) for the potential impacts of Outer Dowsing Offshore Wind ('the Project') on Marine Water and Sediment Quality (MW&SQ). Specifically, this chapter considers the potential impact of the Project seaward of Mean High Water Springs (MHWS) during the construction, operation and maintenance (O&M), and decommissioning phases. Of note is that MW&SQ provides impact pathways (e.g., changes to water or sediment quality) for other receptors (e.g., marine ecological features).
2. GT R4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant', is proposing to develop the Project. The Project Array area will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, Offshore Reactive Compensation Platforms (ORCPs), onshore cables, connection to the electricity transmission network, ancillary and associated development and areas for the delivery of up to two Artificial Nesting Structures (ANS) and the creation of a biogenic reef (if these compensation measures are deemed to be required by the Secretary of State) (see Volume 1, Chapter 3: Project Description (document reference 6.1.3) for full details).
3. This chapter should be read alongside the following chapters and documents:
   - Volume 1, Chapter 3: Project Description (document reference 6.1.3);
   - Volume 1, Chapter 7: Marine Physical Processes (document reference 6.1.7);
   - Volume 1, Chapter 9: Benthic Subtidal and Intertidal Ecology (document reference 6.1.9);
   - Volume 1, Chapter 10: Fish and Shellfish Ecology (document reference 6.1.10); and
   - Volume 3, Chapter 8.1: Water Framework Directive(document reference 6.3.8.1)

8.2 Statutory and Policy Context

4. Legislation, policy and statutory requirements relevant to MW&SQ, including the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 and Water Environment (Water Framework Directive) (England and Wales) Regulations 2017, are summarised in this section.

5. The Environment Act 2021 provides powers to enable the Secretary of State (SoS) to amend/modify any legislation for the purpose of making provision about the substances to be taken into account and to specify standards in relation to those substances in assessing the chemical status of surface waters or ground waters. Therefore, the provisions of the Environment Act 2021 could result in amendments/modifications to the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. Whilst the UK left the European Union (EU) on 31 January 2020, the UK continues to be committed to meeting high environmental standards. A number of the directives listed below (2000/60/EC; 2008/105/EC; 2006/7/EC; 2008/56/EC) have been transposed into UK Regulations[1] and they remain relevant to this MW&SQ assessment, providing context to required environmental considerations.
6. In undertaking the assessment, the following policy and legislation has been considered, with further detail provided in subsequent sections:
   - The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017;
   - Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (the Water Framework Directive; WFD);
   - The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017;
   - Directive 2008/105/EC of the European Parliament establishing Environmental Quality Standards for contaminants in water (Environmental Quality Standards Directive; EQSD);
   - Directive 2006/7/EC of the European Parliament concerning the management of Bathing Water quality (revised Bathing Water Directive);
   - The Bathing Water Regulations 2013;
   - The Shellfish Waters Directive (2006/113/EC);
   - The Nitrates Directive (91/676/EEC);
   - Urban Waste Water Treatment Directive (91/271/EEC);
   - Directive 2008/56/EC of the European Parliament establishing a framework for community action in the field of marine environmental policy (Marine Strategy Regulations 2010); and
   - The International Convention for the Prevention of Marine Pollution by Ships (MARPOL Convention) 73/78.
7. Guidance on the issues to be assessed for offshore renewable energy developments has been obtained through reference to:
   - The Overarching National Policy Statement (NPS) for Energy (EN-1) (Department for Energy Security and Net Zero (DESNZ, 2023a));

[1] The Retained EU Law (Revocation and Reform) Act 2023 revoked the supremacy of certain retained EU law, including Directives such as the WFD, meaning that UK domestic law is now supreme in this regard. However, the Directives are referred to in both domestic legislation and relevant current guidance and therefore they are referred to as such in this Chapter. Consequently, references to Directives in this Chapter mean the Directive as originating in EU law but as implemented by domestic law such as the WFD Regulations 2017.

- The NPS for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023b);
- The NPS for Electricity Networks Infrastructure (EN-5) (DESNZ, 2023c); and
- The UK Marine Policy Statement (HM Government, 2011).

8. The relevant legislation and planning policy for offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to MW&SQ, is outlined in Table 8.1.

Table 8.1: Legislation and policy context relevant to MW&SQ

Legislation/policy	Key provisions	Section where comment addressed
Overarching National Policy Statement for Energy (EN-1) ((DESNZ, 2023a)	Paragraphs 5.16.1 and 5.16.2 state: (5.16.1) "*Infrastructure development can have adverse effects on the water environment, including groundwater, inland surface water, transitional waters, coastal and marine waters. .* (5.16.2) *During the construction, operation and decommissioning phases, it can lead to increased demand for water, involve discharges to water and cause adverse ecological effects resulting from physical modifications to the water environment. There may also be an increased risk of spills and leaks of pollutants to the water environment. These effects could lead to adverse impacts on health or on protected species and habitats (see Section 4.3) and could, in particular, result in surface waters, groundwaters or protected areas failing to meet environmental objectives established under the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 and the Marine Strategy Regulations 2010."*	Potential impacts upon water quality are assessed in Section 8.8 of this ES chapter and in the WFD Compliance Assessment, Volume 3, Appendix 8.1: WFD (combined offshore and onshore).
	Paragraph 5.16.3 states: *"Where the project is likely to have effects on the water environment, the application should undertake an assessment of the existing status of, and impacts of the proposed project, on water quality, water resources and physical characteristics of the water environment as part of the ES or equivalent*".	The existing MW&SQ baseline, including that for relevant WFD waterbodies, is presented in Section 8.4 of this ES chapter. Potential impacts are assessed in Section 8.8 of this ES chapter.

Legislation/policy	Key provisions	Section where comment addressed
		A standalone WFD Compliance Assessment is presented in Volume 3, Appendix 8.1.
	Paragraph 5.16.7 states: *"The ES should in particular describe the existing quality of waters affected by the proposed project and the impacts of the proposed project on water quality, noting any relevant existing discharges, proposed new discharges and proposed changes to discharges*".	A description of the baseline (existing) water quality conditions is provided in Section 8.4 of this ES chapter. An assessment of the potential impacts of the Project upon water quality is provided in Section 8.8 of this ES chapter
	Paragraph 5.16.7 also states: "*any impacts of the proposed project on water bodies or protected areas (including shellfish protected areas) under the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 and source protection zones (SPZs) around potable groundwater abstractions*".	The existing MW&SQ baseline, including that for relevant WFD waterbodies, is presented in Section 8.4 of this ES chapter. Potential impacts are assessed in Section 8.8 of this ES chapter. A standalone WFD Compliance Assessment is presented in Volume 3, Appendix 8.1.
	Paragraph 5.16.9 states: *"The risk of impacts on the water environment can be reduced through careful design to facilitate adherence to good pollution control practice*".	An outline Project Environment Management Plan (PEMP) will be submitted with the Development Consent Order (DCO) application, which will detail best practice and embedded mitigation measures that will ensure good pollution control practice.
National Policy Statement for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023b)	Paragraph 2.8.111 states: *"The construction, operation and decommissioning of offshore energy infrastructure (including the preparation and installation of the cable route and any electricity networks infrastructure) can affect the following elements of the physical offshore environment, which can have knock on impacts on other biodiversity receptors…:* ▪ *water quality – disturbance of the seabed sediments or release of contaminants can result in*	An assessment of the potential impacts during the construction, O&M and decommissioning of the Project are presented in Section 8.8 of this ES chapter. Contaminant analysis of sediment samples collected during the Project specific benthic survey are presented in Section 8.4. Potential impacts upon habitats and biodiversity are assessed in Volume 1, Chapter 9.

Legislation/policy	Key provisions	Section where comment addressed
	direct or indirect effects on habitats and biodiversity, as well as on fish stocks thus affecting the fishing industry; ▪ *suspended solids – the release of sediment during construction, operation and decommissioning can cause indirect effects on marine ecology and biodiversity*".	Potential impacts upon fish ecology are assessed in Volume 1, Chapter 10. Potential impacts upon the fishing industry are assessed in Volume 1, Chapter 14: Commercial Fisheries.

8.2.1 Water Framework Directive

9. Established in 2000, the EU WFD (2000/60/EC) provides a single framework for the protection of surface waterbodies (including rivers, lakes, coasts and estuaries) and groundwater. Each surface waterbody has an assigned ecological status. The ecological status is assigned by considering biological, hydromorphological, physio-chemical and specific chemical parameters. The different ecological statuses are:
    - High;
    - Good;
    - Moderate;
    - Poor; or
    - Bad.
10. The WFD is implemented in England and Wales through the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (commonly termed the Water Framework Regulations), noting these were modified by the Floods and Water (Amendment etc) (EU Exit) Regulations 2019 on 31 January 2020. Under the Water Framework Regulations, the Environment Agency is the Competent Authority for implementation of the WFD in England. Programmes of measures have been developed through a process of river basin management planning and are set out in regionally based River Basin Management Plans (RBMPs). These RBMPs were first published in 2009 (Cycle 1), and subsequently updated in 2015 (Cycle 2) and 2022 (Cycle 3). The MW&SQ study area is located within the Anglian River Basin District which is reported in the Anglian RBMP (Environment Agency, 2022).
11. The WFD's objective of "*good chemical status*" is defined in terms of compliance with all the quality standards established for chemical substances at a European level. This will ensure at least a minimum chemical quality, particularly in relation to very toxic substances.
12. The WFD's objective of "*good ecological status*" also requires certain chemical conditions, including:
    - the achievement of environmental quality objectives for discharged priority substances; and

- the identification of other substances liable to cause pollution or being discharged in significant quantities.

13. The Environmental Quality Standards Directive (EQSD; 2008/105/EC amended by 2013/39/EU) list identifies priority substances and polluting chemicals which should be considered in WFD assessments for both transitional and coastal waterbodies. The WFD and EQSD both seek to reduce these substances entering into the marine environment, primarily from discharges and outfalls. Priority substances include, but are not limited to benzene, nickel and lead.
14. Article 4.9 of the WFD notes that compliance with other community environmental legislation (as implemented in domestic legislation) must be ensured, with WFD Protected Areas identified under the following Directives (described further below):
    - Bathing Water Directive;
    - Shellfish Waters Directive;
    - Nitrates Directive; and
    - Urban Waste Water Treatment Directive (UWWTD).

8.2.2 Bathing Water Directive

15. The EU's revised Bathing Water Directive (rBWD; 2006/7/EC) came into force in March 2006. The rBWD provides more stringent standards than the previous directive and places an emphasis on providing information to the public. The rBWD focuses on fewer microbiological indicators, whilst setting higher standards compared to those of the original Bathing Water Directive. It has four different classifications of performance according to the levels of certain types of bacteria (intestinal enterococci and *Escherichia coli*) in samples obtained during the bathing season (from 15 May to 30 September), as follows:
    - Excellent - the highest, cleanest class;
    - Good - generally good water quality;
    - Sufficient - water quality meets minimum required standards; and
    - Poor - water quality does not meet the minimum required standards.
16. The original Bathing Water Directive (76/160/EEC) was repealed at the end of 2014 and monitoring of bathing water quality has been reported against rBWD indicators since 2015, as implemented under the Bathing Water Regulations 2013 (as amended). The new classification system considers all samples obtained during the previous four years; data have been collected for revised Bathing Water Directive indicators since 2012.
17. During the 2022 bathing season, there were 419 identified and monitored Bathing Waters in England (Department for Environment, Food and Rural Affairs (Defra), 2022). Nearly all Bathing Waters in England (407; 97.1%) met the new minimum standards required by the revised Bathing Waters Directive and 72.1% (302) met the very highest Excellent standard; compared to 63.6% in 2015.

8.2.3 Shellfish Waters Directive

18. The Shellfish Waters Directive (2006/113/EC) was repealed in December 2013 and subsumed within the WFD. However, the Shellfish Water Protected Areas (England and Wales) Directions 2016 require the EA (in England) to endeavour to observe a microbial standard in all 'Shellfish Water Protected Areas'. The microbial standard is 300 or fewer colony forming units of *E. coli* per 100ml of shellfish flesh and intravalvular liquid. The Directions also requires the EA, in England, to assess compliance against this standard to monitor microbial pollution (75% of samples taken within any period of 12 months must be below the microbial standard, and sampling/analysis must be in accordance with the Directions).

8.2.4 Nitrates Directive

19. The Nitrates Directive (91/676/EEC), implemented in England and Wales through the Nitrate Pollution Prevention Regulations 2015, aims to reduce water pollution from agricultural sources and to prevent such pollution occurring in the future (nitrogen is one of the nutrients that can affect plant growth). Under the Nitrates Directive, surface waters are identified if too much nitrogen has caused a change in plant growth which affects existing plants and animals and the use of the waterbody.

8.2.5 Urban Waste Water Treatment Directive

20. The UWWTD (91/271/EEC), implemented in England and Wales through the Urban Waster Water Treatment (England and Wales) Regulations 1994, aims to protect the environment from the adverse effects of the collection, treatment and discharge of urban waste water. The Directive sets treatment levels on the basis of sizes of sewage discharges and the sensitivity of waters receiving the discharges.
21. In general, the Directive requires that collected waste water is treated to at least secondary treatment standards for significant discharges. Secondary treatment is a biological treatment process where bacteria are used to break down the biodegradable matter (already much reduced by primary treatment) in waste water. Sensitive areas under the UWWTD are waterbodies affected by eutrophication of elevated nitrate concentrations and act as an indication that action is required to prevent further pollution caused by nutrients.

8.3 Consultation

22. Consultation is a key part of the DCO application process. Consultation regarding elements of MW&SQ has been included within the Marine Ecology, Processes and Derogation and Compensation ETG and as part of the EIA scoping process (Outer Dowsing Offshore Wind, 2022) and the Preliminary Environmental Information Report (PEIR) process (Outer Dowsing Offshore Wind, 2023). An overview of the Project's Technical Consultation (document reference 6.1.6) and wider consultation is presented in the Consultation Report (document reference 5.1).
23. A list of the key issues raised during consultation to date, specific to MW&SQ, is outlined in Table 8.2 below, together with how these issues have been considered in the production of this ES chapter. The Project notes that no issues were raised by stakeholders during the EPP engagement process.

24. As identified in Volume 1, Chapter 3: Project Description and Volume 1, Chapter 4: Site Selection and Consideration of Alternatives, the Project design envelope has been refined throughout the stages of the Project prior to DCO submission. This process has been reliant on stakeholder consultation feedback. Design amendments to cable routing and landfall are of relevance to this chapter.

Table 8.2: Summary of consultation relating to MW&SQ

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion		
Scoping Opinion (The Planning Inspectorate, 09 September 2022) Comment ID: 3.2.1	The Scoping Report proposes to scope out accidental pollution resulting from construction, operation and decommissioning of the Proposed Development. The Planning Inspectorate acknowledges that for all project phases the risk of significant effects from accidental pollution can generally be controlled by the use of mitigation plans and measures, and therefore accepts that significant effects are unlikely. Nevertheless, the ES must detail the potential sources and types of accidental pollution for all project phases and set out the proposed mitigation measures, including those to be included in the PEMP and its constituent Marine Pollution Contingency Plan (MPCP). The ES should also explain how such measures will be secured.	The Applicant welcomes the acknowledgement that accidental release during all project phases is likely to be insignificant due to the implementation of mitigation measures. This effect can therefore remain scoped out. The Applicant will clearly and in detail state the potential sources and types of accidental pollution for all project phases within the ES. Details regarding the proposed mitigation measures and how these will be secured is provided within the ES.
Scoping Opinion (The Planning Inspectorate, 09 September 2022) Comment ID: 3.2.2	The Scoping Report proposes to scope out deterioration of water quality due to re-suspension of sediments and contaminants as a result of scour around project infrastructure (including WTGs and cable protection). This is on the basis that the volume of suspended sediment released during operation via scour will be much lower than during construction, and that the effect would be highly localised and associated volumes of mobilised sediment (and associated contaminants) are considered to be within the range of natural variability. On the basis of the above, the Planning Inspectorate is content that this effect can be scoped out.	The Applicant welcomes confirmation that the deterioration in water quality due to re-suspension of sediments and contaminants resulting from scour during O&M can be scoped out.
Scoping Opinion (The Planning	The Scoping Report proposes to scope out release of sediment-bound contaminants from disturbed sediments on water quality as a result of cumulative effects with other projects and plans.	The Applicant welcomes confirmation that the release of sediment-bound contaminants from disturbed sediments in water quality due to

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Inspectorate, 09 September 2022) Comment ID: 3.2.3	This is on the basis that effects will be highly localised and small scale. The Scoping Report has not identified other projects or plans that could act cumulatively with respect to sediment-bound contaminant release. On the basis that there are no projects or plans that would act cumulatively to release sediment-bound contaminants, the Planning Inspectorate agrees that this effect can be scoped out of the assessment.	cumulative effects with other projects and plans can be scoped out.
Scoping Opinion (The Planning Inspectorate, 09 September 2022) Comment ID: 3.2.4	The Scoping Report states that due to the localised nature of any potential impacts (e.g., suspended sediment plumes), transboundary impacts will not occur. The Planning Inspectorate agrees that significant effects on European Economic Area (EEA) States are unlikely to arise as a result of changes to marine water and sediment quality and therefore agrees this matter can be scoped out of further assessment.	The Applicant welcomes confirmation that transboundary effects with respect to MW&SQ can be scoped out.
Scoping Opinion (The Planning Inspectorate, 09 September 2022) Comment ID: 3.2.5	The Scoping Report states that the study area includes both a nearfield and far-field consideration, the latter stated as being informed through further analysis of the marine physical process pathways. As noted at point 3.1.4 above [*in reference to Scoping Opinion*], the ES should clearly define the study area for the marine water and sediment quality aspect, based on the Zone of Influence (ZoI) from the Proposed Development, together with a justification for its selection.	The study area is based on the ZoI, derived from numerical modelling of sediment plume and tidal excursions. Full justification for this is provided within the ES documentation. The study area is presented in Section 8.4 and illustrated on Figure 8.1 (Document Reference 6.2.8.1),.
Scoping Opinion (The Planning Inspectorate, 09 September 2022) Comment ID: 3.2.6	The Applicant should seek to agree the baseline datasets with relevant consultation bodies, including Natural England, as part of the EPP. The ES should provide clear justification to demonstrate that the datasets used to inform the assessment are fit for purpose and representative.	The Applicant confirms that the suitability of the baseline datasets will be confirmed with the relevant consultees, initially through the Scoping Process. The full suite of baseline datasets used to inform the MW&SQ aspects of this ES, including project

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
		specific surveys, are presented in Section 8.4 of this ES chapter.
Scoping Opinion (The Planning Inspectorate, 09 September 2022) Comment ID: 3.2.7	The Applicant's attention is directed to the response of the Marine Management Organisation (MMO) at Appendix 2 of the Scoping Opinion with regards to the sediment sampling included in the project-specific benthic surveys. The Applicant should seek to agree the scope of the sampling and testing for contaminants with relevant consultation bodies, including the MMO, as part of the EPP. The ES should include clear justification for the chosen analysis, with reference to any agreements reached.	The Applicant notes the direction to the MMO response regarding sediment sampling. The project specific sediment sampling has been discussed with the MMO reference, with further detail provided in Volume 1, Chapter 9.
Scoping Opinion (Environment Agency, 19 August 2022) Comment ID: N/A	We have also reviewed the Scoping Report chapters regarding marine ecology and marine water and sediment quality, in so far as these issues/chapters relate to the Environment Agency's remit, and we can advise that we are satisfied with the methodologies etc proposed.	This is welcomed by the Applicant.
Scoping Opinion (Marine Management Organisation, 26 August 2022) Comment ID: 3.11.1	The MMO defers to the Environment Agency on the suitability of the scope of the assessment with regards to water quality.	This is noted by the Applicant and responses from the Environment Agency noted above.
Scoping Opinion (Natural England, 30 August 2022) Comment ID: N/A	Increases in suspended sediment concentrations (SSC) during construction and operation (e.g., future dredging works) have the potential to smother sensitive habitats. The ES should include information on the sediment quality and potential for any effects on water quality through suspension of contaminated sediments. The EIA should also consider whether increased suspended sediment concentrations resulting are	The Applicant confirms that the ES will consider sediment and water quality and subsequential detrimental effects upon designated sites. Section 8.4 of this ES chapter presents a consideration of the baseline sediment and water quality characteristics. Section 8.8 provides an

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	likely to impact upon the interest features and supporting habitats of the designated sites as listed above.	assessment of the potential impacts of Project activities upon these parameters.
Scoping Opinion (Natural England, 30 August 2022) Comment ID: N/A	The ES should consider whether there will be an increase in the pollution risk as a result of the construction or operation of the development.	The Applicant defers to the Planning Inspectorate agreement that accidental release during all project phases is likely to be insignificant due to the implementation of mitigation measures. This effect can therefore remain scoped out.
Scoping Opinion (Natural England, 30 August 2022) Comment ID: N/A	For activities in the marine environment up to 1 nautical mile out at sea, a WFD assessment is required as part of any application. The ES should draw upon and report on the WFD assessment considering the impact the proposed activity may have on the immediate water body and any linked water bodies. Further guidance on WFD assessments is available here: https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters	The Applicant confirms that a WFD Compliance Assessment is included within the Project's DCO application. A WFD Compliance Assessment is provided in Volume 3, Appendix 8.1.
Scoping Opinion (Natural England, 30 August 2022) Comment ID: N/A	Natural England welcomes that a PEMP including a Marine Pollution Contingency Plan (MPCP) will be produced and advise that an Outline plan/s is provided to support application submission.	An outline PEMP and MPCP are submitted alongside the ES.
Scoping Opinion (Natural England, 30 August 2022) Comment ID: N/A	Assessment of heavy metals Arsenic and mercury levels between AL1 and AL2 in 5 out of 6 samples collected within the offshore Export Cable Corridor (ECC) in 2019. Natural England advises that, as per Cefas guidance on disposal of material offshore, material with contaminant levels between AL1 and AL2 may require further consideration before a decision can be made. Therefore, assessment of impacts from the disposal of potentially contaminated sediment, or the potential for works	The Applicant notes that material with contaminant levels between Cefas Guideline Action Level 1 (AL1) and Action Level 2 (AL2) may require further consideration prior to disposal. Project specific sediment sampling has assessed levels of contamination according to MMO guidelines.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	to release contamination into the water column should be undertaken as part of the environmental assessment process.	The results of the contaminated sediment analysis are presented in Table 8.9 to Table 8.12 of this ES chapter. An assessment of these levels with respect to Project activities are presented in Section 8.8
Scoping Opinion (Natural England, 30 August 2022) Comment ID: N/A	It is stated that MW&SQ may be further refined following detailed assessments of tidal excursions and specifically sediment transport pathways to allow a definition of the ZoI. Please can further information be provided as to when these more detailed assessments will be conducted and how will the data inform the PEIR and submission?	Outputs from the numerical modelling and specifically tidal excursions/sediment plume modelling have been used within the ES to confirm the definition of the ZoI. Volume 5, Chapter 1.1 presents the numerical modelling technical report and Volume 1, Chapter 7 provides detail on tidal excursions and sediment transport pathways.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion (Natural England, 30 August 2022) Comment ID: N/A	Natural England's comments refer both to the text within section 7.2.5 and Table 7.2.1. It is noted that the majority of source data listed offers 'partial' spatial coverage. The 'Project specific benthic surveys (2022)' are anticipated to provide 'full coverage'. Additionally, several of the other ES for Offshore Winds Farms (OWFs) referenced here are over the 5 years of age specified within Natural England's best practice guidance for data. Can you confirm that the data will inform the PEIR? Natural England notes that these survey results will be vital in filling in spatial gaps in previous data referenced. Further, it should be noted that due to the potential for change in the marine environment data older than the 5 years shouldn't be relied on without appropriate ground truthing, NB: Our Best Practice guidance highlights the age of data should ideally be no older than two years	Project specific benthic surveys have informed the ES ensuring that data available to the project are less than five years of age. Volume 1, Chapter 9 presents further detail on the Project specific benthic surveys undertaken within both the Array and ECC.
Scoping Opinion (Natural England, 30 August 2022) Comment ID: N/A	Data referenced here was collected between 1998 to 2015 – please see best practice guidance in relation to age of data.	Please see previous response.
Phase 2 Consultation (Section 42 consultation on PEIR) Comments		
Section 42 Consultation Response (Environment Agency, 20 July 2023)	The proposed works are near to several designated bathing waters on the Lincolnshire Coast as correctly identified in Figure 8.1. In particular, the works are in very close proximity to Anderby and Moggs Eye (Huttoft) bathing waters. Both bathing waters are currently classified as 'Excellent'. Mobilisation of sediments associated with the works could have the potential to increase bacteriological concentrations and impact bathing water quality. Information submitted indicates that sediment	The Applicant can confirm that, due to the use of trenchless installation techniques at the landfall, there is no requirement to close the beach during the works.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	plumes and negative impacts on bathing water quality are likely to be short-lived. However, even short-lived water quality impacts have the potential to impact bathing water classification, where those impacts coincide with sampling. It is also unclear if the beaches would be closed during the works. It should be noted that even short-lived impacts could impact bathers at the time mobilisation of sediment works occurs.	
Section 42 Consultation Response (Environment Agency, 20 July 2023)	We note that works will be outside the intertidal zone. However, whilst the exact distances from the bathing waters to the proposed exit pits are not clear, it appears this could be as little as a few hundred metres. We would strongly recommend that elements of the works with the potential to mobilise sediments close to the bathing waters are carried out outside of the Bathing Water season. Bathing Water season runs from 15th May to 30th September. We therefore would like to see the inclusion of the following condition in the draft DCO, Schedule 12 Part 2 (deemed Marine Licence conditions): Works within 500m of the intertidal area (or within the intertidal area itself) shall not be undertaken between 15 May and 30 September in any year unless a scheme to protect the current Bathing Water status has been submitted to and approved by the Marine Management Organisation, following consultation with the Environment Agency. The scheme must include: (1) An assessment of the impact of any works (with a particular focus on the potential bacti issues that may be caused by	The HDD exit pits will be designed to be no closer than 500m to the MLWS mark. Therefore, no restriction on works is considered necessary as there will be no impact to the bathing waters. The Project activities are temporary and short-lived and following cessation of the activities the SSC levels are likely to reach background levels, it is therefore expected that any bacterial increases in the water column would be in the order of days (i.e., occurring for the plume duration only). Following the sediment plumes dispersion, and subsequent increases in UV light, the bacterial counts in the water column will return to "do-nothing" baseline conditions. Given the assessment undertaken we consider having a seasonal restriction to be disproportionate as a negligible significance on bathing water quality has been determined.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	disturbed sediment), which will be undertaken during the bathing water season of 15 May to 30 September. (2) Identification of measures to mitigate any identified risks to ensure the current Bathing Water status is not impacted, shall be implemented in accordance with the approved scheme.	
Section 42 Consultation Response (Marine Management Organisation, 20 July 2023)	The Applicant has undertaken project specific surveys to characterise the material within the project area, which includes sediment grab samples collected for particle size analysis (PSA) and contaminant analysis (trace metals, organotins, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and organochlorine pesticides (OCPs)). Under this survey, 30 samples were collected from within the Array area, and 28 samples were collected from within the Export Cable Corridor (ECC) area, all of which were analysed for contaminants by SOCOTEC. The MMO notes that SOCOTEC are not validated to undertake PSA in support of marine licences, but as this is not strictly a dredge and disposal application, the MMO is content that the data may be used as appropriate evidence.	The Applicant welcomes MMO's validation of the use of SOCOTEC to analyse sediment PSA and contaminants.
Section 42 Consultation Response (Marine Management Organisation, 20 July 2023)	The results of the contaminant analysis were compared to Cefas Action Levels (AL) (where available) and, for PAHs, to Effects Range Low (ERL) and Effects Range Median (ERM) based on the Gorham-Test method (Gorham-Test et al., 1999), which is appropriate. In addition, results were compared to the Canadian Marine Sediment Quality Guidelines and United States Environmental Protection Agency Guidelines, which is appreciated for the additional level of detail.	The Applicant welcomes MMO's validation of the assessment of sediment contamination

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Section 42 Consultation Response (Marine Management Organisation, 20 July 2023)	It is noted that the report does not specify the need for a disposal site to be designated for these works. However, as per the UK's obligations under the London Convention and Protocol (LCLP) and OSPAR, any disposal of material below MHWS must be to a licenced disposal site, and the volumes of material disposed under such operations must be reported annually. The seabed preparation works detailed within the report, particularly as it refers to the use of Trailing Suction Hopper Dredgers (TSHD), would fall under this requirement, and therefore the MMO recommends this need is identified within the Environmental Statement (ES). A Site Characterisation Report must be submitted to enable the MMO to designate one or more disposal sites.	The Applicant can confirm that a Site Characterisation Report has been submitted to the MMO alongside the ES.
Section 42 Consultation Response (Marine Management Organisation, 20 July 2023)	Drill arisings must be included within the Chapters and be included in any disposal site worst case scenario figures.	A full and detailed assessment of drill arisings, including numerical modelling, is provided in Volume 1, Chapter 7 of this ES; the results of this have been applied to this assessment where appropriate.
Section 42 Consultation Response (Marine Management Organisation, 22 November 2023)	With regard to marine sediment and water quality, the Environmental Update Report states that the increased number of turbines alone would be expected to increase total sediment displacement and the associated effects to water and sediment quality, but when considering the reduction in number of GBS (as the worst-case foundation type for seabed impacts and sediment displacement volumes) the changes to the project design are not expected to result in new or materially different impacts than assessed at PEIR and that hydrodynamic modelling	The Applicant welcomes the agreement from the MMO with regard to the combined effect of the change to the number of turbines and the reduction of the number of GBS.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	will be undertaken to inform the Environmental Statement (ES). MMO agrees with this statement.	
Section 42 Consultation Response (Marine Management Organisation, 22 November 2023)	As the number of gravity bases has been reduced to 50% the likely estimated volume for relocation/dredging is likely to be lower. Therefore table 1 (summarised in Annex 1) in the PEIR, must be amended to take the changes in design into account. This is to be able to inform consideration of the need for designation of a disposal site(s).	The Applicant has considered the need for disposal sites as part of the updated assessment presented in the ES and has provided a disposal site characterisation report alongside the DCO application.
Section 42 Consultation Response (Marine Management Organisation, 22 November 2023)	A summary of the expected area and volume of dredge material from the works (e.g., bed levelling, trenching or arisings) should be provided. This is to be able to inform considerations for disposal of the material.	The Applicant has considered the need for disposal sites as part of the updated assessment presented in the ES and has provided a disposal site characterisation report alongside the DCO application.
Section 42 Consultation Response (Marine Management Organisation, 22 November 2023)	MMO requests the inclusion of a discussion on the requirement for a disposal site to be designated across the array and/or Export Cable Corridor (EEC) area together with potential beneficial use or existing disposal sites for the disposal of sediment/arisings as a result of proposed seabed preparation activities, and where appropriate provide adequate characterisation. MMO requests that this information is provided at the earliest opportunity so any disposal sites can be designated and included within the DML.	The Applicant has considered the need for disposal sites as part of the updated assessment presented in the ES and has provided a disposal site characterisation report alongside the DCO application.
Section 42 Consultation Response (Marine Management	Although reference is made to the reduction in the requirement for the number of gravity bases, it is not known from reading the Environmental Update Report whether there will be a need for an increase in the need for scour protection (rock dumping)	Changes to the scour protection required following design refinement has been considered within the ES, specifically in Volume 1, Chapter 7 of this ES.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Organisation, 22 November 2023)	due to the change in foundation, this must be amended as appropriate if required.	

8.4 Baseline Environment

8.4.1 Study Area

25. The baseline description of the MW&SQ environment provides a regional (far-field) overview prior to focussing upon the study area. The study area, as presented in Figure 8.1 (Document Reference 6.2.8.1), includes those elements that are located seaward of MHWS and include the:

- Offshore array (including Wind Turbine Generators (WTGs), Offshore Reactive Compensation Platforms (ORCPs), interlink and inter-array cables);
- Offshore ECC (including the export cables);
- Compensation areas, including areas identified for Artificial Nesting Structures (ANS) and biogenic reef restoration; and
- The seabed and water column surrounding these areas that may be influenced by changes to MW&SQ due to the potential impacts of the Project.

8.4.1.1 Zone of Influence (ZoI)

26. A ZoI has been used to identify those receptors likely to be impacted by changes to MW&SQ which have the potential to be affected by the Project infrastructure and associated activities. The ZoI, Figure 8.1 (Document Reference 6.2.8.1), has been defined using the outputs from the Project specific numerical modelling (Volume3, Appendix 7.2: Physical Processes Modelling Report), encapsulating the maximum extent of measurable sediment plumes resulting from activities within the ECC and array.
27. The ZoI is scaled to conservatively represent the equivalent distance of tidal excursion on a mean spring tide and comprises a distance of between approximately 10km (at landfall) and 15km (within the ECC) (see Volume 1, Chapter 7). An ellipse around the array has been used to define the ZoI for the activities within the array, owing to the plumes generally moving in parallel relative to the coast in less dispersive plumes. This ellipse similarly encapsulates the maximum extent of measurable sediment plumes predicted by the modelling (see Volume 3, Appendix 7.2).

8.4.2 Data Sources

28. Project specific surveys have been used to provide site-specific and contemporary data/information with which to characterise the seabed conditions within the array and offshore ECC. Specifically, and of relevance to this MW&SQ Chapter, sediment grab samples were collected for Particle Size Analysis (PSA) and contaminant analysis (in line with the corresponding guidance provided by the MMO (2022). The corresponding survey reports are provided in Volume 3, Appendix 3.1 and 3.2.
29. Where relevant, survey data from other offshore windfarms and marine industries have been used to characterise the MW&SQ environment. Information pertaining to these data/information sources are provided in Table 8.3.

30. In line with Scoping Opinion advice, only data less than five years is included within the MW&SQ assessment, with caution afforded to those datasets older than two years. Comprehensive coverage of the project-specific surveys within both the array and ECC is such that data from other sources have not been heavily relied upon to fill data gaps.
31. Monitoring data and status information from the Environment Agency, as presented within Table 8.7, have also been used within this assessment to characterise Bathing Waters and WFD waterbodies.

Table 8.3: Data sources used within the MW&SQ

Data Source	Summary
Project specific surveys	
The Project benthic survey - Array	Sediment sampling and contaminant analysis. Laboratory analyses included PSA, total organic content, trace metals, organotins, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and organochlorine pesticides (OCPs; DDT and dieldrin). Array area – 30 samples (for contaminants) ECC – 28 samples (for contaminants)
The Project benthic survey - ECC	
The Project metocean survey - Array	Inclusion of turbidity measurements (April to July 2022; entire water column)
Other data sources	
Anglian RBMP (and associated data). Source: https://www.gov.uk/government/publications/anglian-river-basin-district-river-basin-management-plan	The RBMP provides information on the current status, pressures, objectives and programme of measures of the water environment within the Anglian River Basin District.
Environment Agency Catchment Data Explorer. Source: https://environment.data.gov.uk/catchment-planning	WFD water body classification reported by the Environment Agency, including overall status, ecological status/potential and chemical status of surface water bodies, and overall status, quantitative status and chemical (groundwater) status for groundwater water bodies.
Environment Agency Water Quality Archive. Source: https://environment.data.gov.uk/water-quality/view/landing	Data collected by the Environment Agency to quantify the chemical performance of the water environment.
List of Shellfish Water Protected Areas in England. Source: https://www.gov.uk/government/publications/water-framework-directive-shellfish-protected-areas	List of Shellfish Water Protected Areas in England, designated by the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017.
Environment Agency Bathing Water classifications. Source: https://environment.data.gov.uk/bwq/profiles	Data collected by the Environment Agency to quantify the performance of the local bathing waters.
Food Standards Agency shellfish classifications.	Data reported by the Food Standards Agency to classify the performance of the designated bivalve mollusc production areas.

Data Source	Summary
Source: https://www.food.gov.uk/business-guidance/shellfish-classification	
EA Nitrate Vulnerable Zones. Source: https://environment.data.gov.uk/farmers	Surface and ground waters designated as being at risk from agricultural nitrate pollution.
Urban Waste Water Treatment Directive Sensitive Areas Map – Lincolnshire and Northamptonshire. Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/797779/sensitive-areas-map-lincoln-northamptonshire.pdf	River stretches and bodies of water, including bathing waters and shellfish waters, identified as sensitive areas under the UWWTD.
Suspended Particulate Matter (SPM) data (Cefas, 2016).	Annual average of non-algal SPM data available from Cefas. These data are based on the satellite derived Ifremer OC5 algorithm (Gohin, 2011).
OSPAR Intermediate Assessment 2017 (OSPAR Commission, 2017).	This assessment provides OSPAR's understanding of the marine environment's current status.
Industry data	
Hornsea Project Four Offshore Wind Farm ES (Orsted, 2021)	Characterisation and monitoring data for the Hornsea Project Four Offshore Wind Farm (e.g., PSA; contaminant analysis).
Dudgeon and Sheringham Shoal Offshore Wind Farm Extensions PEIR (Royal HaskoningDHV, 2021)	Characterisation and monitoring data for the Dudgeon and Sheringham Shoal Extensions (e.g., PSA; contaminant analysis).

8.4.3 Sediment Contamination Guidelines

32. There are two commonly used guidelines applied to assessing the contamination levels within sediment samples; Cefas Guideline Action Levels (Table 8.4) and the Canadian Marine Sediment Quality Guidelines (Table 8.5). For those PAH compounds for which guidance is not provided in the Cefas nor Canadian guidelines, United States Environmental Protection Agency (USEPA) PAH Guidelines (Table 8.6) can be applied.

8.4.3.1 Cefas Guideline Action Levels

33. In the absence of Environmental Quality Standards (EQSs), survey sediment contaminant data have been analysed relative to the Cefas Guideline Action Levels for the disposal of dredged material. Presented in Table 8.4, Action Levels are used in this assessment to determine whether further assessment is required.

34. Contaminants below Cefas Guideline Action Level 1 (AL1) are, for dredging projects, not considered to be of concern and thus can be disposed of at sea. Contaminant levels which exceed Cefas Guideline Action Level 2 (AL2) are not considered suitable for disposal at sea. Those sediments which record concentrations between AL1 and AL2 may be disposed of at sea but may require some consideration prior to doing so.

35. Whilst the Project is not a dredging project *per se*, it does involve a proposal to dredge, drill and dispose of seabed sediments within the draft Order Limits.

Table 8.4: Cefas Guideline Action Levels[2]

Contaminant/compound	Action Level 1	Action Level 2
	mg/kg Dry Weight (ppm)	
Arsenic (As)	20	100
Mercury (Hg)	0.3	3
Cadmium (Cd)	0.4	5
Chromium (Cr)	40	400
Copper (Cu)	40	400
Nickel (Ni)	20	200
Lead (Pb)	50	500
Zinc (Zn)	130	800
Organotins; TBT; DBT; MBT	0.1	1
PCBs, sum of ICES 7	0.01	n/a
PCBs, sum of 25 congeners	0.02	0.2
PAHs	0.1	n/a
DDT(*)	0.001	n/a
Dieldrin(*)	0.005	n/a
(*) levels set in 1994		

2 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/573075/Appendix_B_Action_Levels.pdf

36. The standard procedure for Cefas in reviewing PAH concentrations in marine sediment samples is to consider against the Effects Range Low (ERL) and the Effects Range Median (ERM) for a discrete suite of low molecular weight (LMW) and high molecular weight (HMW) PAHs (Gorham-Test *et al*., 1999). This effectively presents a similar AL1 (ERL) and AL2 (ERM) approach to provide context to sediment quality for PAHs, and has been applied to support this MW&SQ assessment. The sum of the following PAH concentrations is used in the calculations:
    - HMW: Fluoranthene, Pyrene, Benz[a]anthracene, Chrysene, Benzo[a]pyrene, Dibenz[a,h]anthracene; and
    - LMW: Naphthalene, Acenaphthene, Fluorene, Anthracene, C1-naphthalenes, Acenaphthylene, Phenanthrene.
37. The ERL (equivalent to AL1) for the sum of LMW and HMW PAHs is 552 and 1,700µg/kg, respectively. The ERM (equivalent to AL2) for the sum of LMW and HMW PAHs is 3,160 and 9,600µg/kg, respectively.

8.4.3.2 Canadian Marine Sediment Quality Guidelines

38. The Canadian Marine Sediment Quality Guidelines (Table 8.5) have also been used within this assessment to provide context to the sediment contaminant levels reported within the project-specific samples. These Guidelines provide some information for those contaminants not currently reported within the Cefas Guideline Action Levels (Table 8.4), specifically PAHs. Developed by the Canadian Council of Ministers of the Environment, these Guidelines are applied within this Project to provide an indication on the degree of sedimentary contamination and the likely ecological impact (Volume 1, Chapter 9).
39. The Guidelines allow the identification of three ranges of chemical contaminants, with regard to biological effects:
    - Below the Threshold Effect Levels (TEL): the minimal effect range within which adverse effects rarely occur;
    - Between the TEL and Probable Effect Levels (PEL): the possible effect range within which adverse effects occasionally occur; and
    - Above the PEL: the probable effect range within which adverse effects frequently occur.

Table 8.5: Canadian Marine Sediment Quality Guidelines for PAHs

Contaminant/compound	Threshold Effect Levels	Probable Effect Levels
	µg/kg	
Acenaphthene	6.71	88.9
Acenaphthylene	5.87	128
Anthracene	46.9	245
Benz(a)anthracene	74.8	693
Benzo(a)pyrene	88.8	763
Chrysene	108	846
Dibenz(a,h)anthracene	6.22	135

Contaminant/compound	Threshold Effect Levels	Probable Effect Levels
	µg/kg	
Fluoranthene	113	1, 494
Fluorene	21.2	144
2-Methylnaphthalene	20.2	201
Naphthalene	34.6	391
Phenanthrene	86.7	544
Pyrene	153	1, 398

8.4.3.3 United States Environmental Protection Agency Guidelines

40. The USEPA Guidelines (Table 8.6) have been used in addition to the Cefas and Canadian guidelines to provide an additional layer of analysis to the sediment contaminant results. The USEPA has guidelines available for a suite of PAHs they deem to be priority PAHs.

41. The Guidelines provide an ERL and ERM for each of the priority PAHs.

- ERL is a concentration at which adverse effects would not be expected from the sediment contaminant concentrations.
- ERM is a concentration above which adverse effects would normally be observed due to sediment contaminant concentrations.

Table 8.6: USEPA Guidelines for PAHs

Contaminant/compound	Effects Range Lower	Effects Range Median
	µg/kg	
Acenaphthene	16	500
Acenaphthylene	44	640
Anthracene	853	1,100
Benzo(a)anthracene	261	1,600
Benzo(a)pyrene	430	1,600
Chrysene	384	2,800
Dibenzo(a,h)anthracene	63.4	260
Fluoranthene	600	5,100
Fluorene	19	540
Naphthalene	160	2,100
Phenanthrene	240	1,500
Pyrene	665	2,600

8.4.3.4 Water Quality – Physical Characteristics

42. Information pertaining to the physical attributes of the water column is provided by monitoring undertaken by the EA at coastal monitoring stations. Of direct relevance to the ECC and ZoI is the Lincs Coast Chapel St. Leonards 3.0km Offshore station which is located at the southern boundary of the ECC (Figure 8.1 (Document Reference 6.2.8.1)). A total of 54 parameters have been analysed at the monitoring point since 2000 (up to 15 September 2022), of which the following are most pertinent to the MW&SQ assessment:
    - Water temperature;
    - Turbidity (*in situ*);
    - Salinity (*in situ*);
    - Dissolved oxygen (% saturation); and
    - Dissolved oxygen (as O_2).
43. A summary of these parameters at the Lincs Coast Chapel St. Leonards 3.0 km OS station is provided in Table 8.7.

Table 8.6: Summary of Environment Agency monitoring data collected from the relevant monitoring stations from 2018 to 2022

Parameter	Details	
Sampling Point Description	LINCS COAST CHAPEL-ST-LEONARD 3.0 KM O/S	LINCS COAST OUTER DOGS HEAD 4.5 KM O/S
Sampling Point ID	AN-LC558374	AN-LC560357
Temperature of Water (°C)	$\bar{x}$ = 11.4 (2.6 – 21.0; n= 46)	$\bar{x}$= 11.1 (2.7 – 20.0; n=49)
Turbidity (*in situ*) (ftu)	$\bar{x}$ = 82.0 (1.6 – 262.2; n=46)	$\bar{x}$= 18.9 (1.3 – 99.8; n=49)
Salinity (*in situ*) (ppt)	$\bar{x}$ = 32.7 (29.0 – 34.2; n=47)	$\bar{x}$= 33.3 (30.2 – 34.4; n=49)
Dissolved Oxygen (Saturation) (%)	$\bar{x}$ = 97.9 (85.7 – 117.0; n=45)	$\bar{x}$= 101.3 (91.3 – 157.8; n=48)
Dissolved Oxygen (as O_2) (mg/l)	$\bar{x}$ = 8.9 (6.5 – 11.0; n=45)	$\bar{x}$= 9.1 (7.1 – 13.1; n=48)

8.4.3.5 Water Quality – Contaminants

44. The offshore ECC transverses (Figure 8.1 (Document Reference 6.2.8.1)) through the Lincolnshire coastal waterbody (ID: GB4042492000). This waterbody is 'heavily modified' due to flood protection works and is currently (2022 classification) at moderate overall status, based on moderate ecological potential and a chemical status which 'does not require assessment' (noting, this waterbody was failing to achieve good chemical status in the previous (2019) classification). A summary of the current waterbody status (overall, ecological and chemical) and parameters currently failing to achieve 'good' status is provided in Table 8.8.

Table 8.7: Summary of the Lincolnshire coastal waterbody

Parameter	Details
Water Body ID	GB640402492000
Waterbody Type	Coastal
Waterbody Area (Surface)	170km^2
Hydromorphological Designation (Reasons)	Heavily modified (flood protection)
Overall Status (2022)	Moderate
Ecological Potential (2022)	Moderate
Chemical Status (2022)	Does not require assessment
Parameters not at Good Status/Potential	Angiosperms; Invertebrates; Dissolved inorganic nitrogen; Mitigation measures assessment
Higher Sensitivity Habitats	Chalk reef (35.6km^2); Saltmarsh (5.6km^2)
Lower Sensitivity Habitats	Cobbles, gravel and shingle (7.0km^2); Intertidal soft sediment (7.5km^2); Subtidal soft sediments (136km^2)
Phytoplankton Status (2022)	Good
History of Harmful Algae	Not monitored

45. There is one designated Bathing Water located within the Project's ECC, Anderby. There are six additional designated Bathing Waters located within the MW&SQ study area. Details pertaining to all seven designated Bathing Waters are provided in Table 8.9 (classifications from 2023 have not been published at the time of writing) and the locations illustrated in Figure 8.1 (Document Reference 6.2.8.1).

Table 8.8: Bathing Water classifications

Bathing Water	Classification				
	2017	2018	2019	2021	2022
Mablethorpe Town	Excellent	Excellent	Excellent	Excellent	Excellent
Sutton-on-Sea	Excellent	Excellent	Excellent	Excellent	Excellent
Moggs Eye	Excellent	Excellent	Excellent	Excellent	Excellent
Anderby	Excellent	Excellent	Excellent	Excellent	Excellent
Chapel St Leonards	Excellent	Excellent	Excellent	Excellent	Excellent
Ingoldmells South	Excellent	Excellent	Excellent	Excellent	Excellent
Skegness	Excellent	Excellent	Excellent	Excellent	Excellent
Note, data was not collected in 2020 due to COVID-19.					

46. Of relevance to determining the baseline conditions for the MW&SQ chapter is that there is an absence of Shellfish Water Protected Areas within the ZoI, with the closest being in The Wash (Figure 8.1 (Document Reference 6.2.8.1)).

47. Further, the Lincolnshire coastal waterbody is not designated under the Nitrates Pollution Prevention Regulations 2015. There are two Nitrate Vulnerable Zones (NVZ) (Environment Agency, 2021) designations within the study area:
    - Ingoldmells Main Drain NVZ; and
    - Willoughby High Drain NVZ.
48. With respect to the offshore extents of the ECC and array, the Interim Quality Status Report (QSR) (OSPAR Commission, 2017) states that overall within the OSPAR region, including the North Sea, contaminant concentrations have decreased since 2010. Whilst concentrations are generally below levels likely to cause harm to marine species, they are not yet reduced to background levels. Localised areas of concern remain for high concentrations of Mercury, Lead, CB118 (PCB), PAHs and Cadmium (OSPAR Commission, 2022).

8.4.3.6 Water Quality – Suspended Sediment Concentrations

49. The southern North Sea is characterised by a high degree of spatial and temporal (both annual and inter-annual) variability in SSC. In general, there exists an inshore to offshore gradient in SSC, with the highest concentrations observed close to, and especially at the mouths of, large estuaries such as The Wash and the Humber (Cefas, 2016).
50. As presented in detail in Volume 1, Chapter 7, surface Suspended Particulate Matter (SPM) levels less than 5mg/l were recorded within the array area during the period 1998 to 2015 (Cefas, 2016). Levels of SPM are directly relatable to SSC levels. Higher SSC values will occur during spring tides and storm conditions, with the greatest concentrations encountered close to the bed. Within the nearshore extent of the ECC, surface SPM concentrations reach 40mg/l (Cefas, 2016). Closer to Humber Estuary and outwith the ZoI, surface SPM concentrations reach 60mg/l and can be related to the proximity to terrestrial sources (Cefas, 2016).
51. Further offshore within the array area, Project-specific turbidity data indicated mean near-surface (around 5m below surface) and near-bed spring and summer concentrations of circa 2.4mg/l and 9.2mg/l, respectively, between April and November August 2022 within the array area, and winter concentrations of 2.3mg/l and 8.9mg/l, respectively, between November 2022 and May 2023 (Fugro, 2022). Further detail on the Project-specific turbidity campaign are provided in Volume 3, Appendix 7.1 of this ES.

8.4.3.7 Sediment – Physical Characteristics

52. As presented in Volume 1, Chapter 7, surficial seabed sediments within the ZoI are predominately characterised by the presence of sand and gravel sized material (Figure 8.2 (Document Reference 6.2.8.2)). Specifically, and as identified through Project-specific surveys, the following surficial sediment populations are present:
    - Array area: generally characterised by a mix of sand and gravel, with a greater proportion of sand at shallower depths associated with the sandbank features. The proportion of fines was generally minimal, with a slightly higher content observed at deeper sample points.

ECC: indicate a variable sediment type with a general dominance of sand, with higher fines content than the array area, consistent with the pre-existing BGS data (Figure 8.2 (Document Reference 6.2.8.2)). Closer to the coast, the proportion of sand generally decreases, with a corresponding increase in gravel and fines content.

- Sediment – Contaminants

53. Historically in the southern North Sea sediment, contamination levels have been elevated beyond natural background levels as a consequence of anthropogenic activities, both onshore (industrial contaminants released into fluvial systems) and offshore (discharges from the oil and gas industry). Environmental controls introduced over recent years have resulted in the reduction of concentrations for many contaminants; this is continually monitored through survey programmes including those reported by OSPAR (2022) and within publications such as the UK Marine Monitoring and Assessment Strategy (UKMMAS, 2010).
54. The most recent OSPAR assessments (OSPAR, 2022) have indicated that, in general, the health of seabed sediments has been improving as:
    - A significant reduction in the mean concentration for all metals since the previous assessment, with:
        - Copper exhibiting a mean concentration that is significantly below the Background Assessment Concentration (BAC);
        - Cadmium assessed to have a mean concentration that is significantly below the ERL; and
        - Chromium, Lead, Mercury and Zinc shown to have mean concentrations that are not significantly below the ERL.
    - The level of other marine contaminants, including PAHs and Organotins have, predominately, been reducing.
55. Sediments with larger particle sizes (e.g., sands) are not typically associated with elevated concentrations of anthropogenic contaminants. Hydrocarbons, in particular, are closely correlated to the spatial distribution of sediment types. Metal concentrations in sediments are generally higher in the coastal zone and around estuaries, reducing offshore, indicating that river input and run-off from land are significant sources. As noted above and described in further detail in Volume 1, Chapter 7, the sediments within the array have been characterised as predominately sands and gravels (Figure 8.2 (Document Reference 6.2.8.2)). As such it is not expected that these will contain elevated concentrations of anthropogenic contaminants.
56. Project-specific surveys have analysed sediment for contaminant levels both within the array and ECC. Analysis has been undertaken by SOCOTEC, an MMO-accredited laboratory. The sediment sample locations are shown in Figure 8.2 (Document Reference 6.2.8.2). The key results are presented in this section, with further survey information presented in Volume 5, Appendix 3.1 and 3.2.

57. When considering the contaminant levels present at each of the stations, both within the array and ECC, it becomes important to note that regionally there are a large number of Oil and Gas production facilities within it. Further detail on the presence of oil and gas infrastructure is provided in Volume 1, Chapter 18: Infrastructure and Other Marine Users.

Metals - Array Area

58. The full suite of metals analysed at each of the 30 stations within the Array area are provided in Table 8.10. Of these, 23 had metal concentrations below AL1. Of the remaining seven stations, the location of which are shown on Figure 8.3b (Document Reference 6.2.8.3b), which recorded metal concentrations exceeding AL1, none exceeded the AL2 threshold. AL1 was exceeded for:

- Arsenic – at four stations; and
- Nickel – at three stations.

Metals - Export Cable Corridor

59. The full suite of metals analysed at each of the 28 stations within the ECC are provided in Table 8.11. Of these, 19 had metal concentrations below AL1. Of the remaining 12 stations which recorded metal concentrations exceeding AL1, none exceeded the AL2 threshold. AL1 was exceeded at those stations shown on Figure 8.3b (Document Reference 6.2.8.3b) (noting six stations exceeded the threshold for more than one contaminant) for:

- Arsenic – at eight stations;
- Chromium – at one station; and
- Nickel – at four stations.

Table 8.9: Metal contaminant levels (mg/kg) as analysed from the Project-specific array survey

	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
AL1	20	0.4	40	40	50	0.3	20	130
AL2	100	5	400	400	500	3	200	800
OWF_01	6.50	0.08	5.00	6.90	4.90	0.02	4.10	16.1
OWF_06	19.7	0.15	19.1	10.5	6.50	0.03	22.5	40.6
OWF_10	6.50	0.08	4.70	5.60	4.90	0.01	4.10	14.3
OWF_11	5.10	0.04	4.10	4.60	3.60	0.01	3.10	12.7
OWF_12	9.90	0.07	5.40	4.30	3.30	<0.01	5.10	18.8
OWF_17	4.90	0.05	4.00	4.30	2.70	<0.01	2.80	9.60
OWF_19	17.0	0.08	4.00	3.70	10.5	0.01	5.10	20.2
OWF_21	37.3	0.16	13.7	8.40	9.90	0.01	15.9	45.5
OWF_23	19.9	0.19	14.0	8.30	7.90	0.01	15.2	54.1
OWF_27	31.4	0.12	10.3	7.20	7.20	0.05	11.9	33.5
OWF_30	18.7	0.12	8.90	6.90	6.60	0.02	11.1	26.6
OWF_32	15.4	0.14	10.8	9.50	6.00	0.02	12.8	33.0
OWF_34	11.8	0.07	5.40	6.30	4.10	0.01	4.50	15.0
OWF_35	11.1	0.07	7.40	7.30	5.60	0.01	6.70	19.9
OWF_36	24.0	0.17	15.9	9.80	7.10	0.01	18.3	47.4
OWF_38	16.5	0.12	13.4	9.90	6.40	0.02	14.5	34.0
OWF_39	15.1	0.08	10.3	7.20	6.40	<0.01	9.80	24.8
OWF_41	15.5	0.24	17.1	20.7	6.50	0.02	39.4	55.6
OWF_45	14.7	0.16	16.2	9.80	6.70	<0.01	19.0	33.0
OWF_46	21.5	0.14	13.1	9.40	5.90	<0.01	14.8	47.4
OWF_47	17.5	0.09	8.90	6.20	6.80	0.01	9.00	27.6
OWF_50	9.00	0.06	6.50	5.70	4.50	0.01	6.00	17.0
OWF_52	19.9	0.11	17.5	12.2	5.80	<0.01	17.7	47.2
OWF_55	18.9	0.09	7.90	6.30	5.00	0.04	7.90	25.6
OWF_62	6.90	0.06	6.70	6.20	3.60	0.01	4.90	14.2

	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
OWF_65	9.40	0.08	6.80	6.70	5.20	0.01	5.70	18.6
OWF_68	12.6	0.05	6.30	6.50	3.90	0.01	6.80	20.6
OWF_72	14.7	0.07	10.4	8.20	6.50	<0.01	11.3	26.6
OWF_73	8.60	<0.04	7.10	5.70	3.30	<0.01	7.50	16.8
OWF_79	14.2	0.13	28.9	12.5	8.40	0.01	28.2	42.9

Table 8.11: Metal contaminant levels (mg/kg) as analysed from the Project-specific ECC survey

	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
AL1	20	0.4	40	40	50	0.3	20	130
AL2	100	5	400	400	500	3	200	800
FA_02	12.2	0.05	6.7	5.6	3.9	0.02	5.9	18.6
FA_04	15.8	0.07	14.2	7.7	6.2	0.02	18.8	32.5
ECC_06	30.0	0.05	9.2	7.0	5.4	0.03	9.5	34.9
ECC_08	15.8	0.06	12.1	8.6	6.0	0.02	15.3	32.3
ECC_10	6.2	<0.04	4.2	4.6	3.4	0.02	3.2	12.9
ECC_14	9.8	0.05	4.7	5.6	9.3	0.02	5.5	23.0
ECC_16	10.5	0.06	4.3	5.1	7.2	0.05	5.2	19.3
ECC_18	19.2	0.09	12.0	11.1	8.4	0.04	13.4	27.9
ECC_20	12.3	0.06	9.6	6.4	6.6	0.03	9.4	25.2
ECC_22	13.0	<0.04	9.9	27.9	3.9	0.02	9.1	30.1
ECC_24	13.2	<0.04	5.7	4.9	3.8	0.02	5.6	32.5
ECC_26	21.3	0.05	7.0	6.4	9.1	0.05	9.1	34.4
ECC_30	36.9	0.06	12.0	8.2	9.1	0.03	14.3	42.1
ECC_32	12.8	0.08	6.6	6.3	5.9	0.05	23.8	38.0
ECC_34	8.1	<0.04	7.9	8.0	7.6	0.04	6.7	22.9
ECC_36	9.6	0.05	11.1	8.2	9.1	0.04	9.2	34.6
ECC_38	16.4	0.06	5.7	5.5	12.0	0.04	8.1	32.3
ECC_40	19.6	<0.04	12.6	8.3	10.2	0.04	15.0	38.3
ECC_43*	22.9	0.25	16.2	10.4	8.6	0.08	19.8	46.3
ECC_45*	24.0	0.11	21.1	13.5	9.1	0.04	22.8	53.9
ECC_47	17.8	<0.04	13.6	9.6	12.1	0.07	13.8	43.1
ECC_49	22.0	0.05	17.3	13.0	16.2	0.06	23.0	45.1
ECC_50*	16.2	<0.04	10.5	8.3	10.6	0.04	10.2	30.6
ECC_51*	72.0	0.09	55.7	10.2	9.5	0.12	40.4	57.5
ECC_54	13.7	<0.04	8.7	6.3	5.4	0.03	8.7	23.5

	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
ECC_57	14.3	0.04	11.4	8.9	9.0	0.03	11.4	32.9
ECC_58*	12.7	<0.04	10.0	8.1	11.3	0.03	9.3	33.5
ECC_60*	20.3	0.05	16.9	11.6	15.2	0.04	18.0	46.7

Polycyclic Aromatic Hydrocarbons

60. PAHs are a group of structurally related hydrocarbons. Whilst these hydrocarbons are not typically intentionally released into the environment, they are naturally present in fossil fuels and other hydrocarbon-based materials (such as bitumen on roads). PAHs persist in the environment and have the potential to bio-accumulate with consequential potential adverse effects on aquatic life and humans (Environment Agency, 2019). PAHs are classed as priority hazardous substances and ubiquitous persistent, bio-accumulative and toxic compounds under the WFD in the related EQSD (2008/105/EC amended by 2013/39/EU).

Polycyclic Aromatic Hydrocarbons – Array Area

61. The full suite of contaminants analysed at each of the 30 stations within the array area are provided in Table 8.12. Of these, only one recorded a PAH that exceeded the TEL threshold. This threshold exceedance is indicated by the blue cells in Table 8.12. The concentration recorded did not exceeded the PEL threshold. TEL thresholds were exceeded at this single station for:
    - Acenaphthene; and
    - Phenanthrene.
62. Acenaphthene is a component of crude oil and is a product of combustion, released, for example from diesel fuelled engines. It is considered that acenaphthene biodegrades rapidly in the environment, although it may persist under anaerobic conditions and at high concentrations is toxic to microorganisms. Acenaphthene is not currently explicitly included as a priority substances and certain other polluting chemicals in the WFD and EQSD.
63. Phenanthrene is widely distributed in the aquatic environment, occurring naturally in fossil fuels and is present in products of incomplete combustion. This PAH is not currently explicitly included as a priority substances and certain other polluting chemicals in the WFD and EQSD.
64. The station (OWF_19) for which the two contaminants exceed the TEL, as shown in Figure 8.3a (Document Reference 6.2.8.3a), is in close proximity to Pickerill-B, a decommissioned gas platform previously operated by Perenco.
65. When these observed PAH levels are assessed using the Gorham-Test approach (Gorham-Test *et al*., 1999), one site did exceed the ERL (AL1). Site OWF_19 did exceed the limit for LMW PAHs, due to the high concentrations of acenaphthene and phenanthrene, as discussed previously. None of the sample locations exceeded the ERL for HMW PAHs, indicating low contaminant levels.
66. The same suite of contaminants from the 30 stations have also been compared to the USEPA sediment quality guidelines. None of the PAH levels recorded exceeded the USEPA ERL or ERM thresholds.

Table 8.10: PAH contaminant levels (µg/kg) as analysed from the Project-specific array survey, against Canadian guidelines

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo[b]fluoranthene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1 Naphthalenes	C1-phenanthrene	C2 Naphthalenes	C3 Naphthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno[123,cd]pyrene	Naphthalene	Phenanthrene	Pyrene
TEL	6.71	5.87	46.9	74.8	88.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	108	6.22	113	21.2	n/a	34.6	86.7	153
PEL	88.9	128	245	693	763	n/a	n/a	n/a	n/a	n/a	n/a	n/a	846	135	1,494	144	n/a	391	544	1,398
OWF_01	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
OWF_06	<1	<1	<1	4.36	4.83	3.74	4.83	3.74	15	16.5	16.2	24.6	4.67	<1	6.74	<1	1.77	2.25	10.6	10.6
OWF_10	<1	<1	<1	<1	<1	<1	<1	<1	2.78	1.94	2.84	2.64	<1	<1	1.06	<1	<1	<1	1.5	<1
OWF_11	<1	<1	<1	<1	1.41	1.27	1.41	1.27	2.39	5.16	4.74	6.84	1.28	<1	1.99	<1	<1	<1	3.41	2.17
OWF_12	<1	<1	<1	<1	<1	<1	<1	<1	1.67	1.05	1.56	1.23	<1	<1	1.07	<1	<1	<1	<1	<1
OWF_17	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	4.34	<1	<1	<1	<1	<1	<1	<1	<1	<1
OWF_19	10.2	5.13	13.4	41	37	28.8	37	28.8	267	327	372	429	41.1	3.27	60.3	12.2	12.1	14.9	265	77.2
OWF_21	<1	<1	<1	<1	<1	<1	<1	<1	1.37	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
OWF_23	<1	<1	<1	1.14	1.97	1.78	1.97	1.78	4.49	7.10	6.15	11.3	1.9	<1	2.87	<1	1.02	1.21	4.1	2.98
OWF_27	<1	<1	<1	<1	<1	<1	<1	<1	1.45	4.74	1.7	4.32	<1	<1	1.2	<1	<1	<1	1.93	1.23
OWF_30	<1	<1	<1	<1	<1	<1	<1	<1	1.27	<1	1.19	<1	<1	<1	<1	<1	<1	<1	<1	<1
OWF_32	<1	<1	<1	<1	1.56	1.17	1.56	1.17	5.11	6.83	12.2	16	1.16	<1	2.01	<1	<1	1.18	4.73	2.68

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo[b]fluoranthene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1 Naphthalenes	C1-phenanthrene	C2 Naphthalenes	C3 Naphthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno[123,cd]pyrene	Naphthalene	Phenanthrene	Pyrene
OWF_34	<1	<1	<1	<1	1.3	1.29	1.3	1.29	1.41	2.17	2.08	2.34	1.21	<1	1.55	<1	<1	<1	1.31	1.65
OWF_35	<1	<1	<1	<1	1.84	1.32	1.84	1.32	3.1	3.86	3.68	6.77	1.46	<1	2.37	<1	<1	<1	3.08	2.5
OWF_36	<1	<1	2.47	2.44	2.03	1.38	2.03	1.38	1.06	5.76	1.43	2.61	3.1	<1	2.55	<1	<1	<1	1.58	5.04
OWF_38	<1	<1	<1	<1	1.17	<1	1.17	<1	4.12	3.46	3.41	4.96	1.19	<1	1.54	<1	<1	1.16	2.24	1.98
OWF_39	2.17	<1	<1	2.87	5.14	4.33	5.14	4.33	7.12	15.3	19.2	28.8	4.39	<1	7.45	1.23	2.22	2.28	9.47	8.42
OWF_41	<1	<1	<1	<1	2.24	1.49	2.24	1.49	4.9	4.85	4.94	5.96	1.47	<1	1.84	<1	<1	1.28	3.33	2.47
OWF_45	<1	<1	<1	1.48	2.52	2.01	2.52	2.01	2.1	5.89	3.22	5.05	1.94	<1	2.44	<1	1.13	<1	2.72	3.19
OWF_46	<1	<1	<1	5.55	6.95	6.03	6.95	6.03	55.6	33.3	38.2	33.5	8.65	<1	11	<1	2.24	19.8	33.6	10.3
OWF_47	<1	<1	<1	<1	<1	1.06	<1	1.06	1.21	1.93	1.66	2.41	<1	<1	1.48	<1	<1	<1	1.6	1.35
OWF_50	<1	<1	<1	<1	1.86	1.63	1.86	1.63	3.35	4.61	5.07	7	1.89	<1	2.61	<1	<1	1.36	2.98	3.23
OWF_52	<1	<1	<1	1.12	1.53	1.48	1.53	1.48	4.18	5.79	6.25	7.47	1.48	<1	2.24	<1	<1	<1	4.63	2.45
OWF_55	<1	<1	<1	1.01	1.23	2.25	1.23	2.25	3.83	4.17	4.7	5.59	1.32	<1	2.56	<1	<1	<1	3.35	1.72
OWF_62	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
OWF_65	<1	<1	<1	<1	<1	<1	<1	<1	1.24	1.55	2.01	1.96	<1	<1	<1	<1	<1	<1	<1	<1

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo[b]fluoranthene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1 Naphthalenes	C1-phenanthrene	C2 Naphthalenes	C3 Naphthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno[123,cd]pyrene	Naphthalene	Phenanthrene	Pyrene
OWF_68	<1	<1	<1	<1	1.22	<1	1.22	<1	2.99	4.19	4.35	5.92	1.37	<1	2.1	<1	<1	1.34	2.66	2.51
OWF_72	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.20	1.18	1.15	<1	<1	1.41	<1	<1	<1	<1	1.15
OWF_73	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.06	<1	<1	<1	<1	<1	<1	<1	<1	<1
OWF_79	<1	<1	<1	1.34	2.47	1.98	2.47	1.98	3.04	5.72	4.44	7.71	1.8	<1	2.81	<1	<1	<1	3.54	3.58

67. The full suite of contaminants analysed at each of the 28 stations within the ECC are provided in Table 8.13. Of these, 26 had PAH concentrations below the TEL threshold. Of the remaining two stations which recorded contaminants exceeding the TEL threshold, none exceeded the PEL threshold. As seen in the shaded cells of Table 8.13 (ECC-49 and ECC-60), TEL thresholds were exceeded at these stations for:
    - Dibenzo(a,h)anthracene;
    - Naphthalene; and
    - Phenanthrene.
68. Dibenzo(a,h)anthracene is produced by the incomplete combustion of organic matter such as fossil fuels. There have been very limited studies considering the toxicity of Dibenzo(a,h)anthracene. Dibenzo(a,h)anthracene is not currently explicitly included as a priority substances and certain other polluting chemicals in the WFD and EQSD.
69. Naphthalene is the most abundant component of coal tar and is not naturally occurring. This PAH is included as a priority substances and certain other polluting chemicals in the WFD and EQSD.
70. Phenanthrene is widely distributed in the aquatic environment, occurring naturally in fossil fuels and is present in products of incomplete combustion. This PAH is not currently explicitly included as a priority substances and certain other polluting chemicals in the WFD and EQSD.
71. The location of the two stations (ECC_49; ECC_60) at which the three contaminants exceed the TEL are shown in Figure 8.3a (Document Reference 6.2.8.3a). These stations are located over 10km away from each other.
72. The PAH concentrations from the sample sites did not exceed either the ERL for LMW or HMW PAHs using the Gorham-Test approach. This indicates PAH levels are considered low overall, with no adverse environmental impact expected.
73. The same suite of contaminants from the 28 stations were compared to the USEPA ERL and ERM thresholds, shown in Table 8.14. Only one of these stations (ECC_60) had a PAH above the ERL threshold, with the ERL exceeded for:
    - Fluorene.
74. Fluorene is also produced from incomplete combustion of fossil fuels (similar to Dibenzo(a,h)anthracene combustion), with limited information available on the contamination of fluorene in subsea sediments.

Table 8.11: PAH contaminant levels (µg/kg) as analysed from the Project-specific ECC survey, against Canadian guidelines

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	B.enzo[b]fluoranthene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1 Naphthalenes	C1-phenanthrene	C2 Naphthalenes	C3 Naphthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno[123,cd]pyrene	Naphthalene	Phenanthrene	Pyrene
TEL	6.71	5.87	46.9	74.8	88.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	108	6.22	113	21.2	n/a	34.6	86.7	153
PEL	88.9	128	245	693	763	n/a	n/a	n/a	n/a	n/a	n/a	n/a	846	135	1,494	144	n/a	391	544	1,398
FA_02	<1	<1	<1	<1	1.08	1.65	1.61	<1	1.27	1.62	1.58	1.72	1.4	<1	1.59	<1	1.09	<1	<1	1.69
FA_04	<1	<1	<1	3.46	3.91	6.1	7.02	1.76	4.5	29.5	14.1	22.3	7.71	1.04	9.15	<1	2.56	1.42	18.8	10.3
ECC_06	<1	<1	<1	<1	1.02	1.43	1.38	<1	2.52	2.99	3.8	3.06	1.25	<1	1.43	<1	1.13	1.66	2.12	1.67
ECC_08	<1	<1	<1	<1	<1	1.12	1.38	<1	2.38	2.25	2.52	2.38	1.16	<1	1.31	<1	<1	1.12	1.44	1.29
ECC_10	<1	<1	<1	<1	<1	1.12	1.05	<1	1.83	1.94	2.11	1.68	1.12	<1	1.47	<1	<1	<1	1.04	1.44
ECC_14	<1	<1	<1	1.94	2.17	3.46	3.51	1.29	6.23	7.86	7.57	7.36	3.64	<1	4.21	<1	1.93	1.58	5.15	4.46
ECC_16	<1	<1	<1	1.41	1.43	2.22	2.31	<1	5.81	6	5.82	5.73	2.4	<1	2.64	<1	1.29	1.54	4.22	3.22
ECC_18	1.09	<1	1.66	4.45	5.65	7.61	7.19	2.91	24.1	17.10	23.8	22.2	6.77	1.35	8.83	1.99	5.87	7.69	12.9	8.35
ECC_20	<1	<1	<1	3.62	4.51	6.39	5.4	1.88	18.1	13.90	18.4	17.8	5.39	1.13	6.92	1.32	4.02	5.32	10.7	6.92
ECC_22	<1	<1	1.28	2.81	3.57	4.33	4.4	1.45	6.29	14.50	8.49	13.7	4.76	<1	5.81	<1	2.85	2.29	8.1	6.04
ECC_24	<1	<1	<1	1.58	2.12	2.14	2.13	1.36	2.1	4.16	1.83	2.52	2.48	<1	2.63	<1	1.24	<1	1.91	4.5
ECC_26	<1	<1	<1	1.49	1.98	2.87	3.08	1.21	1.65	3.55	1.39	1.51	3.07	<1	3.1	<1	1.53	<1	1.3	3.41

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	B.enzo[b]fluoranthene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1 Naphthalenes	C1-phenanthrene	C2 Naphthalenes	C3 Naphthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno[123,cd]pyrene	Naphthalene	Phenanthrene	Pyrene
ECC_30	<1	<1	<1	1.11	1.39	1.81	2.16	1.17	3.48	3.61	3.1	3.36	1.96	<1	2.5	<1	1.24	1.16	2.43	2.67
ECC_32	<1	<1	<1	2.7	2.23	3.34	3.19	1.26	5.26	11.40	6.13	7.39	4.12	<1	5.86	<1	1.61	1.87	6.16	5.2
ECC_34	2.09	1.13	3.5	9.52	10.2	11.8	13.1	5.68	50.2	50.40	59.7	60	15.8	2.05	20.3	3.64	7.94	13.2	40.6	18.3
ECC_36	2.32	1.27	2.87	9.4	10.6	12.4	11.2	6.52	85.5	38.30	63	56.5	13.2	1.99	19.1	4.01	7.75	32.7	32	18.4
ECC_38	<1	<1	1.53	3.27	2.98	2.96	3.16	1.22	6.49	18.1	9.81	18.3	4.39	<1	6.16	<1	1.76	2.22	9.82	7.72
ECC_40	2.01	1.25	2.76	11.7	13.3	13.8	13.5	6.79	43.4	27.80	39.9	34.2	15.3	2.2	22.7	3.7	10.7	14.7	23.4	21.1
ECC_43*	<1	<1	<1	2.43	2.9	3.28	4.04	1.76	9.47	12.60	9.06	10.3	4.23	<1	5.5	<1	1.78	2.99	7.45	6.27
ECC_45*	<1	<1	<1	1.25	1.7	2.57	3.01	1.12	8.01	6.3	6.44	5.55	2.74	<1	3.39	<1	1.19	2.49	4.7	3.8
ECC_47	3.9	2.36	6.77	17.6	21.5	25.2	24.6	10.4	86.7	54.70	73.8	66.8	26	4.06	36.5	7.77	18.1	28.5	45.5	34.7
ECC_49	6.86	3.44	10.6	32.9	38.9	45.4	42.8	18.6	163	114.00	138	123	48.7	7.02	68.8	12.1	32	52.3	93.4	65.5
ECC_50*	2.43	1.29	3.57	12.3	13.7	15.9	15.8	6.34	64.5	57.30	59.3	63	18.3	2.55	24.9	4.35	9.06	18.4	41.6	25.1
ECC_51*	<1	<1	<1	1.21	1.47	2.8	2.76	1.13	3.3	3.76	2.63	2.86	2.85	<1	4.04	<1	1.42	1.1	2.59	4.25
ECC_54	<1	<1	<1	1.13	1.55	2.06	2.81	1.1	5.38	4.79	4.94	4.93	2.44	<1	2.6	<1	1.29	1.73	3.45	3.05
ECC_57	1.68	<1	1.7	6.24	8.01	7.99	9.46	3.67	36.6	27.20	31.9	31.8	10.5	1.68	14.4	3.02	6.01	11.7	21.3	14.5

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	B.enzo[b]fluoranthene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1 Naphthalenes	C1-phenanthrene	C2 Naphthalenes	C3 Naphthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno[123,cd]pyrene	Naphthalene	Phenanthrene	Pyrene
ECC_58*	<1	<1	<1	5.71	5.4	7.25	8.71	3.09	13	20.30	12.6	13.2	11	1.11	13	<1	3.73	5.1	20.6	14.9
ECC_60*	10	5.34	12.8	43.8	54.9	61.9	59.6	29.7	201	138.00	180	156	66	10	94.6	19.1	45.7	68.2	119	88.9

Table 8.12: PAH contaminant levels as analysed from the Project specific ECC survey, against USEPA guidelines

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo[b]fluoranthene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1 Naphthalenes	C1-phenanthrene	C2 Naphthalenes	C3 Naphthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno[123,cd]pyrene	Naphthalene	Phenanthrene	Pyrene
ERM	16	44	853	261	430	n/a	n/a	n/a	n/a	n/a	n/a	n/a	384	63.4	600	19	n/a	160	240	665
ERL	500	640	1,100	1,600	1,600	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2,800	260	5,100	540	n/a	2,100	1,500	2,600
FA_02	<1	<1	<1	<1	1.08	1.65	1.61	<1	1.27	1.62	1.58	1.72	1.4	<1	1.59	<1	1.09	<1	<1	1.69
FA_04	<1	<1	<1	3.46	3.91	6.1	7.02	1.76	4.5	29.5	14.1	22.3	7.71	1.04	9.15	<1	2.56	1.42	18.8	10.3
ECC_06	<1	<1	<1	<1	1.02	1.43	1.38	<1	2.52	2.99	3.8	3.06	1.25	<1	1.43	<1	1.13	1.66	2.12	1.67
ECC_08	<1	<1	<1	<1	<1	1.12	1.38	<1	2.38	2.25	2.52	2.38	1.16	<1	1.31	<1	<1	1.12	1.44	1.29
ECC_10	<1	<1	<1	<1	<1	1.12	1.05	<1	1.83	1.94	2.11	1.68	1.12	<1	1.47	<1	<1	<1	1.04	1.44
ECC_14	<1	<1	<1	1.94	2.17	3.46	3.51	1.29	6.23	7.86	7.57	7.36	3.64	<1	4.21	<1	1.93	1.58	5.15	4.46
ECC_16	<1	<1	<1	1.41	1.43	2.22	2.31	<1	5.81	6	5.82	5.73	2.4	<1	2.64	<1	1.29	1.54	4.22	3.22
ECC_18	1.09	<1	1.66	4.45	5.65	7.61	7.19	2.91	24.1	17.10	23.8	22.2	6.77	1.35	8.83	1.99	5.87	7.69	12.9	8.35
ECC_20	<1	<1	<1	3.62	4.51	6.39	5.4	1.88	18.1	13.90	18.4	17.8	5.39	1.13	6.92	1.32	4.02	5.32	10.7	6.92
ECC_22	<1	<1	1.28	2.81	3.57	4.33	4.4	1.45	6.29	14.50	8.49	13.7	4.76	<1	5.81	<1	2.85	2.29	8.1	6.04
ECC_24	<1	<1	<1	1.58	2.12	2.14	2.13	1.36	2.1	4.16	1.83	2.52	2.48	<1	2.63	<1	1.24	<1	1.91	4.5
ECC_26	<1	<1	<1	1.49	1.98	2.87	3.08	1.21	1.65	3.55	1.39	1.51	3.07	<1	3.1	<1	1.53	<1	1.3	3.41

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo[b]fluoranthene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1 Naphthalenes	C1-phenanthrene	C2 Naphthalenes	C3 Naphthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno[123,cd]pyrene	Naphthalene	Phenanthrene	Pyrene
ECC_30	<1	<1	<1	1.11	1.39	1.81	2.16	1.17	3.48	3.61	3.1	3.36	1.96	<1	2.5	<1	1.24	1.16	2.43	2.67
ECC_32	<1	<1	<1	2.7	2.23	3.34	3.19	1.26	5.26	11.40	6.13	7.39	4.12	<1	5.86	<1	1.61	1.87	6.16	5.2
ECC_34	2.09	1.13	3.5	9.52	10.2	11.8	13.1	5.68	50.2	50.40	59.7	60	15.8	2.05	20.3	3.64	7.94	13.2	40.6	18.3
ECC_36	2.32	1.27	2.87	9.4	10.6	12.4	11.2	6.52	85.5	38.30	63	56.5	13.2	1.99	19.1	4.01	7.75	32.7	32	18.4
ECC_38	<1	<1	1.53	3.27	2.98	2.96	3.16	1.22	6.49	18.1	9.81	18.3	4.39	<1	6.16	<1	1.76	2.22	9.82	7.72
ECC_40	2.01	1.25	2.76	11.7	13.3	13.8	13.5	6.79	43.4	27.80	39.9	34.2	15.3	2.2	22.7	3.7	10.7	14.7	23.4	21.1
ECC_43*	<1	<1	<1	2.43	2.9	3.28	4.04	1.76	9.47	12.60	9.06	10.3	4.23	<1	5.5	<1	1.78	2.99	7.45	6.27
ECC_45*	<1	<1	<1	1.25	1.7	2.57	3.01	1.12	8.01	6.3	6.44	5.55	2.74	<1	3.39	<1	1.19	2.49	4.7	3.8
ECC_47	3.9	2.36	6.77	17.6	21.5	25.2	24.6	10.4	86.7	54.70	73.8	66.8	26	4.06	36.5	7.77	18.1	28.5	45.5	34.7
ECC_49	6.86	3.44	10.6	32.9	38.9	45.4	42.8	18.6	163	114.00	138	123	48.7	7.02	68.8	12.1	32	52.3	93.4	65.5
ECC_50*	2.43	1.29	3.57	12.3	13.7	15.9	15.8	6.34	64.5	57.30	59.3	63	18.3	2.55	24.9	4.35	9.06	18.4	41.6	25.1
ECC_51*	<1	<1	<1	1.21	1.47	2.8	2.76	1.13	3.3	3.76	2.63	2.86	2.85	<1	4.04	<1	1.42	1.1	2.59	4.25
ECC_54	<1	<1	<1	1.13	1.55	2.06	2.81	1.1	5.38	4.79	4.94	4.93	2.44	<1	2.6	<1	1.29	1.73	3.45	3.05
ECC_57	1.68	<1	1.7	6.24	8.01	7.99	9.46	3.67	36.6	27.20	31.9	31.8	10.5	1.68	14.4	3.02	6.01	11.7	21.3	14.5

	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo[b]fluoranthene	Benzo[e]pyrene	Benzo[k]fluoranthene	C1 Naphthalenes	C1-phenanthrene	C2 Naphthalenes	C3 Naphthalenes	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno[123,cd]pyrene	Naphthalene	Phenanthrene	Pyrene
ECC_58*	<1	<1	<1	5.71	5.4	7.25	8.71	3.09	13	20.30	12.6	13.2	11	1.11	13	<1	3.73	5.1	20.6	14.9
ECC_60*	10	5.34	12.8	43.8	54.9	61.9	59.6	29.7	201	138.00	180	156	66	10	94.6	19.1	45.7	68.2	119	88.9

Other Contaminants Content

75. This section considers the concentrations of the remaining contaminants listed in the Cefas Guideline Action Levels, namely:
    - Organotins (TBT, DBT and MBT);
    - PCBs, sum of ICES 7;
    - PCBs, sum of 25 congeners; and
    - OCPs (DDT and Dieldrin).

Other Contaminants Content - Array Area

76. At all 30 stations within the Array area, the full suite of remaining contaminants analysed were at concentrations below AL1.

Other Contaminants Content - Export Cable Corridor

77. At all 28 stations within the ECC, the full suite of remaining contaminants analysed were at concentrations below AL1.

8.4.3.8 Compensation Areas

78. The potential compensation areas considered for the Project include areas for two artificial nesting structures (ANSs) and one biogenic reef restoration area. The areas are presented in Figure 8.1 (Document Reference 6.2.8.1).
79. Physical characteristics of water quality related to the compensation areas are presented in Table 8.7. The nearest monitoring station of relevance to the compensation areas is the 'Lincs Coast Outer Dogs Head 4.5km O/S', which is located adjacent to the biogenic reef restoration area. The physical characteristics of the water column for the two ANS areas are anticipated to be similar to that of the array area due to their geographic proximity.
80. None of the compensation areas overlap, or are located immediately adjacent to coastal and/or transitional waterbodies. Nor do the areas directly interact with designated sites such as shellfish water protected areas, bathing waters, and nitrate vulnerable zones. Therefore, the contaminant information is as presented in Table 8.8 and Table 8.9.
81. As presented in Volume 1, Chapter 7, SSCs are generally low within the ANS areas, with the biogenic reef restoration area possessing increasing suspended sediment concentrations closer to the coast. This is due to the shallower coastal areas being more susceptible to tidal action.
82. The physical characteristics of the sediment relating to the proposed compensation areas are as follows (presented in Figure 8.2 (Document Reference 6.2.8.2)):
    - Northern ANS area: generally surficial sediments comprising of mainly gravel and sandy gravel (Volume 1, Chapter 7);
    - Southern ANS area: generally consisting of gravelly sand sediment; and
    - Biogenic reef restoration area: the characterisation is expected to be similar to that of the offshore ECC, as described in Volume 1, Chapter 7.

83. Project-specific sediment contamination surveys were not undertaken for the proposed ANS and biogenic reef areas. It is anticipated that the sediment contaminant concentrations (metallic, PAH, and other) for the ANSs areas will be similar to the array area, due to the relative location and similar sediment characteristics. The sediment contaminant concentrations (metallic, PAH, and other) for the biogenic reef restoration area is anticipated to the akin to the offshore ECC, due to the geographic proximity and similar physical sediment characteristics.

8.4.3.9 Offshore Reactive Compensation Platforms (ORCPs)

84. The ORCPs (shown in Figure 8.1 (Document Reference 6.2.8.1)) will house reactive compensation electrical equipment, control and instrument systems, and will provide access to facilities for work vessels. Within the project design envelope presented for the Project there is potential for up to two ORCPs to be installed, which would be located within the boundaries of the ORCP area. As the ORCP area lies within the offshore ECC boundary, the potential impacts from ORCP installation are considered within Section 8.7.

8.5 Future Baseline Environment

85. The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 state that the following should be included within the ES (EIA Regulations, Schedule 4, Paragraph 3):

"A description of the relevant aspects of the current state of the environment (baseline scenario) and an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge".

86. From the point of assessment and over the Project's lifetime, including the Project's operational lifetime (anticipated to be, approximately, 35 years from first power), long-term trends mean that the baseline environment is expected to evolve. This section provides a qualitative description of future changes to the baseline environment on the assumption that the Project is not constructed and using best available information and scientific knowledge of MW&SQ.

87. Predictions of SPM levels, which in turn influence water clarity, over decadal to centennial scales indicate that the former is likely to increase and the latter decrease within the North Sea (Thewes et al., 2022). The factors which are influencing this variation are considered to include changes in:

- bed shear stress, sea level rise (Volume 1, Chapter 7: Marine Physical Processes);
- anthropogenic uses/changes (Volume 1, Chapter 18: Other Marine Users); and
- increased precipitation over land and associated run-off (Volume 1, Chapter 24: Hydrology and Flood Risk).

88. However, when considered alongside predicted reductions in wind speeds and wave heights within the North Sea (Volume 1, Chapter 7), it has also been hypothesized that SPM levels will reduce (van der Molen et al., 2013).

89. Contaminant levels within the sediments and biota of the North Sea have generally been shown to be reducing (OSPAR Commission, 2022). Indeed, contaminant release into the North Sea from both land-based sources and the Oil and Gas Industry has been observed to have reduced since 2010; this is expected to continue due to improved regulation and diffuse pollution control initiatives (OSPAR Commission, 2017).
90. Seawater chemistry, such as reductions in pH and salinity, have been observed and attributed to anthropogenic climate change. These changes may result indirectly in changes in coastal dynamics, water column stability and water quality.

8.6 Basis of Assessment

8.6.1 Scope of the Assessment

91. The following impacts have been scoped into this assessment:
    - Construction:
        - Impact 1: Deterioration in water quality due to suspension of sediments.
        - Impact 2: Release of sediment-bound contaminants from disturbed sediments.
        - Impact 3: Deterioration in water clarity due to the release of drilling mud.
    - Operational and Maintenance:
        - Impact 4: Deterioration in water quality due to suspension of sediments from O&M activities.
    - Decommissioning:
        - Impact 5: Deterioration in water quality due to re-suspension of sediments.
92. Impacts were scoped out of the assessment in line with feedback provided through the Scoping Opinion (The Planning Inspectorate, 2022), Section 42 responses and further consultation through the EPP. The scoping for assessment was additionally based on the receiving environment and expected parameters of the Project (Volume 1, Chapter 3: Project Description), the expected scale of impact and the potential for a pathway for effect on the environment. The following impacts have been scoped out of the assessment:
    - Construction:
        - Impact 1: Accidental releases or spills of materials or chemicals.
    - Operational and Maintenance:
        - Impact 2: Deterioration in water quality due to re-suspension of sediments and contaminants.
        - Impact 3: Accidental releases or spills of materials or chemicals.
    - Decommissioning:
        - Impact 4: Accidental releases or spills of materials or chemicals.
    - Cumulative:

- Impact 5: Release of sediment-bound contaminants from disturbed sediments and deterioration in water quality due to cumulative effects with other projects and plans.
- Impact 6: Accidental releases or spills of materials or chemicals.

- Transboundary:
  - Impact 7: Release of sediment-bound contaminants from disturbed sediments and deterioration in water quality resulting in transboundary impacts.

8.6.2 Realistic Worst-Case Scenario

93. This section identifies the Maximum Design Scenario (MDS) in environmental terms and upon which the MW&SQ assessment has been undertaken. Defined by the Project Design Statement (PDS) (Volume 1, Chapter 3), the methodology used within this assessment is in accordance with the requirements of the Rochdale Envelope approach to environmental assessment. Further detail on the Rochdale Envelope approach is provided in Advice Note Nine: 'Using the Rochdale Envelope' (The Planning Inspectorate, 2018) and as detailed in Volume 1, Chapter 5: EIA Methodology.
94. The MDS parameters used for this MW&SQ assessment are provided in Table 8.16 and have been applied to assess the Realistic Worst Case (RWC) scenario for each of the identified potential impacts (Section 8.7). These have been presented and discussed within the EPP.

Table 8.13: Maximum Design Scenario for the MW&SQ assessment

Potential effect	Maximum design scenario assessed	Justification
Construction		
Impact 1: Deterioration in water quality due to suspension of sediments Impact 2: Release of sediment-bound contaminants from disturbed sediments	**Volume of sediment disturbed and released from dredging for seabed preparation for foundations over the entire array area (2,280,000m^3):** ▪ 100 (15MW) Wind Turbine Generator (WTG) foundations, 50% of which Gravity Base Structures (GBS) and 50% jackets with suction buckets, with a total spoil volume of 2,037,500m^3 and ▪ Five OSPs within array area (four OSSs and one offshore accommodation platform), total spoil volume = 242,500m^3. **Volume of sediment disturbed and released from dredging for seabed preparation prior to foundation installation remote from the array area (169,600m^3):** ▪ Two Offshore Reactive Compensation Platforms (ORCPs) within the ECC, with a total spoil volume of 97,000m^3 (48,500m^3 per offshore platform foundation); and ▪ Two Artificial Nesting Structures (ANS), with a total spoil volume of 72,600m3. **Greatest volume of sediment disturbed and released by drilling as part of foundation installation at a single foundation location** ▪ Jacket foundation offshore platform with pin-piles, embedment depth = 110m, drill volume per location (Area 1) = 74,644m^3 (including overburden). See Volume 3, Appendix 7.2 for further details. **Greatest volume of sediment disturbed and released by drilling as part of the foundation installation over the entire array area** ▪ Total estimated drilling volume for 100 monopile foundations: = 780,000m^3;	This design scenario results in the greatest sediment volumes being disturbed for all construction activities. The RWC method selected also allows for the most energetic sediment release into the water column: ▪ MFE for cable trenching; ▪ Trailer Suction Hopper Dredger (TSHD) for seabed preparation works and sediment disposal at the sea surface. Further detail is provided in Volume 1, Chapter 7

Potential effect	Maximum design scenario assessed	Justification
	▪ Total estimated drilling volume for five offshore platform foundations = 137,000m^3; ▪ Total estimated drilling volume for WTGs and offshore platforms = 917,000m^3. **Greatest volume of sediment disturbed and released by drilling as part of foundation installation remote from the array** ▪ Average drill spoil volume for a jacket ORCP foundation with pin-piles (embedment depth of 110m) = 27,400m^3; ▪ Total estimated drilling volume for two ORCP foundations = 54,800m^3; ▪ Average drill spoil volume for jacket ANS with pin-piles (embedment depth of 95m) = 7,800m^3; ▪ Total estimated drilling volume for two ANS foundations = 15,600m^3. **Sandwave clearance via dredging (cables within the array area):** ▪ With 32.5% of the inter-array and interlink cables requiring sandwave clearance (to a width of 33m and an average depth of 2.5m), and 20% of the export cables within the array area (to a width of 33m and an average depth of 2.25m); ▪ Sandwave clearance volume within the array area (for 100 WTGs):11,615,616m^3 **Sandwave clearance via dredging (outside the array area) (4,518,513m^3):** ▪ Total length of up to four export cables: 440km; ▪ Material disposed of within the Project array area and offshore ECC in areas of similar sedimentary characteristics.	

Potential effect	Maximum design scenario assessed	Justification
	Installation of inter-array cables via MFE (6,038,720m^3): ▪ Total length: 377.43km; ▪ V-shaped trench; width = 15m, depth = 2.5m; ▪ Assume 100% of material is forced into suspension to a height of, approximately, 2m above the seabed; ▪ Total volume of disturbance: 6,038,720m^3; ▪ Assumed installation rate of up to 215m/hr. **Installation of interlink cables via MFE (1,980,000m^3):** ▪ Total length: 123.75km; ▪ V-shaped trench; width = 15m, depth = 2.5m; ▪ Assume 100% of material is forced into suspension to a height of, approximately, 2m above the seabed; ▪ Total volume of disturbance: 1,980,000m^3; ▪ Assumed installation rate of up to 215m/hr. **Installation of export cables via MFE (13,899,600m^3):** ▪ Total length of (4) export cables = 440km, each up to 110km in length from array area to landfall; ▪ V-shaped trench; width = 15m, depth = 2.5m; ▪ Assume 100% of material is forced into suspension to a height of approximately 2m above the seabed; ▪ Total volume of disturbance: 7,040,000m^3; ▪ Assumed installation rate of up to 215m/hr.	
Impact 3: Deterioration in water clarity due to the release of drilling mud	**Horizontal Directional Drilling (HDD)** ▪ Exit pit location for HDD: Subtidal;	The maximum volume of bentonite which could be released as part of the Project's landfall activities is to be

Potential effect	Maximum design scenario assessed	Justification
	▪ Six HDD exit pits, allowing for two failures, excavated to a depth of up to 5m over a total area = 1,000m^2; ▪ Maximum of three exit pits open at one time; and ▪ Estimated maximum excavated material volume = 5,000m^3 per pit and total = 30,000m^3. **HDD drilling fluid release** ▪ Maximum volume and mass of drilling fluid released per HDD conduit: 773m^3 fluid (138,000kg bentonite); and ▪ Period of release: 12 hours with estimated release rate of 3,195g/s.	determined. It is assumed that the RWC method does not allow for the capture of bentonite and as such it is released directly into the marine environment.
Operation and Maintenance		
Impact 4: Deterioration in water quality due to suspension of sediments from O&M activities	**Cable protection** ▪ Standard options include rock placement, concrete mattresses, flow dissipation devices, protective aprons, bagged protection, etc.; ▪ Rock berm protection with crest height = 1.5m, crest width = 2m, side slopes = 1:3 gradient and width at seabed = 12m(including a provision for 1m buffer either side); and ▪ Total length of cables which may potentially require seabed protection anticipated to be up to, approximately: ▪ 22.75% of inter-array, for a total area of 814,496m^2; ▪ 18.75% interlink cable length, for a total area of 278,438m^2 ; ▪ 25% of export cable length within the array area, for a total area of 330,000m^2; ▪ 25% of export cable length outside the SAC, for a total volume of 657,552m^2; ▪ 5% of export cable length within Sandbank Area 1, for a total area of 2,880m^2; ▪ 5% of export cable length within Sandbank Area 2, for a total area of 2,880m^2;	The maximum cable length (export; interlink; inter-array) which may require maintenance and repair works has been considered as the RWC.

Potential effect	Maximum design scenario assessed	Justification
	▪ 20% of export cable length within the SAC (excluding Sandbank Areas 1 and 2), for a total area of 227,558m^2.	
Decommissioning		
Impact 5: Deterioration in water quality due to re-suspension of sediments	▪ As a WCS scenario, it is assumed that the decommissioning phase of works is a reverse of the construction process, should there be a requirement to remove the seabed infrastructure. ▪ Array comprising the largest number of foundations (100 WTG, two ORCPs); ▪ 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); ▪ Scour and cable protection left *in situ*; and ▪ Decommissioning activities lasting approximately three years. ▪ The Project infrastructure will be decommissioned in accordance with the decommissioning plan in addition to the best environmental practice/option at the time.	This scenario represents the MDS for decommissioning at the time of writing.

8.6.3 Embedded Mitigation

95. Mitigation measures that were identified and adopted as part of the evolution of the project design (embedded into the project design) and that are relevant to MW&SQ are listed in Table 8.17. Thereafter mitigation measures that would apply specifically to MW&SQ issues associated with the array, export cable corridor and landfall are described separately.

Table 8.14: Embedded mitigation relating to MW&SQ

Project phase	Mitigation measures embedded into the project design
Construction	
Construction method statement	A Construction Method Statement (CMS) which will confirm construction methods and the roles and responsibilities of parties engaged in construction. It will detail any construction-related mitigation measures.
Cable burial risk assessment	Where possible, subsea cable burial will be the preferred option for cable protection. Cable burial will be informed by the cable burial risk assessment (CBRA) – which will take account of the presence of designated sites – and detailed within the Cable Specification and Installation Plan (CSIP). An outline CSIP alongside the ES (document reference 8.5), which will be finalised post-consent.
Project Design	A Project Environmental Management Plan (PEMP) will be developed post-consent and adopted, which will cover the construction and O&M phases of the Project. This will be secured through a Condition in the deemed Marine Licence. This PEMP will include a Marine Pollution Contingency Plan (MPCP), which provides protocols to cover accidental spills and potential contaminant release, and provide key emergency contact details.
Operation and Maintenance	
Project Design	Development of a Scour Protection Management Plan (SPMP) and Cable Specification and Installation Plan (CSIP) which will consider the need for scour protection
Project Design	The installation of scour protection where required for engineering purposes. Scour protection may take the form of rock/gravel placement, concrete mattresses, flow energy dissipation devices, protective aprons or coverings, ecological based solutions and bagged solutions.
Decommissioning	
Decommissioning Programme	Development of, and adherence to, a Decommissioning Programme.

8.7 Assessment Methodology

8.7.1 Introduction

96. The baseline and assessment works have been undertaken using an evidence-based approach, supported by Project specific surveys and numerical modelling undertaken within the Marine Physical Processes study (Volume 1, Chapter 7), as appropriate.

97. Contaminants may be released into the water column from the sediments as a result of the proposed activities. This has the potential to reduce the water quality in the locality of the release. Consequently, the potential for a reduction in water quality will be assessed in terms of the contaminants present in the sediment.

98. The assessment undertaken here has been used to inform the WFD Compliance Assessment, presented in Volume 3, Appendix 8.1.

8.7.1.1 Assessing Designated Waters

99. The quality of Bathing Waters is considered against the baseline performance of each site relative to the rBWD. There is a requirement for further assessment if there is the potential for the Bathing Waters to have reduced performance against the rBWD as a direct or indirect result of the proposed Project activities.

100. Given that NVZs are predominately associated with risk of nitrates inputs from agricultural activities, it is considered that the Project's proposed offshore works do not involve such activities and as such will not result in the introduction, release or disturbance of nitrates. As such, no likely significant effect is anticipated.

101. This assessment is consistent with the EIA methodology presented in Volume 1, Chapter 5.

102. The magnitude of identified impacts is defined in Table 8.18; a distinction is made throughout the assessment between the magnitude, extent and duration of 'impacts' and the resulting significance of the 'effects' upon the receptors likely to be impacted by changes to MW&SQ. Various actions may result in impacts: for instance, the export cable installation results in a localised and short-term (temporary) SSC change (which is defined as a water quality receptor). The significance of effect associated with the impact is dependent upon the receptor's sensitivity/importance, with due consideration afforded to the receptor's ability to tolerate and recover from the impact, as well as its status.

103. The descriptions of magnitude are specific to the assessment of MW&SQ and are considered against the magnitude descriptions presented in Table 8.18. Potential impacts have been considered in terms of permanent or temporary, and adverse or beneficial effects. Where an effect could reasonably be assigned to more than one level of magnitude, professional judgement has been used to determine which is applicable.

Table 8.15: Impact magnitude definitions

Magnitude	Description/reason
High	Large scale change to key characteristics of the water quality status of the receiving water feature. Water quality status degraded to the extent that a

Magnitude	Description/reason
	permanent or long-term change (i.e., a WFD reporting cycle) occurs. Inability to meet EQS as a result of the proposed activities.
Medium	Medium scale change to key characteristics of the water quality status of the receiving water feature. Water quality status is likely to take considerable time (for example, a change in the annual average turbidity classification (Tyler-Walters *et al*., 2018) to recover to baseline conditions. Ability to meet EQS becomes compromised.
Low	Noticeable but not considered to be substantial changes to the water quality status of the receiving water feature. Activity is not likely to alter local status to the extent that water quality characteristics change considerably and/or EQS become compromised.
Negligible	Although there may be some impact upon water quality status, activities are predicted to occur over a short period. Any change to water quality status will be quickly reversed once activity ceases.

104. The sensitivity/importance of the receptor is defined in Table 8.19.

Table 8.16: Sensitivity/importance of the environment

Receptor sensitivity/ importance	Definition
High	The water quality of the receptor supports or contributes towards the designation of an internationally or nationally important feature and/or has a very low capacity to accommodate any change to current water quality status.
Medium	The water quality of the receptor supports or contributes towards the designation of an internationally or nationally important feature and has a moderate to low capacity to accommodate the proposed form of change to current water quality status.
Low	The water quality of the receptor supports or contributes towards the designation of an internationally or nationally important feature and has a high capacity to accommodate the proposed form of change to current water quality status. The proposed change on the receptor would be undetectable within one tidal cycle of the activity.
Negligible	Specific water quality conditions of the receptor are likely to be able to tolerate change with very little or no impact upon the baseline conditions detectable.

105. Assessment of the significance of potential effects is described in Table 8.20.

Table 8.20: Matrix to determine effect significance

		Magnitude of impact			
		Negligible	*Low*	*Medium*	*High*
Sensitivity of receptor	*Negligible*	Negligible (Not significant)	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)
	Low	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)	Moderate (Significant)
	Medium	Minor (Not significant)	Minor (Not significant)	Moderate (Significant)	Major (Significant)
	High	Minor (Not significant)	Moderate (Significant)	Major (Significant)	Major (Significant)

8.7.2 Assumptions and Limitations

106. Whilst many of the baseline characteristics are well understood, in some instances, data sources or assumptions are less well studied and/or quantified for the study area. This section seeks to identify areas of uncertainty and potential data gaps.

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

108. There is some uncertainty associated with the sediment plume assessment and accompanying bed level changes due to Project related activities and analogous developments. This arises due to the uncertainty regarding how the seabed geology will respond to drilling and jetting. There are a number of factors which determine the exact volume of material that is entrained into the water column; including the type of drilling/cable installation equipment used, the variability of the forcing conditions at the installation time (i.e. the waves and tidal conditions) and the mechanical properties of the geological units. In the absence of this detailed information, a series of potential release scenarios have been considered in Volume 1, Chapter 7. Together, these scenarios capture the WCS impacts in terms of the highest concentration and persistent suspended sediment plumes, the maximum and greatest spatial extent of changes in bed level elevation.

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

110. The availability of robust data relevant for the characterisation and assessment of MW&SQ is such that, despite some data limitations, it is considered that a thorough and meaningful characterisation for the purposes of EIA can be undertaken. As such, the available evidence base is sufficiently robust to underpin the assessment presented here and an overall high confidence is placed on the assessment.

8.8 Impact Assessment

8.8.1 Construction

8.8.1.1 Summary of the Project Specific Modelling

111. A full and detailed assessment of the potential increases in suspended sediments is provided within Volume 1, Chapter 7 for all phases of the Project development. This section presents a summary of the Project specific numerical modelling undertaken to support the MW&SQ assessment of this EIA, of which full details are given in Volume 3, Appendix 7.2.

Mass Flow Excavator (MFE)

112. The use of a MFE for cable installation results in a relatively low height of initial suspension of sediment above the seabed. For the inter-array cable installation, the following is demonstrated in the numerical modelling:

- Sediment releases associated with these activities result in a long, relatively narrow plume extending downstream from the point of active disturbance, particularly during high current speeds.

- SSC resulting from the disturbance of all sediment types located at any one location can be expected to be very high at, and in the immediate locality of, the MFE activities. Immediately adjacent to, and within several metres of the activity, SSC can be expected to be millions of mg/l or more. Of note is that the effect is very localised and of very short (temporary) duration.
- SSC is expected to reduce to hundreds of mg/l within tens to low hundreds of metres.
- During the first half of the tidal cycle (~six hours), the plume width will increase through dispersion to between approximately 500 and 2000m, all sediments sand-sized and larger will have re-settled to the seabed. The SSC will reduce to below 50mg/l within, approximately, 5 km.
- After 15 hours, SSC will have generally reduced to below 50mg/l, with localised areas (smaller than 500m^2) up to 100mg/l with fine sediments widely dispersed. After 20 hours (~one full tidal cycle after the cessation of MFE activities), SSC will have reduced to below 20mg/l, with localised areas up to 50mg/l. Elevated SSC is expected to continue to disperse, so that no measurable SSC is expected to be present after several tidal cycles.

113. For the ECC installation, the following is demonstrated in the numerical modelling:

- The behaviour of sediment releases is comparable to those for MFE activities in the array area, with a long, relatively thin plume extending downstream from the point of active disturbance. The SSC within several meters of the activity will be highly elevated, although this effect is localised and temporary.
- Within the first five hours, the plume width will increase through dispersion to approximately between 500m and 1500m. SSC reduces to below 150mg/l within 1.5km. SSC will reduce to below 50mg/l after 15 hours, and below 5mg/l after 20 hours.

Trailer Suction Hopper Dredger (TSHD)

114. Seabed preparation may be required prior to the installation of Project infrastructure and is likely to include seabed levelling. The MDS for this activity involves the excavation of sediment using a TSHD:

- Whilst the hopper is being filled, overspill is likely to develop a near-surface sediment plume composed primarily of fine sediments. Once each hopper is filled, dredged material (spoil) will be returned to the seabed at an equal distance from the surrounding foundations as a relatively sudden release from under the vessel (i.e. at the water surface); and
- Once the dredger moves to discharge a full hopper load, the majority of the finer sediments are expected to have already been lost to overspill, although this will vary based on the sediment type and filling rate. During spoil disposal, sediments will be discharged as a highly turbid dynamic plume, with the coarser sediment fraction falling quickly to the seabed (on timescales of minutes to tens of minutes) with limited opportunity to be advected away by tidal currents, leading to a correspondingly greater localised depth of accumulation on the seabed. Finer sediments in the spoil will remain in suspension for longer (up to around a day), forming a passive plume which will then be advected by tidal currents.

115. Numerical modelling results for seabed levelling activities which require the use of a TSHD, as presented in Table 8.16, in the array area can be summarised as follows:

- In the first four hours, SSC up to 5000mg/l is present within several hundred metres of the activity, reducing to below 2500mg/l within approximately 1km. The plume of elevated SSC may be advected by the tide up to 5km away during spring tides, with concentrations up to 1000mg/l.
- After five hours, a narrow, roughly continuous plume up to 1.5km wide and 5km long has been advected away from original point of activity by between 500m and 3km, with SSC ranging between, approximately, 20mg/l and 500mg/l, although concentrations may locally reach up to 1000mg/l.
- The plume continues to be dispersed and advected along the axis of tidal flow, reducing to below 100mg/l after 15 hours and below 20mg/l after 20 hours.

116. For the ECC installation, the following is demonstrated in the numerical modelling:

- Within the first five hours, SSC between approximately 150mg/l and 500mg/l is present within, approximately, 3km of the activity, although concentrations may reach 2500mg/l. This reduces to between, approximately, 20mg/l to 150mg/l up to, approximately, 5km away, and advected up to 15km away during spring tides. Sediment plumes continue to disperse along the tidal axis, with SSC less than 150mg/l at all points after 20 hours.

Drilling

117. Monopile foundations and pin-piles will be installed into the seabed using standard piling techniques. In some locations, the geology may present some obstacle to piling, in which case, some or all of the seabed material might be drilled within the pile footprint to assist in the piling process. Around 50% of locations within the array area have been estimated to potentially require drilling (for the purposes of the MDS); the presence of chalk is expected in some parts of the array area at around 20m below the seabed, and specifically in the western half of the array area.

118. Numerical modelling results for drilling activities in the western part of the array area where chalk is assumed at a 20m depth below seabed level can be summarised as follows:

- Numerical modelling has simulated drilling at two adjacent locations along the tidal axis in the array area, lasting for 24.5 hours, with overburden lasting for 3.5 hours. Both locations were drilled simultaneously.
- SSC resulting from foundation drilling is minimal, never exceeding 10mg/l. SSC may be advected up to 20km away in low concentrations of less than 7.5mg/l. These concentrations are expected to occur for the full extent of the drilling works, approximately 55 hours, before dispersing. Considering the average near-bed turbidity measurements this change is likely to be indiscernible from background conditions.

8.8.1.2 Impact 1: Deterioration in Water Quality due to Suspension of Sediments

Conceptual Understanding of Change

119. The offshore construction activities presented in Table 8.16 are likely to elevate SSC in the marine environment through the generation of sediment plumes. Increases in SSC and consequently turbidity may reduce the depth to which natural light can penetrate into the water column. This, in turn, may result in a temporary and localised reduction in primary productivity and/or an increase in bacterial growth. The disturbance of the seabed sediments may also result in the release of sediment-bound nutrients, therefore increasing the concentration(s) in the water column.

120. Fish and many other organisms require dissolved oxygen in the water to survive. Dissolved oxygen levels can decrease due to various factors, including rapid temperature and salinity changes, as well as from the respiration of organic matter. Dissolved oxygen levels can also decrease as a reaction to nutrient inputs. When nutrient loading is too high, phytoplankton and/or seaweed can bloom and then die. Bacteria and other decomposer organisms then use oxygen to break down the available organic matter.

121. There are a range of factors which will influence both the magnitude and extent of change in SSC. These include, but are not limited to, the actual total volumes and rates of sediment disturbance, the local water depth and current speed at the time of the activity, the local sediment type and grain size distribution in addition to the local seabed topography and slopes. Due to the wide range of possible combinations of these factors it is not possible to predict specific dimensions with complete certainty. To provide a robust assessment, a range of realistic combinations have been considered within Volume 1, Chapter 7, based on conservatively representative location (environmental) and project specific (MDS) information, including a range of water depths, sediment ejection/initial resuspension heights, and sediment types.

122. In addition to the output from the numerical modelling undertaken for the marine physical processes assessment (Volume 1, Chapter 7; Volume 3, Appendix 7.2, the understanding of the potential increase in suspended sediments due to Project installation activities can be informed by the evidence base regarding marine dredging impacts, specifically sediment plumes (e.g., Cooper and Brew, 2013). Highly concentrated sediment plumes formed of coarser material (sands) will only occur for short-time periods and in the immediate vicinity of the seabed disturbance.

123. Any sediment that is disturbed due to construction activities will be, where possible, re-deposited within the ECC and/or array area in an adjacent seabed area with similar sediment type.

Magnitude of Impact

124. Given that no nutrients are anticipated to be released in concentrations significantly greater than those released during storm events, it is considered that the proposed activities are unlikely to affect phytoplankton abundance or dissolved oxygen levels. The short-term nature of the proposed construction activities is such that any effects will also be temporary in nature.

125. As there are no outfalls or discharges associated with the Project, the proposed activities are not expected to cause a reduction in the dissolved oxygen within the water column. Consequently, no source-receptor-pathways are identified for a deterioration of dissolved oxygen, phytoplankton blooms or eutrophication as a result of the proposed construction activities.

126. The maximum concentration immediately adjacent to the Project works, for the majority of the activities, one day following the activity cessation, is less than 100mg/l (Volume 1, Chapter 7; Volume 3, Appendix 7.2). In accordance with the UKTAG water turbidity ranking (see Tyler-Walters *et al*., 2018), this is classified as intermediate[3]. For the use of TSHD during sandwave clearance activities, the maximum concentration is less than 200mg/l after one day following the cessation of activities, classifying the water as medium[4] according to the UKTAG ranking (Tyler-Walters *et al*., 2018).

127. Bacterial mortality, including *E. coli* and intestinal enterococci, within the water column is strongly influenced by the amount of ultra-violet (UV) light which penetrates the water column; under higher UV scenarios, bacterial mortality is higher. Therefore, any Project activities in the coastal zone which reduce water clarity could result in temporary increases in bacterial counts within the water column due to the decreased bacterial mortality and UV light within the water column. Further, it could result in the potential release of sediment bound bacteria (including *E. coli* and intestinal enterococci). In theory, elevated bacterial counts could cause a deterioration in the water quality and if present at the identified Bathing Waters during the designated bathing season, could theoretically cause a deterioration in their performance classifications (see Table 8.9).

128. Given that these Project activities are temporary and short-lived, and that following cessation of the activities the SSC levels are likely to reach background levels, it is expected that any bacterial increases in the water column would be in the order of days (i.e., occurring for the plume duration only). Following the sediment plumes dispersion, and subsequent increases in UV light, the bacterial counts in the water column will return to "do-nothing" baseline conditions. The resultant decrease in water clarity would be analogous to storm events (see Volume 1, Chapter 7). These potential changes are within the natural variation of the marine environment in the study area during high energy, low frequency events.

129. Project activities which result in sediment disturbance within the array area and offshore ECC are not anticipated to impact on the designated WFD waterbodies (Figure 8.1 (Document Reference 6.2.8.1)). The Project specific numerical modelling indicates that no works undertaken in the array and offshore ECC have measurable changes in SSC within the WFD waterbodies (Volume 1, Chapter 7).

[3] Where intermediate describes the water turbidity as being between 10 and 100mg/l (Tyler-Walters et al., 2018).

[4] Where medium describes the water turbidity as being between 100 and 300mg/l (Tyler-Walters et al., 2018).

130. The SSC elevation and associated decrease in bacterial mortality, would be localised, within the range of natural variability and temporary. The magnitude of these elevated SSC and potential bacterial counts on water quality receptors are considered to be negligible.

Sensitivity of the Receptor

131. The sensitivity of the identified Bathing Waters to the potential for increased bacterial counts is *medium* with a moderate capacity to accommodate the proposed change. The potential for elevated counts resulting from decreased turbidity is within the natural variation.

132. The sensitivity of the Lincolnshire coastal waterbody to the reduction in water clarity is considered to be *low.*

133. The sensitivity of non-designated waters, such as those within the array, is judged to be insensitive to short-term and discrete reductions in water clarity arising from the proposed construction activities. There is no applicable quality status which may be affected by these works. The sensitivity of non-designated waters is judged to be negligible.

Significance of Effects

134. The magnitude of the increases to SSC and associated decrease in bacterial mortality has been assessed as negligible. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: *minor*, which is **not significan**t in terms of the EIA Regulations.
- Lincolnshire coastal waterbody: *negligible* which is **not significant** in terms of the EIA Regulations.
- Non-designated waters: *negligible*, which is **not significant** in terms of the EIA Regulations.

135. No additional mitigation to that already identified in Table 8.17: Embedded mitigation relating to MW&SQ is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of the receptors likely to be impacted as a result of changes to MW&SQ.

8.8.1.3 Impact 2: Release of Sediment-Bound Contaminants from Disturbed Sediments

Conceptual Understanding of Change

136. The construction activities associated with the project have the potential to increase SSC in the marine environment through the generation of sediment plumes, as presented in Table 8.16. Whilst in suspension, there is the potential for sediment-bound contaminants, such as metals, hydrocarbons and organic pollutants, to be released into the water column and lead to an adverse effect on water quality receptors.

Magnitude of Impact

137. Details relating to the sediment contamination levels within the array and ECC are presented in Table 8.10 through to Table 8.14. The project-specific surveys indicated that contamination within the array is generally low:

- AL1 was exceeded for Arsenic and Nickel, but not AL2. TEL was exceeded for Arsenic at all but five stations, but PEL was not exceeded. The TEL for copper and cadmium was exceeded at one station, but not PEL;
- TEL thresholds were exceeded at a single station for acenaphthene and phenanthrene, in addition to the ERL (equivalent to AL1) threshold for LMW PAHs; and
- None of the PAH levels recorded exceeded the US EPA ERL or ERM thresholds.

138. The Project specific surveys indicate that generally the contamination along the ECC are low:

- AL1 was exceeded for Arsenic, Chromium and Nickel, but not AL2. TEL was exceeded for Arsenic and Copper at one station, but PEL was not exceeded;
- TEL, but not PEL, thresholds were exceeded at two stations for Dibenzo(a,h)anthracene, Naphthalene and Phenanthrene. PAH concentrations did not exceed ERL (equivalent to AL1) for either LMW or HMW PAHs; and
- One station had a PAH level that exceeded the US EPA ERL (not ERM) threshold for Fluorene.

139. The tidal regime has been shown to be relatively energetic within both the array and ECC:

- Within the array, modelled flows are, approximately 1.0 to 1.2m/s, with higher values generally towards the southwest (Volume 1, Chapter 7). Current speeds decrease towards the seabed due to drag effects, with annual mean surface and near-bed (1m above bed) current speeds in the centre of the array area modelled at 0.53m/s and 0.34m/s, respectively (MetOceanWorks, 2021a; 2021b; 2021c).
- Along the ECC and closer inshore, current speeds generally increase to between 1.2 and 1.4m/s, reaching over 1.4m/s south of the Inner Silver Pit (Volume 1, Chapter 7). To the south and west of the Inner Silver Pit, tidal flows are oriented north to south, apart from in close proximity to the coast where are they are oriented approximately parallel to the shoreline (MetOceanWorks, 2021c).

140. The energetic tidal currents indicate that the discharge location has no restricted dilution or dispersion. Thus, it is expected that, whilst there may be some contaminant release (noting analysis indicates sediment contamination levels do not exceed respective AL2 or ERM thresholds), this is likely to be rapidly dispersed with the tidal currents. As such, an increase in the bioavailability of the contaminants which could result in any adverse eco-toxicological effects is not expected. This rapid dispersion and dilution are demonstrated through the sediment disturbance assessment undertaken in Volume 1, Chapter 7.

141. Typically, whilst very small sediment-bound contaminant concentrations enter to the dissolved phase, the vast majority remain adhered to the sediment particles when temporarily entering suspension in the water column. It is considered highly unlikely that the Maximum Allowable Concentration (MAC) EQS threshold will be exceeded for any of the substances as a result of disturbing sediment from the proposed activities, given the fates of the plumes.

142. Moreover, given the short-term nature of the works and presence of the sediment plumes, any small uplift in the water concentrations of ESQ substances would be anticipated to return to background levels very quickly (and thus not materially impact any Annual Average (AA) EQS).

143. It should be noted that any activities disturbing sediment within the array area and offshore ECC are not anticipated to impact on the designated WFD waterbodies. The Project specific modelling indicates that no works undertaken in the array or offshore ECC will result in measurable changes in SSC within the WFD water bodies (Volume 1, Chapter 7).

144. The magnitude of this potential impact is considered to be low as a result of the short-term nature of the impact. Furthermore, it is not anticipated that disturbance of sediment-bound contaminants would affect the waterbody's performance (at a waterbody scale) as the potential impacts will be temporary and localised in nature.

Sensitivity of the Receptor

145. The sensitivity of the identified Bathing Waters is considered to be *negligible,* for potential increases in sediment contamination concentrations.

146. The sensitivity of the Lincolnshire coastal waterbody is considered *negligible*, with respect to the release of sediment bound contaminants.

147. The sensitivity of the non-designated waters is judged to be *negligible* with respect to the release of sediment bound contaminants.

Significance of Effects

148. The magnitude of the release of sediment bound contaminants is considered low. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: *negligible*, which is **not significant** in terms of the EIA Regulations.
- Lincolnshire coastal waterbody: *negligible*, which is **not significant** in terms of the EIA Regulations.
- Non-designated waters: *negligible*, which is **not significant** in terms of the EIA Regulations.

8.8.1.4 Impact 3: Deterioration in Water Clarity due to the Release of Drilling Mud

Conceptual Understanding of Change

149. In order to undertake trenchless technique activities and make landfall there will be a requirement to use drilling mud, such as bentonite (or another inert mud). This may result in the release of drilling mud within the subtidal area at the punch out point under the MDS assessed (Table 8.16).

150. Bentonite is a non-toxic, inert, natural clay material with a particle size less than 63µm. It is included in the List of Notified Chemicals approved for use and discharge into the marine environment and is classified as a Group E substance under the Offshore Chemical Notification Scheme. Substances in Group E are defined as the group least likely to cause environmental harm and are “readily biodegradable and non-bioaccumulative”. This is further supported by bentonite being included on the OSPAR List of Substances Used and Discharged Offshore which are considered to Pose Little or No Risk to the Environment (PLONOR).

151. With respect to bentonite release into the water column for receptors likely to be impacted as a result of changes to MW&SQ, the principal concern relates to the potential for an increase in SSC (and so turbidity) within the water column and potential reduction in bacterial mortality. With the exception of the potential for increased turbidity from a bentonite release, no other potential deterioration in water or sediment quality, such as the introduction of contaminants or nutrients, is considered as a consequence of bentonite release.

Magnitude of Impact

152. Bentonite is a clay-based substance and as such may remain in suspension for hours to days following its release, becoming diluted to very low concentrations (indistinguishable from natural background levels and variability). As presented in Volume 1, Chapter 7, the plume will predominately be advected in the direction of the ambient tidal currents, which are broadly aligned to the coast. The transport direction (generally to the south) will depend on the tidal state (flood or ebb) at the time of the release. The bentonite plume is expected to be dispersed to relatively low concentrations within hours of release and to background concentrations within a few tidal cycles.

153. As previously described (Impact 1), there is a relationship between increased turbidity and decreased bacterial mortality within the water column. However, given the predicted dilution levels, punch-out in the subtidal, the temporary nature of the Project activities, and tidal dispersion of the released bentonite, it is expected that any bacterial increases within the water column would be in the order of days. Following the bentonite plume dispersion, and subsequent UV increases, the bacterial counts in the water column will return to "do-nothing" baseline conditions. The resultant decrease in water clarity would be analogous to storm events. Therefore, these potential changes are considered to remain within the natural variation of the marine environment.

154. The increased SSC and potential decrease in bacterial mortality which may result from the release of inert drilling mud, such as bentonite, is expected to be localised, within the range of natural variability and temporary. The magnitude of these elevated concentrations and potential bacterial counts on water quality receptors are considered to be *low.*

Sensitivity of the Receptor

155. The sensitivity of the identified Bathing Waters, to the potential for increased bacterial counts is *medium* with a moderate capacity to accommodate the proposed change. The potential for elevated counts resulting from decreased turbidity are within the natural variation.

156. The sensitivity of the Lincolnshire coastal waterbody to the reduction in water clarity is considered to be *low*; these elevated concentrations would occur over time periods in the order of days and are within natural variation of the waterbody.

157. With respect to the sensitivity of non-designated waters, for example those within the array area, are judged to be insensitive to short-term and discrete reductions in water clarity. There is also no applicable quality status which may be affected by these works. The sensitivity of non-designated waters is judged to be negligible.

Significance of Effects

158. The magnitude of the increases to SSC, associated with the release of inert drilling mud, and associated decrease in bacterial mortality has been assessed as low. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: *minor*, which is **not significant** in terms of the EIA Regulations.
- Lincolnshire coastal waterbody: *minor*, which is **not significant** in terms of the EIA Regulations.
- Non-designated waters: *negligible*, which is **not significant** in terms of the EIA Regulations.

8.8.2 Operations and Maintenance

159. The effects of the Project activities within the O&M phase have been assessed upon receptors likely to be impacted by changes to MW&SQ within the Project's MW&SQ study area (Figure 8.1 (Document Reference 6.2.8.1)). The potentially scoped in environmental impacts arising from the O&M phase are listed in Table 8.16, along with the project design envelope against which each O&M phase impact has been assessed.

160. A description of the significance of effect upon the receptors likely to be impacted by changes to MW&SQ caused by each identified impact is provided below.

8.8.2.1 Impact 4: Deterioration in Water Quality due to Suspension of Sediments from O&M Activities

Conceptual Understanding of Change

161. Should a section of the cable become exposed or damaged it would require reburial and/or replacement (Table 8.16). Reburial (and/or replacement) would be undertaken using similar techniques to those set out in the assessment of SSC and bed level changes associated with cable installation activities (see Volume 1, Chapter 7). The lengths of exposed/damaged cable would be shorter and the potential impacts would consequently be more localised and occur over a shorter duration than those considered during the construction phase. Consideration has been afforded to those O&M project activities which have created the greatest change (increase) in suspended sediments, as assessed by Volume 1, Chapter 7, and thus the assessment is in accordance with the MDS approach (Table 8.16). Smaller scale O&M project activities including the use of jack-up vessels are considered to result in a smaller increase in suspended sediments over a shorter period of time compared to construction activities.

162. Any O&M activities which are undertaken in the array are considered highly unlikely to impact on the designated WFD waterbody, as presented in the assessment undertaken in Volume 1, Chapter 7.

Magnitude of Impact

163. The magnitude (and so significance) of the effects on water quality resulting from O&M activities would be no greater than those assessed in Impact 1. Therefore, the magnitude of the impact is considered to be negligible for the potential deterioration in water quality.

Sensitivity of the Receptor

164. The sensitivity of the identified Bathing Waters to the potential for increased bacterial counts is medium with a moderate capacity to accommodate the proposed change. The potential for elevated counts resulting from decreased turbidity with are within the natural variation.

165. The sensitivity of the Lincolnshire coastal waterbody to the reduction in water clarity is considered to be low.

166. The sensitivity of non-designated waters, such as those within the array, are judged to be insensitive to short-term and discrete reductions in water clarity, arising from the proposed construction activities. There is no applicable quality status which may be affected by these works. The sensitivity of non-designated waters is judged to be negligible.

Significance of Effects

167. The magnitude of the increases to SSC and associated decrease in bacterial mortality has been assessed as negligible. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: *minor*, which is **not significant** in terms of the EIA Regulations.
- Lincolnshire coastal waterbody: *negligible*, which is **not significant** in terms of the EIA Regulations.
- Non-designated waters: *negligible*, which is **not significant** in terms of the EIA Regulations.

168. No additional mitigation to that already identified in Table 8.17 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of the receptors likely to be impacted as a result of changes to MW&SQ.

8.8.3 Decommissioning

169. The effects of the Project's decommissioning activities have been assessed on the receptors likely to be impacted by changes to MW&SQ within the MW&SQ study area (Figure 8.1 (Document Reference 6.2.8.1)). The scoped in environmental impacts arising from decommissioning the Project are listed in Table 8.16 along with the project design envelope against which each decommissioning phase impact has been assessed.

170. As presented in Table 8.16, the nature and extent of the environmental impacts arising during decommissioning is assumed (for the purposes of this assessment) to be similar to that described for the equivalent activities during the construction phase. Therefore impacts during decommissioning have been assessed based on the WC construction impacts.

8.8.3.1 Impact 5: Deterioration in Water Quality due to Re-Suspension of Sediments

171. As presented in Table 8.16, the Project infrastructure will be decommissioned in accordance with the decommissioning plan, also taking account of best environmental practice/options at the time. For the purposes of undertaking this MDS assessment, it is assumed that the decommissioning phase of works is a reverse of the construction process, however it may be that some of the seabed infrastructure, for example the subsea cables, can remain *in situ*.

Magnitude of Impact

172. Impacts arising from decommissioning activities are considered to be similar, or less, than those which occur during construction. Therefore, the magnitude of the impact is considered to be negligible for potential changes in water quality (clarity; microbiology; sediment-bound contaminant release).

Sensitivity of the Receptor

173. The sensitivity of the identified Bathing Waters to the potential for reductions in water quality is medium with a moderate capacity to accommodate the change within the natural variation.

174. The Lincolnshire coastal water body's sensitivity to the water quality reduction is considered to be *low.*

175. The sensitivity of non-designated waters, for example those within the array, are considered to be low to the short-term and localised reductions in water quality. There is no applicable water quality status which may be affected by these Project activities. As such, the sensitivity of non-designated waters is assessed to be *negligible*.

Significance of Effects

176. The magnitude of increases to suspended sediments and the associated reduction in bacterial mortality has been assessed as negligible. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: *minor*, which is not significant in terms of the EIA Regulations.
- Lincolnshire coastal waterbody: *negligible*, which is **not significant** in terms of the EIA Regulations.
- Non-designated waters: *negligible*, which is **not significant** in terms of the EIA Regulations.

177. No additional mitigation to that already identified in Table 8.17 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of the receptors likely to be impacted by changes to MW&SQ.

8.9 Cumulative Impact Assessment

8.9.1 Identification of Other Plans and Projects

178. This cumulative impact assessment for MW&SQ has been undertaken in accordance with the methodology provided in Volume 3, Appendix 5.1: Offshore Cumulative Impact Assessment.

179. The projects and plans selected as relevant to the assessment of impacts to MW&SQ are based upon an initial screening exercise undertaken on a long list. Each project, plan or activity has been considered and scoped in or out on the basis of effect-receptor pathway, data confidence and the temporal and spatial scales involved. For the purposes of assessing the impact of the Project on MW&SQ in the region, the Cumulative Effects Assessment Technical Note submitted through the EPP and forming Volume 3, Appendix 5.1 screened in a number of projects and plans as presented in Table 8.21 and illustrated in Figure 8.4 (Document Reference 6.2.8.4).

180. The cumulative MDS for the Project is outlined in Table 8.22.

Table 8.17: Projects considered within the MW&SQ cumulative effects assessment

Development type	Project	Status	Data confidence assessment/phase	Tier
Offshore windfarm Export Cable	Race Bank OFTO	Active/In Operation	High - Third party project details published in the public domain and confirmed as being 'accurate' by the Crown Estate	Tier 1
	Lincs OFTO			
	Lynn			
	Inner Dowsing			
	Lincs			
	Triton Knoll			
	Hornsea 1 OFTO			
	Hornsea Project 2 OFTO			
Interconnector	Viking Link	Complete/In operation	High - Third party project details published in the public domain and confirmed as being 'accurate' by the Crown Estate	Tier 1
Offshore Energy	Dudgeon	Active/In Operation	High - Third party project details published in the public domain and confirmed as being 'accurate' by the Crown Estate	Tier 1
	Dudgeon Extension	Under Examination		
Pipeline	Gas Shearwater to Bacton Seal Line	Active/In Operation	High - Third party project details published in the public domain and confirmed as being 'accurate' by the Crown Estate	Tier 1
	Malory to Galahad Tee Gas Export			
	Gas Barque PB to Clipper PT			
	Excalibur to Lancelot Tee Gas Export			
	Esmond to Bacton Gas Export Line			
	Gas Barque PL to Clipper PM			

Development type	Project	Status	Data confidence assessment/phase	Tier
	Meg Clipper PM to Barque PL			
	Newsham to West Sole Gas Line			
	West sole to Easington Gas Line			
	Seven Seas to Newsham Gas Export			
	Lancelot to Bacton Gas Export			
	West sole to Easington Gas Line			
	Hyde to West Sole Bravo Gas Line			
	Babbage export top West Sole			
	Waveney to Lancelot Gas Line			
	Meg Clipper PR to Carrack QA			
	Gas Export Carrack QA to Clipper PR			
	Gas Clipper PT to Bacton			
	Glycol Bacton to Clipper PT			
Aggregate Production and Disposal Area	Outer Dowsing Westminster Gravels (515/1)	Operation	High - Third party project details published in the public domain and confirmed as being 'accurate' by the Crown Estate	Tier 1
	Outer Dowsing Westminster Gravels (515/2)			
	Humber Estuary Hanson Aggregates Marine Ltd (106/1)			
	Humber Estuary Hanson Aggregates Marine Ltd (106/2)			
	Humber Estuary Hanson Aggregates Marine Ltd (106/3)			
	Humber Estuary Hanson Aggregates Marine Ltd (400)			

Development type	Project	Status	Data confidence assessment/phase	Tier
	Off Saltfleet Tarmac Marine Ltd (197)			
	Humber Overfalls Tarmac Marine Ltd (493)			
	Inner Dowsing Tarmac Marine Ltd and Van Oord (481/1)			
	Inner Dowsing Tarmac Marine Ltd and Van Oord (481/2)			
	Hanson Aggregates Marine Ltd (1805)			
	Hornsea Disposal Area 1			
Oil and Gas		Active	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'	Tier 1
	Galahad (platform)			
	Malory (platform)			
	Barque PB (platform)			
	Excaliber EA (platform)			
	Barque PL (platform)			
	West Sole A (6 leg) (platform)			
	West Sole A (8 leg) (platform)			
	West Sole A pp (platform)			
	West Sole A SP (platform)			
	Amethyst B1D (platform)			
	Lancelot A (platform)			
	West Sole B (platform)			
	West Sole C (platform)			
	Waveney StepOutTee (pipe junction)			
	Clipper PH (platform)			
	Clipper PW (platform)			
	Clipper PT (platform)			
	Clipper PC (platform)			
	West Sole C (platform)			
	Clipper PR (platform)			
	Clipper PM (platform)			
	Waveney			
	Pickerill B (platform)	Decommissioning		

Development type	Project	Status	Data confidence assessment/phase	Tier
	Pickerill A (platform)			
	Guinevere A (platform)			

Table 8.18: Cumulative MDS for MW&SQ

Impact	Scenario	Justification
Impact 6: Cumulative effects resulting in the deterioration in water quality from the suspension of sediments	Tier 1: ▪ Offshore windfarm Export Cable (O&M activities) ▪ Pipeline (O&M activities) ▪ Aggregate Production Area (aggregate extraction) ▪ Sea Disposal Site (sediment disposal) ▪ Oil and Gas (O&M activities, including decommissioning)	If these intermittent activities overlap temporally with either the construction or O&M of the Project, there is potential for cumulative SSC and sediment deposition to occur within the modelled plume footprints.

8.9.1.1 Impact 6: Cumulative Effects Resulting in the Deterioration in Water Quality due to Re-Suspension of Sediments

181. Due to uncertainty associated with the exact (day/month) timings of other plans and projects, there are insufficient data on either project scale or timings on which to undertake a quantitative or semi-quantitative assessment. As such, the discussion presented here is qualitative. It is considered highly unlikely that each of the identified projects would require routine maintenance work, in particular asset reburial or repairs, as these are infrequent occurrences during the lifetime of such developments.

182. A detailed cumulative assessment for the temporary increase in SSC (and associated deposition) resulting from this Project and others within the study area is presented in Volume 1, Chapter 7. Given the high levels of sediment dispersion as demonstrated by the Project specific sediment assessment, alongside the location (Figure 8.4 (Document Reference 6.2.8.4)) of the majority of the other projects, there is not anticipated to be a notable overlap with concentrated sediment plumes created from other industry and offshore windfarm activities. As shown in Figure 8.4, there is one aggregate site (1805; Table 8.21) which overlaps with the ECC. This aggregate site is currently in application and as such, there are no confirmed programme details. Based on published aggregate extraction information, only 12.84% of the entire East Coast licensed area was dredged in 2020, with 0.39km^2 of the total area being dredged at a high intensity (for more than one hour 15 minutes) (BMAPA and The Crown Estate, 2020). The probability for both activities (aggregate extraction and ECC cable installation) occurring at the same time, and of a close enough proximity that the tidal excursions and thus sediment plumes overlap, is therefore considered extremely low.

183. In addition, and in line with The United Nations Convention on the Law of the Sea (UNCLOS), cable installation vessels typically request a one nautical mile (c. 1.85km) area of avoidance when installing or handling cables.

184. Sediment plumes generated by other projects considered here are anticipated to behave in a similar pattern as the sediments being disturbed for the Project due to expected similarities in operational design combined with a similar environmental setting and sediment characteristics. The potential increases in SSC, when considered cumulatively, are still anticipated to be within the natural variation within the MW&SQ study area. Therefore the potential cumulative effects on water quality and thus microbial growth are deemed to be comparable to the Project alone and as such are considered not significant in terms of the EIA Regulations. No additional mitigation to that already identified in Table 8.17 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of the receptors likely to be impacted as a result of changes to MW&SQ.

8.10 Inter-Relationships

185. Inter-relationships are those impacts and associated effects of different aspects of the proposed Project upon the same receptor. These can be identified as:

- 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, etc., may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects may be short-term, temporary or transient but may also incorporate longer term effects.
- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, O&M 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 (for example subsea noise effects from piling, operational WTGs, vessels and decommissioning).

186. The potential inter-relationships which are relevant to this MW&SQ assessment are presented in Table 8.23.

Table 8.19: MW&SQ Inter-Relationships

Potential effect	Related chapter	Consideration within ES	Rationale
Construction			
Deterioration in water quality due to suspension of sediments	▪ Volume 1, Chapter 9: Benthic Subtidal and Intertidal Ecology ▪ Volume 1, Chapter 10: Fish and Shellfish Ecology ▪ Volume 1, Chapter 14: Commercial Fisheries	Section 8.8 (Foundation installation; cable (inter-array; export) installation).	Benthic communities and fish species could be adversely affected by increased suspended sediment concentrations.
Release of sediment-bound contaminants from disturbed sediments	▪ Volume 1, Chapter 9: Benthic Subtidal and Intertidal Ecology ▪ Volume 1, Chapter 10: Fish and Shellfish Ecology ▪ Volume 1, Chapter 14: Commercial Fisheries		Benthic communities and fish species could be adversely affected by the release of sediment-bound contaminants.
Deterioration in water clarity due to the release of drilling mud	▪ Volume 1, Chapter 9: Benthic Subtidal and Intertidal Ecology ▪ Volume 1, Chapter 10: Fish and Shellfish Ecology		Benthic communities and fish species could be adversely affected by the reduced water clarity and bacterial mortality.
Operation and Maintenance			
Deterioration in water quality due to suspension of sediments from O&M activities	▪ Volume 1, Chapter 9: Benthic Subtidal and Intertidal Ecology ▪ Volume 1, Chapter 10: Fish and Shellfish Ecology ▪ Volume 1, Chapter 14: Commercial Fisheries	Section 8.8 (Cable (inter-array; interlink; export) maintenance and repair)	Benthic communities and fish species could be adversely affected by increased suspended sediment concentrations.
Decommissioning			
Deterioration in water quality due to re-suspension of sediments	▪ Volume 1, Chapter 9: Benthic Subtidal and Intertidal Ecology ▪ Volume 1, Chapter 10: Fish and Shellfish Ecology ▪ Volume 1, Chapter 14: Commercial Fisheries	Section 8.8 (Foundation removal; cable (inter-array; interlink; export) removal).	Benthic communities and fish species could be adversely affected by increased suspended sediment concentrations.

8.11 Transboundary Effects

187. Transboundary effects have been scoped out with none predicted to result from the construction, O&M nor decommissioning phases of the proposed Project with respect to the receptors likely to be impacted by changes to MW&SQ.

188. No significant transboundary effects are predicted for MW&SQ and as such an assessment of transboundary effects is not considered necessary in this chapter.

8.12 Conclusions

189. This ES chapter has investigated the potential effects upon the receptors likely to be impacted as a result of changes to MW&SQ arising from the Project. The range of potential impacts and associated effects has been informed by the Scoping Opinion and consultation responses (including those submitted during the EPP) from stakeholders, alongside reference to existing legislation and guidance.

190. The potential for the Project to interact directly and indirectly with receptors likely to be impacted as a result of changes to MW&SQ is presented for the proposed development alone and cumulatively with other projects within the ZoI. These potential impacts have been investigated using a combination of methods including analytical techniques, the existing evidence base and project specific sediment plume modelling. In accordance with the requirements of the MDS approach to EIA, the WCS potential effects of the Project have been considered thereby providing a highly conservative assessment.

191. A summary of the effects of the proposed development during construction, O&M and decommissioning phases on MW&SQ are presented in Table 8.20.

Table 8.20: Summary of Potential Impacts on MW&SQ

Description of effect	Effect	Additional mitigation measures	Residual impact
Construction			
Deterioration in water quality due to suspension of sediments	Minor significance of effect (at worst)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Release of sediment-bound contaminants from disturbed sediments	Negligible significance of effect (at worst)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Deterioration in water clarity due to the release of drilling mud	Minor significance of effect (at worst)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Operation and Maintenance			
Deterioration in water quality due to suspension of sediments from O&M activities	Minor significance of effect (at worst)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Decommissioning			
Deterioration in water quality due to re-suspension of sediments	Minor significance of effect (at worst)	Not Applicable – no additional mitigation identified	No significant adverse residual effects
Cumulative			
Impact 6: Cumulative effects resulting in the deterioration in water quality from the suspension of sediments	Minor significance of effect (at worst)	Not Applicable – no additional mitigation identified	No significant adverse residual effects

8.13 References

BMAPA and The Crown Estate, 2020. The area involved – 23rd annual report. Marine aggregate extraction 2020. https://www.bmapa.org/documents/23rd-Area-of_Seabed-Dredged-Report-2021.pdf. [Accessed February 2023].

Centre for Environment, Fisheries and Aquaculture Science (Cefas). (2016). Sediment Climatologies around the UK. Report for the BEIS Offshore Energy Strategic Environmental Assessment (OESEA) programme.

Cooper, N.J. and Brew, D.S. (2013). Impacts on the Physical Environment. In: Aggregate Dredging and the Marine Environment.

Department for Environment, Food and Rural Affairs (Defra). (2022). Official Statistics. 2022 Statistics on English coastal and inland bathing waters: A summary of compliance with the 2013 bathing water regulations. Updated 30 November 2022. https://www.gov.uk/government/statistics/bathing-water-quality-statistics/2022-statistics-on-english-coastal-and-inland-bathing-waters-a-summary-of-compliance-with-the-2013-bathing-water-regulations--2 [Accessed January 2023].

Department for Energy Security and Net Zero (DESNZ). (2023a). Overarching National Policy Statement for Energy (EN-1). https://www.gov.uk/government/publications/overarching-national-policy-statement-for-energy-en-1 [Accessed February 2024].

Department for Energy Security and Net Zero (DESNZ). (2023b). National Policy Statement for Renewable Energy Infrastructure (EN-3). https://www.gov.uk/government/publications/national-policy-statement-for-renewable-energy-infrastructure-en-3 [Accessed February 2024].

Department for Energy Security and Net Zero (DESNZ). (2023c). National Policy Statement for Electricity Networks Infrastructure (EN-5). https://www.gov.uk/government/publications/national-policy-statement-for-electricity-networks-infrastructure-en-5 [Accessed February 2024].

Environment Agency. (2019). Polycyclic aromatic hydrocarbons (PAHs): sources, pathways and environmental data. https://consult.environment-agency.gov.uk/++preview++/environment-and-business/challenges-and-choices/user_uploads/polycyclic-aromatic-hydrocarbons-rbmp-2021.pdf [Accessed January 2023]

Environment Agency. (2019). Polycyclic aromatic hydrocarbons (PAHs): sources, pathways and environmental data. https://consult.environment-agency.gov.uk/++preview++/environment-and-business/challenges-and-choices/user_uploads/polycyclic-aromatic-hydrocarbons-rbmp-2021.pdf [Accessed January 2023].

Environment Agency. (2021). Nitrate Vulnerable Zone designations 2021 – 2024. https://environment.data.gov.uk/dataset/60be356d-6475-4d51-9572-9f8c09f1a764. [Accessed January 2023].

Environment Agency. (2022). River basin management plan for the Anglian River Basin District: Habitats Regulations Assessment.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1112555/Anglian_river_basin_management_plan_2022_HRA.pdf [Accessed January 2023].

Fugro, 2022. Turbidity data collected from Floating LiDAR.

Gohin, F. (2011). Annual cycles of chlorophyll-*a*, non-algal suspended particulate matter, and turbidity observed from space and *in-situ* in coastal waters. Ocean Science 7: 705-732.

Gorham-Test, C., Wade, T., Engle, V., Summers, K. and Hornig, E. (1999). Regional Environmental Monitoring and Assessment Program — Galveston Bay 1993. Proceedings, Galveston Bay Estuary Program, State of the Bay Symposium IV, January 28–29, Galveston, TX, 97–109.

HM Government. (2011). UK Marine Policy Statement. HM Government, Northern Ireland Executive, Scottish Government, Welsh Assembly Government. March 2011. https://www.gov.uk/government/publications/uk-marine-policy-statement [Accessed January 2023].

MetOceanWorks. (2021a). Outer Dowsing Offshore Wind Farm: Metocean Design Criteria. Location: CENTRAL. Commercial in Confidence.

MetOceanWorks. (2021b). Outer Dowsing Offshore Wind Farm: Metocean Design Criteria. Location: EAST. Commercial in Confidence.

MetOceanWorks. (2021c). Metocean Data Overview: Outer Dowsing Offshore Wind Farm. Commercial in Confidence.

MMO. (2022). Marine Licensing: sediment analysis and sample plans. https://www.gov.uk/guidance/marine-licensing-sediment-analysis-and-sample-plans [Accessed January 2023].

Orsted. (2021). Hornsea Project Four: Environmental Statement (ES). Planning Inspectorate Document Reference: A2.2. APFP Regulation: 5(2)(a). Volume A2, Chapter 2: Benthic and Intertidal Ecology.

OSPAR Commission. (2017). Intermediate assessment quality status report. Available from https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/ [Accessed January 2023].

OSPAR Commission. (2022). Levels and trends in marine contaminants and their biological effects – CEMP Assessment report 2022. Available from https://oap.ospar.org/en/ospar-assessments/committee-assessments/hazardous-substances-and-eutrophication/mime/cemp-levels-and-trends-marine-contaminants/cemp-2022/ [Accessed January 2023].

Royal HaskoningDHV. (2021). Dudgeon and Sheringham Shoal Offshore Wind Farm Extensions Preliminary Environmental Information Report (PEIR). Chapter 9 – Marine water and sediment quality. April 2021.

The Planning Inspectorate. (2018). Advice Note Nine: Rochdale Envelope. https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-nine-rochdale-envelope/ [accessed January 2023].

The Planning Inspectorate. (2022). Scoping Opinion: Proposed Outer Dowsing Offshore Wind. Case Reference: EN010130. 09 September 2022.

Thewes, D., Stanev, E.V. and Zielinski, O. (2022). Steps towards modelling the past and future North Sea ecosystem with a focus on light climate. Frontiers in Marine Science 9: 818383.

Tyler-Walters, H., Tillin, H.M., d'Avack, E.A.S., Perry, F. and 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. https://www.marlin.ac.uk/publications [Accessed January 2023].

UK Marine Monitoring and Assessment Strategy (UKMMAS). (2010). Charting Progress 2: The state of UK seas. https://tethys.pnnl.gov/sites/default/files/publications/UKMMAS_2010_Charting_Progress_2.pdf. [Accessed January 2023].

van der Molen, J., Aldridge, J., Coughlan, C., Parker, E., Stephens, D. and Ruardij, P. (2013). Modelling marine ecosystem response to climate change and trawling in the North Sea. Biogeochemistry 113: 213 – 236.