FIVE ESTUARIES
OFFSHORE WIND FARM

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PRELIMINARY ENVIRONMENTAL INFORMATION REPORT

VOLUME 2, CHAPTER 3: MARINE WATER AND SEDIMENT QUALITY

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DEFINITION OF ACRONYMS

Term	Definition
BAC	Background Assessment Concentration
BEIS	Department for Business, Energy and Industrial Strategy
C. edule	*Cerastoderma edule*
C. gigas	*Crassostrea gigas*
CAL1	Cefas Guideline Action Level 1
CAL2	Cefas Guideline Action Level 2
CBRA	Cable Burial Risk Assessment
CD	Chart Datum
CEA	Cumulative Effects Assessment
CSIP	Cable Specification and Installation Plan
DBT	Dibutyltin
DCO	Development Consent Order
DDT	Dichlorodiphenyltrichloroethane
DECC	Department for Energy and Climate Change
E. coli	*Escherichia coli*
EA	Environment Agency
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
EQS	Environmental Quality Standard
EQSD	Environmental Quality Standards Directive
ERL	Effects Range Lower
EU	European Union
GWD	Groundwater Directive
HMW	High Molecular Weight
HRA	Habitats Regulation Assessment
IE	Intestinal Enterococci
LMW	Low Molecular Weight
LoD	Limit of Detection
LSE	Likely Significant Effect

Term	Definition
MDS	Maximum Design Scenario
MHWS	Mean High Water Springs
MPCP	Marine Pollution Contingency Plan
MW&SQ	Marine Water and Sediment Quality
NPS	National Policy Statement
O. edulis	*Ostrea edulis*
O&M	Operation and Maintenance
OCP	Organochlorine Pesticides
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PEIR	Preliminary Environmental Information Report
PEL	Probable Effect Level
PEMP	Project Environmental Management Plan
PINS	Planning Inspectorate
PSA	Particle Size Analysis
rBWD	revised Bathing Water Directive
RIAA	Report to Inform Appropriate Assessment
RLB	Red Line Boundary
SAC	Special Area of Conservation
SoS	Secretary of State
SPM	Suspended Particulate Matter
SPP	Scour Protection Plan
SQG	Sediment Quality Guidelines
SSC	Suspended Sediment Concentrations
TBT	Tributyltin
TEL	Threshold Effect Level
THC	Total Hydrocarbon Concentration
UKMMAS	UK Marine Monitoring and Assessment Strategy
UNCLOS	The United Nations Convention on the Law of the Sea
UWWTD	Urban Waste Water Treatment Directive
VE	Five Estuaries Offshore Wind Farm

Term	Definition
WFD	Water Framework Directive
WTG	Wind Turbine Generator
ZoI	Zone of Influence

GLOSSARY OF TERMS

Term	Definition
Array areas	The areas where the wind turbines will be located
Array cables	Cables which connect the wind turbines to each other and to the offshore substation(s)
Cumulative effects	The combined effect of Five Estuaries Offshore Wind Farm (VE) in combination with the effects from 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 VE.
Design Envelope	A description of the range of possible elements that make up the Five Estuaries design options under consideration, as set out in detail in the project description. This envelope is used to define Five Estuaries for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
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 Directive and EIA Regulations, including the publication of an Environmental Statement.
Environmental Statement (ES)	The documents that collate the processes and results of the EIA.
Export cables	Cables that transfer power from the offshore substation(s) or the converter station(s) to shore.
Export cable corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Five Estuaries array area to the proposed substation areas, within which the export cables) will be located.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial, resulting from the activities associated with the construction, operation and maintenance, or decommissioning of the project.
Interconnector cables	Cables that may be required to interconnect the offshore substations in order to provide redundancy in the case of cable failure elsewhere, or to connect to the offshore accommodation platforms in order to provide power for operation.

Intertidal	The area of the shoreline which is covered at high tide and uncovered at low tide.
Marine Water and Sediment Quality (MW&SQ)	Encompasses the study of physical and chemical properties of water and sediment in the marine environment (distinct from freshwater environments). MW&SQ can be considered a receptor in its own right (e.g., measured against standards for dissolved oxygen levels, suspended sediments, contaminant concentrations), but can also influence other receptors (e.g., changes in MW&SQ impacting benthic ecology, fish and shellfish ecology, marine mammals, etc.).
Maximum design scenario (MDS)	The maximum design parameters of each asset (both on and offshore) considered to be a worst case for any given assessment.
Mitigation	A term used interchangeably with Commitment(s) by VE. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g., at Scoping, PEIR or ES).
Neap tides	Tides with the smallest range between high and low water, occurring at the first and third quarters of the moon.
Offshore substation(s)	One or more offshore substations to convert the power to higher voltages and/or to HVDC and transmit this power to shore.
Planning Inspectorate (PINS)	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
Preliminary Environmental Information Report (PEIR)	The PEIR is written in the style of a draft Environmental Statement (ES) and forms the basis of statutory consultation. Following that consultation, the PEIR documentation will be updated into the final ES that will accompany the application for the Development Consent Order (DCO).
Scour	Local erosion of sediments caused by local flow acceleration around an obstacle and associated turbulence enhancement.
Scour and cable protection	In order to prevent seabed scour around foundation structures and cables, cable protection may be placed on the seabed to protect from current and wave action.
Sediment	Particulate matter derived from rock, minerals or bioclastic debris.
Spring tides	Tides with the greatest range which occur at or just after the new and full moon.
Subtidal	The region of shallow waters which are below the level of low tide.
Surficial sediments	Sediments located at the seabed surface (not necessarily of the same character as underlying sediments).
Tidal excursion	The Lagrangian movement (the physics of fluid motion as an individual fluid parcel moves through space and time) of a water particle during a tidal cycle.
Tidal excursion ellipse	The path followed by a water particle in one complete tidal cycle.
Tide	The periodic rise and fall in the level of the water in oceans and seas; the result of gravitational attraction of the sun and moon.
Wind turbine	All of the components of a wind turbine, including the tower, nacelle, and rotor.

Wind turbine foundation	The wind turbines are attached to the seabed with a foundation structure typically fabricated from steel or concrete.

3 MARINE WATER AND SEDIMENT QUALITY

3.1 INTRODUCTION

3.1.1 This chapter has been prepared by GoBe Consultants Ltd and presents an assessment of the potential effects on Marine Water and Sediment Quality (MW&SQ) of the offshore works (including construction, Operation and Maintenance (O&M) and decommissioning) associated with the Five Estuaries Offshore Wind Farm (hereafter referred to as VE), on behalf of Five Estuaries Offshore Windfarm Limited (VE OWFL).

3.1.2 This chapter has been informed by the following Preliminary Environmental Information Report (PEIR) chapters and annexes:

- Volume 2, Chapter 1: Offshore Project Description;
- Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes;
- Volume 4, Annex 2.1: Physical Processes Technical Baseline Report;
- Volume 4, Annex 2.3: Physical Processes Modelling Results Report;
- Volume 2, Chapter 5: Benthic and Intertidal Ecology;
- Volume 4, Annex 5.1: Benthic Ecology Subtidal Characterisation (Array);
- Volume 5, Annex 5.2: Benthic Ecology Subtidal Characterisation (Offshore ECC and Intertidal);
- Volume 2, Chapter 6: Fish and Shellfish Ecology; and
- Volume 7, Report 5: Water Framework Directive Compliance Assessment.

3.2 STATUTORY AND POLICY CONTEXT

3.2.1 This section identifies legislation and national and local policy of relevance to MW&SQ. The Marine Works (Environmental Impact Assessment) Regulations 2007 (as amended) and the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (collectively referred to as the 'the EIA Regulations') are considered in addition to legislation and policy specific to MW&SQ.

3.2.2 The following section provides information regarding the legislative and policy context surrounding the assessment of potential effects in relation to the MW&SQ. Full details of all policy and legislation relevant to the VE application are provided in Volume 1, Chapter 2: Policy and Legislation. A summary of the key provisions of relevance to this assessment is provided in Table 3.1.

Table 3.1: Legislation and policy context.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
The Overarching National Policy Statement (NPS) for Energy (NPS EN-1) (Department for Energy and Climate Change (DECR), 2011a)	Paragraph 5.15.1 states: *"Infrastructure development can have adverse effects on the water environment, including groundwater, inland surface waters, transitional waters and coastal waters. During the construction, operation and decommissioning phases, discharges would occur. 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 and could, in particular, result in surface waters, ground waters of protected areas failing to meet environmental objectives established under the Water Framework Directive (WFD)".*	Sections 0 to 0 of this chapter present the assessment of the proposed development on MW&SQ receptors. Specifically, the risk of accidental releases and spills of materials is assessed for each phase of the project explicitly.
	Paragraph 5.15.2 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*".	Sections 3.10 to 3.13 of this chapter present the assessment of the proposed development on MW&SQ receptors. An assessment of the physical characteristics is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes. An assessment of freshwater resources and quality is presented in Volume 3, Chapter 6: Hydrology and Flood Risk.
Draft revised Overarching NPS EN-1 (Department for Business, Energy and Industrial Strategy (BEIS), 2021a)	Paragraph 5.16.1 states: *"Infrastructure development can have adverse effects on the water environment, including groundwater, inland surface waters, transitional waters and coastal waters. During the construction, operation and decommissioning phases, it can lead to increased demand for water, involve*	Sections 3.10 to 3.13 of this chapter present the assessment of the proposed development on MW&SQ receptors. Specifically, the risk of accidental releases and spills of materials is assessed for each phase of the project explicitly.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	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 and could, in particular, result in surface waters, groundwaters of 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".	
	Paragraph 5.16.2 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*".	Sections 3.10 to 3.13 of this chapter present the assessment of the proposed development on MW&SQ receptors. An assessment of the physical characteristics is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes. An assessment of freshwater resources and quality is presented in Volume 3, Chapter 6: Hydrology and Flood Risk.
	Paragraph 5.16.5 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 3.7 of this chapter. An assessment of the potential impacts of the Project upon water quality is provided in Sections 3.10 to 3.13 of this chapter.
	Paragraph 5.16.12 states: "*The risk of impacts on the water environment can be reduced through*	An outline Project Environmental Management Plan (PEMP) will be submitted with the DCO

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	careful design to facilitate adherence to good pollution control practice"	Application, which will detail best practice and embedded mitigation measures that will ensure good pollution control practice.
The NPS for Renewable Energy Infrastructure (NPS EN-3) (DECR, 2011b)	Paragraph 2.6.191 states: *"The Environment Agency regulates emissions to land, air and water out to 3 nautical miles (nm). Where any element of the wind farm or any associated development included in the application to the Infrastructure Planning Commission (IPC) (now the Planning Inspectorate) is located within 3 nm of the coast, the Environment Agency should be consulted at the pre-application stage on the assessment methodology for impacts on the physical environment"*	VE OWFL has sought consultation with the Environment Agency as part of the Evidence Plan Process (EPP) and in ETG meetings on the subject of MW&SQ pre-scoping and on the submission of the Scoping Report. The full suite of Scoping Opinions is presented in Table 3.2 of this chapter.
	Paragraph 2.6.192 states: *"Beyond 3 nm the Marine Management Organisation (MMO) is the regulator. The applicant should consult the MMO and Centre for Environment, Fisheries and Aquaculture Science (Cefas) on the assessment methodology for impacts on the physical environment at the pre-application stage"*	VE OWFL has undertaken consultation with the MMO and Cefas through the EPP and ETG meetings in order to agree methodologies and data sources. The full suite of Scoping Opinions is presented in Table 3.2 of this chapter.
	Paragraph 2.6.189 states: *"The construction, operation and decommissioning of offshore energy infrastructure (including the preparation an installation of the cable route, as noted in the Draft [revised] NPS EN-3) 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 the release of contaminants can result in indirect effects on habitats and biodiversity and fish stocks thus affecting the fishing industry".*	As assessment of the disturbance of sediments and the potential risks is provided in Sections 3.10 to 3.13 of this chapter. The indirect effects on benthic ecology, fish ecology and habitats are provided in Volume 2, Chapter 5: Benthic and Intertidal Ecology; Volume 2, Chapter 6: Fish and Shellfish and the Report to Inform Appropriate Assessment (RIAA).

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
Draft revised NPS for Renewable Energy Infrastructure EN-3 (BEIS, 2021b)	Paragraph 2.25.1 states: *"The construction, operation and decommissioning of offshore energy infrastructure (including the preparation an installation of the cable route, as noted in the Draft [revised] NPS EN-3) 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 the release of contaminants can result in indirect effects on habitats and biodiversity and fish stocks thus affecting the fishing industry".*	As assessment of the disturbance of sediments and the potential risks is provided in Sections 3.10 to 3.13 of this chapter. The indirect effects on benthic ecology, fish ecology and habitats are provided in Volume 2, Chapter 5: Benthic and Intertidal Ecology; Volume 2, Chapter 6: Fish and Shellfish and the RIAA.
East Inshore/ Offshore Marine Plans	Policy ECO1: *"Cumulative impacts affecting the ecosystem of the East marine plans and adjacent areas (marine, terrestrial) should be addressed in decision-making and plan implementation".*	Cumulative impacts are considered within Section 3.12.
	Policy BIO1: *"Appropriate weight should be attached to biodiversity, reflecting the need to protect biodiversity as a whole, taking account of the best available evidence including on habitats and species that are protected or of conservation concern in the East marine plans and adjacent areas (marine, terrestrial)".*	The baseline characterisation of the site has been given in Volume 4, Annex 2.1: Physical Processes Technical Baseline, which is informed by the best available evidence.
	Policy MPA1: *"Any impacts on the overall Marine Protected Area network must be taken account of in strategic level measures and assessments, with due regard*	Designated sites within the study area have been described in Volume 4, Annex 2.1: Physical Processes Technical Baseline Report. Potential impacts to designated sites has been

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	given to any current agreed advice on an ecologically coherent network".	assessed and summarised within Table 3.22.
	Policy CAB1: *"Preference should be given to proposals for cable installation where the method of installation is burial. Where burial is not achievable, decisions should take account of protection measures for the cable that may be proposed by the applicant".*	Impacts resulting from cable installation methods are described in Impact 5: Deterioration in water quality due to suspension of sediments from O&M activities and Table 3.17: Maximum Design Scenario for the project alone.
	Policy TR1: *"Proposals for development should demonstrate that during construction and operation, in order of preference:* *a) They will not adversely impact tourism and recreation activities* *b) How, if there are adverse impacts on tourism and recreation activities, they will minimise them* *c) How, if the adverse impacts cannot be minimised, they will be mitigated* *d) The case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts".*	The inter-relationship between MW&SQ on tourism and recreation is presented in full in Volume 2, Chapter 15: Inter-relationships, but is summarised below in 3.13.3.

WATER FRAMEWORK DIRECTIVE

3.2.3 Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, commonly referred to as the Water Framework Directive (WFD), was established in 2000 in order to provide 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, physico-chemical and specific chemical parameters. The different ecological statuses are:

- High;
- Good;
- Moderate;
- Poor; or
- Bad.

3.2.4 The WFD's objective of 'good chemical status' is defined in terms of compliance with all the quality standards established for chemical substances at European level. This will ensure at least a minimum chemical quality, particularly in relation to very toxic substances.

3.2.5 The WFD's objective of 'good ecological status' also requires certain chemical conditions. The chemical requirements include the achievement of environmental quality objectives for discharged priority substances. It also identifies any other substances liable to cause pollution or being discharged in significant quantities.

3.2.6 The Environmental Quality Standards Directive (EQSD) identifies priority substances and polluting chemicals which should be considered in WFD assessments for transitional and coastal waterbodies. The WFD and EQSD seek to reduce these substances entering into the marine environment, primarily from discharges and outfalls.

3.2.7 The WFD (and Protected Areas including Bathing Waters) and aspects of the Groundwater Directive (2006/118/EC; GWD) were transposed into English and Welsh law by The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (hereafter referred to as the WFD Regulations 2017).

3.2.8 Article 4.9 of the WFD notes that compliance with other community environmental 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.

BATHING WATER DIRECTIVE

3.2.9 The EU's revised Bathing Water Directive (rBWD) came into force in March 2006. The rBWD has been implemented in England and Wales via the Bathing Water Regulations 2013 (as amended), with Bathing Waters classified against the standards set by the rBWD since 2015. The rBWD provides more stringent standards than the previous Directive and places an emphasis on providing information to the public. The rBWD has four different classifications of performance, 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.

3.2.10 The Environment Agency (EA) measures, monitors and reports the number of certain types of bacteria which may indicate the presence of pollution, mainly from sewage or animal faeces. These are *Escherichia coli* (*E. coli*) and intestinal Enterococci (IE). An increase in the concentrations of these bacteria indicates a decrease in water quality.

3.2.11 The EA collects at least eight water samples from each Bathing Water each year during the bathing season (15 May to 30 September). An overall classification for the Bathing Water is then determined by creating a distribution from the monitoring data for the last four years. A separate distribution is calculated for both *E. coli* and IE. This then enables the determination of the classification for each bacterium for the Bathing Water.

3.2.12 If the classification for both types of bacteria is different, then the overall compliance of the Bathing Water is the lowest classification achieved by either type. For example, if *E. coli* were performing at 'Good' but IE was performing at 'Sufficient', then the Bathing Water would be classified as performing at 'Sufficient'.

SHELLFISH WATERS DIRECTIVE

3.2.13 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 100 ml 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).

NITRATES DIRECTIVE

3.2.14 The Nitrates Directive (91/676/EEC) 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 water body.

URBAN WASTE WATER TREATMENT DIRECTIVE

3.2.15 The Urban Waste Water Treatment Directive (UWWTD) (91/271/EEC) 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.

3.2.16 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 water bodies affected by eutrophication of elevated nitrate concentrations and act as an indication that action is required to prevent further pollution caused by nutrients.

ENVIRONMENT ACT (2021)

3.2.17 The Environment Bill was granted Royal Assent on 9 November 2021, meaning it is now an Act of Parliament, the Environment Act 2021. With regard to water quality, 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 specifying 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 which currently transposes the WFD (2000/60/EC) into English Law. Whilst the UK left the European Union (EU) on 31 January 2020, the UK continues to be committed to meeting high environmental standards. The main provisions of the WFD have been retained in English Law through the Floods and Water (Amendment etc.) (EU Exit) Regulations 2019.

3.3 CONSULTATION

3.3.1 As part of the Environmental Impact Assessment (EIA) for VE, consultation has been undertaken with various statutory and non-statutory authorities, through the agreed Evidence Plan process (being used for the EIA process as well as for the Habitats Regulation Assessment (HRA)). A formal Scoping Opinion was sought from the SoS following submission of the Scoping Report (VE OWFL, 2021). The Scoping Opinion (the Planning Inspectorate (PINS), 2020) was issued in November 2021 by PINS. A record of key areas of consultation undertaken during the Scoping Opinion and Evidence Plan phases is summarised within Table 3.2 and will be presented in full within the project consultation report (submitted with the Development Consent Order (DCO) Application).

Table 3.2: Summary of consultation relating to MW&SQ.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Pre-/ Post-scoping Evidence Plan meeting, February 2020 & December 2021	It was agreed as appropriate to scope out transboundary impacts on MW&SQ.	This approach has been applied in 3.13.1.
Scoping Opinion (PINS, 2021)	**Marine Disposal** The proposed Five Estuaries array areas and export cable corridor overlap closed disposal sites. Therefore, construction (and decommissioning) activities could potentially release contaminated sediment or sediment that is not the same as the surrounding seabed during construction. Offshore surveys should be considered for the Five Estuaries OWF site and offshore export cable corridor to determine if any contaminants from previous disposal activities are present.	VE OWFL has commissioned site specific surveys to ensure that the level of existing contamination in seabed sediments is quantified and characterised. The findings of these surveys are presented in Volume 4, Annex 5.1and Volume 4, Annex 5.2: Benthic Ecology Subtidal Characterisation (Offshore ECC and Intertidal), and summarised in Section 3.7. The scope of these surveys was agreed with Natural England prior to collection of data.
Scoping Opinion (PINS, 2021)	**Deterioration in water quality during operational phase** The Scoping Report notes the potential for sediment to be resuspended as a result of scour around structures associated with the Proposed Development but concludes that the volume of material released during operation would be much smaller than that released during construction (within the ranges of natural variability) and highly localised. Accordingly, the	An assessment of the potential impacts on MW&SQ receptors during the O&M phase is included in Section 3.9.6. An assessment of the potential for likely significant effects (LSE) on the Margate and Long Sands Special Area of Conservation (SAC) and other relevant SACs is presented in the RIAA.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	ES should include an assessment of these matters or the information referred to demonstrating agreement with the relevant consultation bodies and the absence of a likely significant effect (LSE) on the environment.	
Scoping Opinion (PINS, 2021)	**Cumulative effects from release of sediment bound contaminants** The Scoping Report seeks to scope this matter out on the grounds that the effects from the Proposed Development would be highly localised and small scale. In the absence of information such as evidence demonstrating clear agreement with relevant statutory bodies, the Inspectorate is not in a position to agree to scope these matters from the assessment. Accordingly, the ES should include an assessment of these matters or the information referred to demonstrating agreement with the relevant consultation bodies and the absence of LSE.	An assessment of the potential cumulative impacts on MW&SQ receptors during is included in Section 0. An assessment of the potential for likely significant effects (LSE) on relevant SACs is presented in the RIAA.
Scoping Opinion (PINS, 2021)	**Transboundary effects from potential deterioration in water quality** The Scoping Report seeks to scope this matter out on the grounds that effects on water quality would be highly localised and small scale	This approach has been applied in 3.13.1.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	with limited potential for transboundary effects. Notwithstanding the comments under ID 4.2.1 above, the Inspectorate agrees that this effect is unlikely to extend far enough to affect a European Economic Area (EEA) state. This matter can be scoped out of further assessment.	
Scoping Opinion (PINS, 2021)	**Mitigation measures** The Scoping Report refers to a PEMP which would be developed post consent. A decommissioning programme would be developed to cover the decommissioning phase. Where the ES relies on mitigation to be delivered through these plans to avoid significant environmental effects, as a minimum an outline version of the plan should be provided as part of the application documents.	The full suite of embedded mitigation measures relevant to MW&SQ are presented in Table 3.18.
Post-scoping Evidence Plan meeting: December 2021	To utilise any available monitoring data from Cefas to inform the baseline characterisation.	All publicly available baseline data has been used to inform the baseline section presented in Section 3.7 of this chapter. A data request was sent to Cefas in December 2023 (awaiting response). It is noted that in January 2021, a Benthic Survey Licensing Meeting with MMO, Cefas and Natural England discussed the proposed geophysical survey and benthic characterisation survey methods, and all parties were in agreement

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
		with the survey approach presented.
Post-scoping Evidence Plan meeting: December 2021	A disposal site characterisation report will be prepared to support the DCO application.	A disposal site characterisation report will be provided to support the DCO application.
Post-scoping Evidence Plan meeting: December 2021	A WFD assessment will be prepared to support the PEIR and DCO application.	A WFD compliance assessment will be provided to support the DCO application.
Post-scoping Evidence Plan meeting: December 2021	The requirement to undertake sediment contaminant analysis to inform the risk of contamination present.	Sediment contaminant analysis has been undertaken in the array areas and offshore Export Cable Corridor (ECC). These data have informed the baseline characterisation presented in Section 3.7. It is noted that in January 2021, a Benthic Survey Licensing Meeting with MMO, Cefas and Natural England discussed the proposed geophysical survey and benthic characterisation survey methods, and all parties were in agreement with the survey approach presented.
Post-scoping Evidence Plan meeting: December 2021	To scope in the potential for deterioration in water quality during the O&M phase.	An assessment of the potential impacts on MW&SQ receptors during the O&M phase is included in Section 3.9.51.
Post-scoping Evidence Plan meeting: December 2021	To scope in the potential for deterioration in water quality cumulatively with other plans and projects.	An assessment of the potential cumulative impacts on MW&SQ receptors is provided in Section 0.
Pre-PEIR Evidence Plan meeting: October 2022	The study area for the PEIR/ ES assessment was detailed and agreed by all parties.	The MW&SQ study area is shown in Figure 3.1 of this chapter.
Pre-PEIR Evidence Plan meeting: October 2022	The key guidance for undertaking the PEIR was agreed by all parties.	The key guidance for undertaking the MW&SQ assessment is presented in Section 3.4 of this chapter.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Pre-PEIR Evidence Plan meeting: October 2022	The key data sources for undertaking the PEIR was agreed by all parties.	The key data sources used in this MW&SQ assessment is presented in Section 3.4 of this chapter.

3.4 SCOPE AND METHODOLOGY

SCOPE OF THE ASSESSMENT

IMPACTS SCOPED IN FOR ASSESSMENT

3.4.1 The following impacts have been scoped into this assessment:

- Construction:
  - Impact 1: Deterioration in water quality due to suspension of sediments;
  - Impact 2: Deterioration in water clarity due to the release of drilling mud;
  - Impact 3: Release of sediment-bound contaminants from disturbed sediments; and
  - Impact 4: Accidental releases or spills of materials or chemicals.
- Operation and maintenance:
  - Impact 5: Deterioration in water quality due to suspension of sediments from O&M activities;
  - Impact 6: Deterioration in water quality due to suspension of sediments from scour; and
  - Impact 7: Accidental releases or spills of materials or chemicals.
- Decommissioning:
  - Impact 8: Deterioration in water quality due to suspension of sediments; and
  - Impact 9: Accidental releases or spills of materials or chemicals.

IMPACTS SCOPED OUT OF ASSESSMENT

3.4.2 As outlined in Table 3.2, transboundary impacts for all stages of the VE development have been scoped out in agreement with stakeholders and the Scoping Opinion (PINS, 2021). No other potential impacts have been scoped out from further assessment in this PEIR chapter.

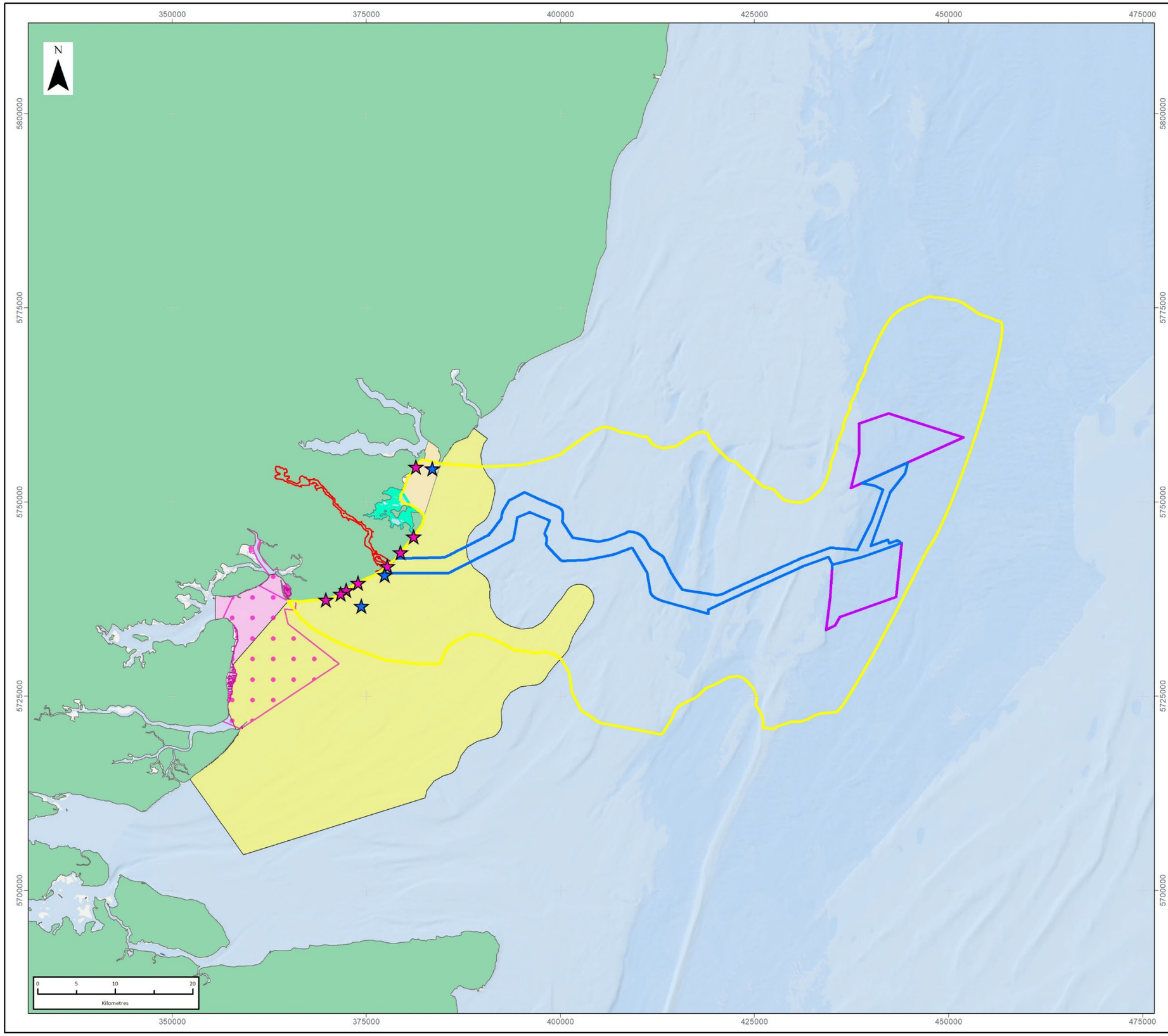
STUDY AREA

3.4.3 For the purposes of this PEIR chapter, the MW&SQ study area (Figure 3.1) has been defined by the following:

- Seaward of Mean High Water Springs (MHWS).

- Near-field: the VE project Red Line Boundary (RLB) is defined as the VE array areas along with the VE offshore ECC, where landfall lies at Holland-on-Sea and Frinton-on-Sea on the Essex coast.
- Far-field: the VE MW&SQ study area is defined by a secondary Zone of Influence (ZoI), which has been defined based on the expected maximum distance that water from within the VE array areas and offshore ECC might be transported on a single mean spring tide, in either the flood and/ or ebb direction. The area conservatively indicates the likely spatial extent over which measurable plume effects arising at anytime from anywhere within the RLB might be experienced, defined by a spring tidal excursion ellipse buffer around the VE array areas and offshore ECC.
    - This area defines the maximum distance suspended sediments disturbed by development activities might have an impact on MW&SQ receptors, although the majority of elevated suspended sediment concentrations (SSC) and deposited sediment is expected to occur much closer to the disturbance activity.

3.4.4 The Cumulative Effects Assessment (CEA) study area is defined by the ZoI, to incorporate the maximum distance suspended sediments will travel in one tidal cycle and therefore the indirect impacts on MW&SQ arising from VE that could interact cumulatively with impacts from other plans or projects.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Zone of Influence
- Designated Bathing Waters
- EA Water Quality Sites
- Transitional Waterbodies
- Shellfish Waters

Coastal WFD Waterbodies:

- Blackwater Outer
- Harwich Approaches Coastal water body
- Essex Coastal water body

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Marine Water and Sediment Quality Study Area

VER	DATE	REMARKS	Drawn	Checked
1	22/02/2023	For Issue	SWM	CH

DRAWING NUMBER:

3.1

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:500,000	A3	WGS84	UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

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DATA SOURCES

3.4.5 Site-specific surveys for VE have been undertaken to characterise the seabed conditions in the array areas and the offshore ECC (Volume 4, Annex 5.1: Benthic Ecology and Subtidal Characterisation (Array) and Annex 5.2: Benthic Ecology and Subtidal Characterisation (Offshore ECC and Intertidal)). This comprised of a geophysical survey of the array area and offshore ECC, supplemented with drop down camera data and grab samples to allow a characterisation of the sediment features and composition within the study area. The survey additionally included sediment Particle Size Analysis (PSA) and contaminant analysis using the grab samples.

3.4.6 Where relevant, data from surveys undertaken for Galloper OWF (Galloper) has been used in the characterisation of the VE study area, complemented by the primary sources of information including site-specific surveys undertaken for VE.

3.4.7 The EA's Bathing Water classification data based on water samples/ monitoring data for the Bathing Waters, within the ZoI, from 2018 to 2021 have been included in this assessment. Data from the EA's Data Catchment Explorer website have also been used to characterise the status of the WFD waterbodies within the study area. Any Shellfish Water Protected Areas within the study area have been considered, and data collated from the Food Standards Agency website.

3.4.8 A data request for any relevant MW&SQ monitoring data, as noted in a Post-scoping Evidence Plan meeting in December 2021 (see Table 3.2), was sent to Cefas in December 2023 (awaiting response). Any suitable data provided will be used to help further characterise the MW&SQ baseline.

ASSESSMENT METHODOLOGY

3.4 CEFAS ACTION LEVELS

3.4.9 There are no Environmental Quality Standards (EQSs) for *in situ* sediments in the UK. In the absence of any defined EQSs, data from the surveys is analysed relative to the Cefas Guideline Action Levels for the disposal of dredged material. This may be used to provide evidence for decision makers about the disposal of dredged material, they are not however, statutory. The Cefas Guideline Action Levels are presented in Table 3.3. These levels are used in this assessment to provide context to sediment quality and determine whether further assessment is required, rather than a pass/ fail criterion.

3.4.10 For dredging projects, contaminants below the Cefas Guideline Action Level 1 (CAL1) are not considered to be of concern and are generally considered suitable for disposal at sea. Contaminant levels above Cefas Guideline Action Level 2 (CAL2) are generally not considered suitable for disposal at sea without further consideration.

3.4.11 It is noted that VE is not primarily a proposed dredging scheme (rather, an offshore wind development) but, given the project proposal to dredge, drill and dispose of seabed material within the RLB, and in keeping with common practice, contaminants will be contextualised against the Cefas Guideline Action Levels to provide an indicative risk to the environment.

3.4.12 The Cefas Guideline Action Levels are used as part of a 'weight of evidence' approach to assessing the suitability of material for disposal at sea but are not themselves statutory standards. The majority of the materials assessed against these standards arise from dredging activities.

Table 3.3: Cefas Guideline Action Levels (MMO, 2020).

Contaminant/ Compound	CAL1 (mg/kg dry weight)	CAL2 (mg/kg dry weight)
Arsenic	20	100
Cadmium	0.4	5
Chromium	40	400
Copper	40	400
Lead	50	500
Mercury	0.3	3
Nickel	20	200
Zinc	130	800
Organotins (TBT, DBT, MBT)	0.1	1
PCB's - sum of ICES 7	0.01	None
PCB's - sum of 25 congeners	0.02	0.2
PAHs	0.1	None
*DDT	*0.001	N/A
*Dieldrin	*0.005	N/A

*as set in 1994

3.4.13 It is also understood to be standard procedure for Cefas, in reviewing PAH concentrations in marine sediment samples, 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 CAL1 (ERL) and CAL2 (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.

3.4.14 The ERL (equivalent to CAL1) for the sum of LMW and HMW PAHs is 552 and 1,700 µg/kg, respectively. The ERM (equivalent to CAL2) for the sum of LMW and HMW PAHs is 3,160 and 9,600 µg/kg, respectively.

CANADIAN MARINE SEDIMENT QUALITY GUIDELINES

3.4.15 In addition to the Cefas Guideline Action Levels, the Canadian sediment quality guidelines have been utilised to provide further context, and for contaminants such as PAHs that are not captured within the Cefas Guideline Action Levels. The Canadian Sediment quality guidelines were developed by the Canadian Council of Ministers of the Environment as broadly protective tools to support the functioning of healthy aquatic ecosystems. They are based on field research programmes that have demonstrated associations between chemicals and biological effects by establishing cause and effect relationships in particular organisms.

3.4.16 Comparison of measured concentrations of various contaminants within the sediments with these guideline values will provide a basic indication on the degree of contamination and likely impact on ecology.

3.4.17 The guidelines consist of Threshold Effect Levels (TELs) (also known as interim sediment quality guidelines) and Probable Effect Levels (PELs). The TELs and PELs are used to identify the following three ranges of chemical concentrations with regard to biological effects:

- Below the TEL - the minimal effect range within which adverse effects rarely occur;
- Between the TEL and 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.

3.4.18 The guidelines for the TELs and PELs are provided in Table 3.4. Where Cefas Guideline Action Levels are not available for a substance then TELs and PELs have been utilised to characterise the baseline environment.

Table 3.4: Canadian Marine Sediment Quality Guidelines (CCME, 2001).

Substance	Units	TEL	PEL
Metals			
Arsenic	mg/kg	7.24	41.6
Cadmium	mg/kg	0.7	4.2
Chromium	mg/kg	52.3	160
Copper	mg/kg	18.7	108
Lead	mg/kg	30.2	112
Mercury	mg/kg	0.13	0.7
Zinc	mg/kg	124	271
Polychlorinated biphenyls (PCB)			

Substance	Units	TEL	PEL
PCBs: total PCBs	mg/kg	21.5	189
Polyaromatic hydrocarbons (PAH)			
Acenaphthene	µg/kg	6.71	88.9
Acenaphthylene	µg/kg	5.87	128
Anthracene	µg/kg	46.9	245
Benz(a)anthracene	µg/kg	74.8	693
Benzo(a)pyrene	µg/kg	88.8	763
Chrysene	µg/kg	108	846
Dibenz(a,h)anthracene	µg/kg	6.22	135
Fluoranthene	µg/kg	113	1,494
Fluorene	µg/kg	21.2	144
2-Methylnaphthalene	µg/kg	20.2	201
Naphthalene	µg/kg	34.6	391
Phenanthrene	µg/kg	86.7	544
Pyrene	µg/kg	153	1,398

ASSESSING DESIGNATED WATERS

3.4.19 Water quality at Bathing Waters is contextualised against the baseline performance of each Bathing Water relative to the rBWD. Further assessment will be required 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 VE activities. A similar exercise has been undertaken for Shellfish Water Protected Areas, with due regard to the current sampling plans and monitoring given (Cefas, 2022).

3.5 ASSESSMENT CRITERIA AND ASSIGNMENT OF SIGNIFICANCE

3.5.1 This assessment is consistent with the EIA methodology presented in Volume 1, Chapter 3: EIA Methodology.

The magnitude of identified impacts is defined in Table 3.5. It is noted here that a distinction is made throughout the assessment between the magnitude, extent and duration of 'impacts' and the resulting significance of the 'effects' upon MW&SQ receptors. Various actions may result in impacts: for instance, the installation of the export cable, causing a localised and short-term change to SSC (which is defined as a water quality receptor). The significance of effect associated with the impact will be dependent upon the sensitivity/ importance of the receptor, with particular consideration given to the receptor's ability to tolerate and recover from the impact, as well as its status.

3.5.2 The descriptions of magnitude are specific to the assessment of MW&SQ impacts and are considered against the magnitude descriptions presented in Table 3.5. Potential impacts have been considered in terms of permanent or temporary, and adverse or beneficial effects. Where an effect could reasonably be assigned more than one level of magnitude, professional judgement has been used to determine which rating is applicable.

3.5.3 As set out in Volume 1, Chapter 3: EIA Methodology, the sensitivity of a receptor is a function of its capacity to accommodate change and reflects its ability to recover if it is affected. It is quantified via a consideration of adaptability, tolerance, recoverability and value.

3.5.4 Table 3.6 sets out the criteria used in defining the sensitivity of the marine water quality receptor. Where a receptor could reasonably be assigned more than one level of sensitivity, professional judgement has been used to determine which level is applicable. The inclusion of internationally or nationally important features within the high sensitivity definition provides the opportunity to increase the sensitivity of the water quality receptor if required, even if capacity for dilution exists.

3.5.5 The matrix used for the determination of significance is shown in Table 3.7. The combination of the magnitude of the impact with the sensitivity of the receptor determines the assessment of significance of effect. For the purposes of this assessment, any effect that is of major or moderate significance is considered to be significant in EIA terms. Any effect that has a significance of minor or negligible is not considered to be significant in EIA terms. An assessment of the significance of potential effects is described in Sections 0 to 0.

Table 3.5: 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 permanent or long-term change (i.e., a WFD reporting cycle) occurs. Inability to meet Environmental Quality Standard(s) (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 (e.g., a change in the annual average turbidity classification (UKTAG, 2014)) 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.

Table 3.6: 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.

Receptor sensitivity/ importance	Definition
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.

Table 3.7: Matrix to determine effect significance.

			Sensitivity			
			High	Medium	Low	Negligible
Magnitude	Negative	High	Major	Major	Moderate	Minor
		Medium	Major	Moderate	Minor	Negligible
		Low	Moderate	Minor	Minor	Negligible
	Neutral	Negligible	Minor	Minor	Negligible	Negligible
	Beneficial	Low	Moderate	Minor	Minor	Negligible
		Medium	Major	Moderate	Minor	Negligible
		High	Major	Major	Moderate	Minor

Note: shaded cells are defined as significant with regards to the EIA Regulations 2017[1].

3.6 UNCERTAINTY AND TECHNICAL DIFFICULTIES ENCOUNTERED

3.6.1 Many aspects of the baseline are well understood. However, 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.

[1] The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 https://www.legislation.gov.uk/uksi/2017/572/contents

3.6.2 Grab sampling, while providing detailed information on the sediment types (and fauna) present, cannot cover wide swaths of the seabed and consequently represent point samples that must be interpreted in combination with the other appropriate datasets. As noted, several surveys undertaking grab samples have been conducted in the area which show good validation against the 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.

3.6.3 There is some uncertainty associated with the assessment of sediment plumes and accompanying changes to bed levels due to project related activities and analogous developments. This arises due to uncertainty regarding how the seabed geology will respond to drilling and jetting. The exact volume of material entrained into the water column will be dependent upon a number of factors including the type of drilling/ cable installation equipment used, the variability of the forcing conditions (i.e., the waves and tidal states) and the mechanical properties of the geological units. In the absence of detailed information, a series of potential release scenarios have been considered in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes. Together, these scenarios capture the worst-case impacts in terms of the highest concentration suspended sediment plumes, the most persistent suspended sediment plumes, the maximum changes in bed level elevation and the greatest spatial extent of change in bed level.

3.6.4 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.

3.7 EXISTING ENVIRONMENT

REGIONAL OVERVIEW

3.7.1 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 estuarine and fluvial systems) and offshore (discharges from the Oil & 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).

3.7.2 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, 2017, 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 Effects Range Low (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.

3.7.3 Sediments with larger particle sizes (e.g., gravels and sands) are not typically associated with elevated concentrations of anthropogenic contaminants. Hydrocarbons are closely correlated to the spatial distribution of sediment types and largely associated with finer material (silt and mud). Metal concentrations in sediments are generally higher in the coastal zone and around estuaries, decreasing offshore, indicating that river input and run-off from land are significant sources.

3.7.4 Project-specific surveys have analysed surficial sediments for contaminant levels both within the array areas, ECC and within the intertidal area. Analysis has been undertaken by SOCOTEC, an MMO-accredited laboratory. The key results are presented in this section, with further survey information presented in Appendix D of this PEIR.

THE ARRAY AREAS

SEDIMENT CHARACTERISATION

3.7.5 Surficial sediments have been collected from within the North Array (eight samples), South Array (six samples) and the Interconnector (three samples). The analyses of these samples indicate that the surficial sediment is composed of a mix of sand, gravel and fines (mud) (Figure 3.2).

3.7.6 Five sediment classes were identified within the array using the Folk (BGS modified) classification, including:

- 1. ‘Gravelly sand’, which typified six stations;
- 2. ‘Sandy gravel’, which typified four stations;
- 3. ‘Sand’, which typified three stations;
- 4. ‘Muddy sandy gravel’, which typified three stations;
- 5. ‘Gravelly mud’, which typified one stations.

3.7.7 Most stations (10) had polymodal distributions, typical of areas with different sediment sources most likely associated with riverine input and sediment disturbance in a high-energy environment.

SEDIMENT CHEMISTRY

3.7.8 Three samples within the array area have been analysed for contaminants, one each within the North Array, South Array and Interconnector areas.

METALS

3.7.9 The metal concentrations within the array samples were all below CAL1.

3.7.10 At all stations, the arsenic concentration exceeded the Canadian TEL but were below the PEL (Table 3.8).

ORGANOTINS

3.7.11 Concentrations of dibutyltin (DBT) and tributyltin (TBT) were analysed in the sediment samples and both returned concentrations less than their respective Level of Detection (LoD). The LoD for both DBT and TBT is below CAL1 and consequently DBT and TBT concentrations were below CAL1.

POLYCYCLIC AROMATIC HYDROCARBONS

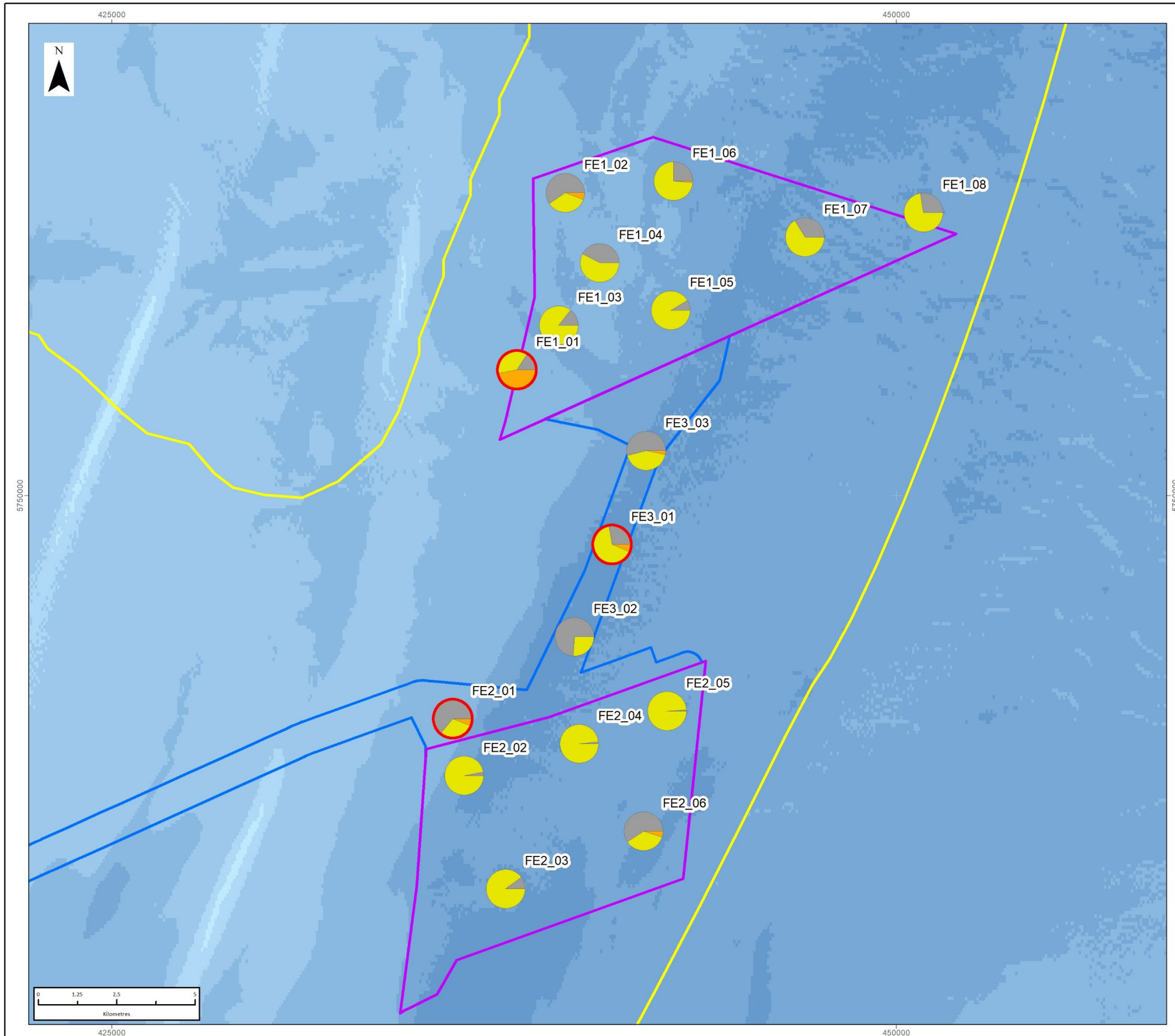
3.7.12 Within the array, concentrations of total Polycyclic Aromatic Hydrocarbons (PAHs) were all less than the LoD and the respective CAL1 thresholds. As such the Gorham-Test was not applied to these samples.

TOTAL HYDROCARBON CONTENT

3.7.13 Within the array, the Total Hydrocarbon Content (THC) at all sediment sample locations were below the Limit of Detection (LoD).

POLYCHLORINATED BIPHENYLS

3.7.14 The sediment samples taken within the array all returned polychlorinated biphenyl (PCB) concentrations below the LoD. Further, the sum of the 25 congeners were below CAL1. The sum of the ICES 7 PCB's were also below CAL1.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Zone of Influence

Sediment Monitoring Stations: Sediment %:

- Gravel
- Sand
- Fines

Sediment Monitoring Stations (Contaminants Monitoring), Sediment %:

- Gravel
- Sand
- Fines

Depth (m)

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Sediment monitoring stations within the array area, presenting sediment composition from PSA (and location of contaminant sampling stations)

VER	DATE	REMARKS	Drawn	Checked
1	22/02/2023	For Issue	SWM	CH

DRAWING NUMBER:

3.3

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:125,000	A3	WGS84	UTM31N

FIVE ESTUARIES OFFSHORE WIND FARM

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SEDIMENT ORGANOCHLORINE PESTICIDES

3.7.15 All eight of the organochlorine pesticides (OCP) analysed for, including dieldrin and dichlorodiphenyltrichloroethane (DDT) for which Cefas Guideline Action Levels are available, returned concentrations less than their respective LoD. The OCP concentrations of dieldrin and DT were below CAL1.

Table 3.8: Summary of the array metal content analysis.

Metal	Station (mg/kg)			Cefas Guideline Action Levels (mg/kg)		Canadian Sediment Quality Guidelines (mg/kg)	
	FE1_05 North Array	FE2_03 South Array	FE3_01 Inter-connector	CAL1	CAL2	TEL	PEL
As	8.7	10.2	18.8	20	100	7.24	41.6
Cd	0.08	0.06	0.08	0.4	5	0.7	4.2
Cr	4.1	3.1	6.9	40	400	52.3	160
Cu	5.4	5.4	5.2	40	400	18.7	108
Hg	0.02	0.01	0.02	0.3	3	0.13	0.7
Ni	5.1	5.5	9.6	20	200	-	-
Pb	3.8	3.1	4.4	50	500	30.2	112
Zn	14.0	11.5	14.4	130	800	124	271

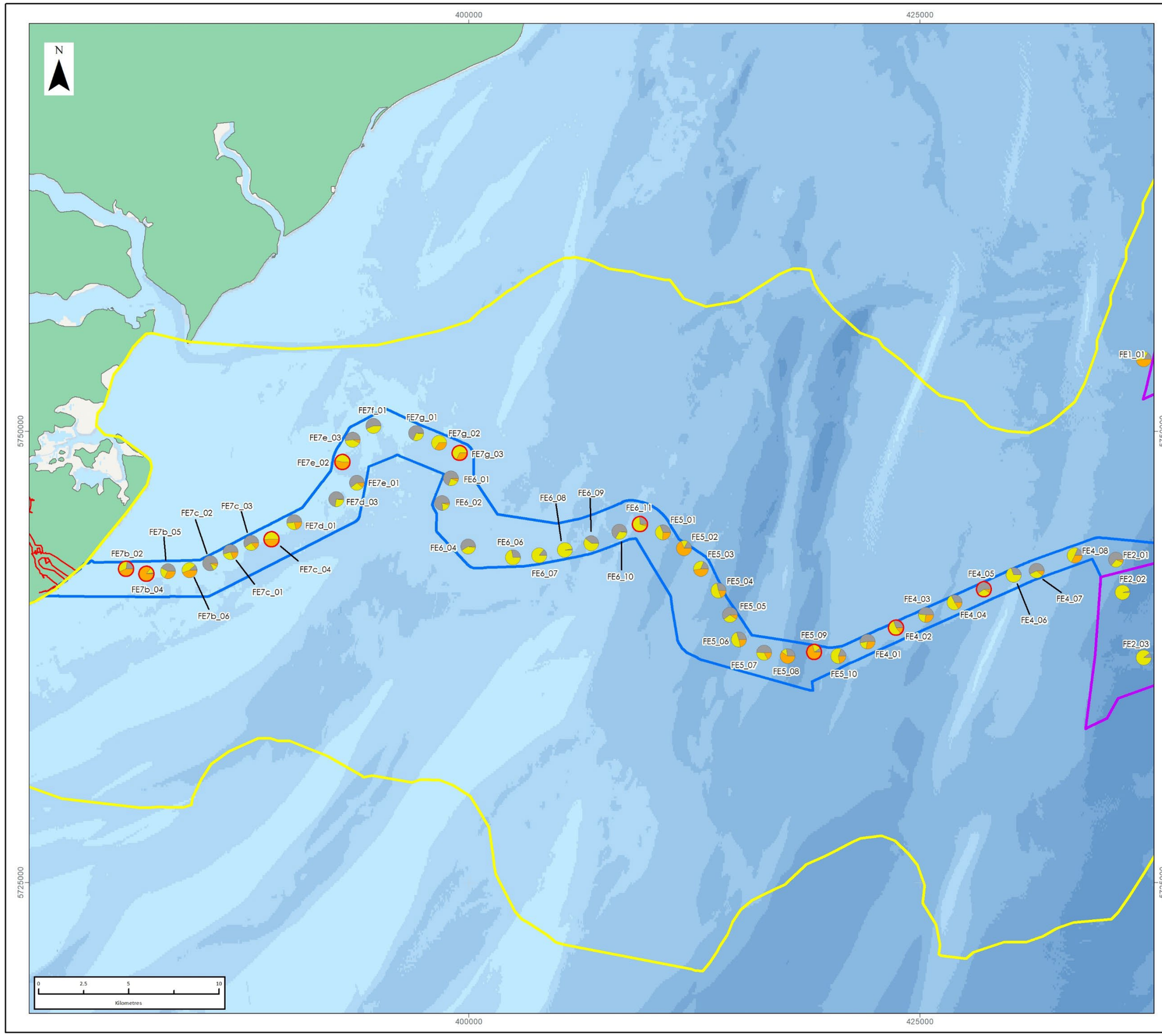
Shaded cells indicate exceedance of TEL only

THE OFFSHORE EXPORT CABLE CORRIDOR

SEDIMENT CHARACTERISATION

3.7.16 Surficial sediments have been collected from along the ECC at 44 locations. As shown in Figure 3.3, the sediment along the offshore ECC comprises a mix of sand, gravel and fines (mud):

- Sand content ranged from 11.64% (station FE7c_01) to 97.30% (station FE6_08.
- Gravel content ranged from 0.07% (station FE7e_02) to 82.14% (station FE7c_01.
- Fines were absent from stations FE4_06, FE6_07 and FE6_08; at the remaining stations, fines content ranged from 0.45% (station FE7f_01) to 84.15% (station FE7b_04). Of the fines, the silt content was consistently higher than the clay content.



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Zone of Influence

Sediment Monitoring Stations: Sediment %:

- Gravel
- Sand
- Fines

Sediment Monitoring Stations (Contaminants Monitoring), Sediment %:

- Gravel
- Sand
- Fines

Depth (m)

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Sediment monitoring stations within the offshore ECC, presenting Ssediment composition from PSA (and location of contaminant sampling stations)

VER	DATE	REMARKS	Drawn	Checked
1	22/02/2023	For Issue	SWM	CH

DRAWING NUMBER:

3.2

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:215,000	A3	WGS84	UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

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3.7.17 Ten sediment classes were identified along the offshore ECC using the Folk (BGS modified) classification, including:

- 1. ‘Muddy, sandy gravel’, which typified 14 stations;
- 2. ‘Sandy gravel’, which typified seven stations;
- 3. ‘Gravelly mud’, which typified five stations;
- 4. ‘Gravelly muddy sand’, which typified five stations;
- 5. ‘Gravelly sand’, which typified three stations;
- 6. ‘Muddy gravel’, which typified three stations;
- 7. ‘Muddy sand’, which typified three stations;
- 8. ‘Sandy mud’, which typified two stations;
- 9. ‘Gravel’, which typified one station; and
- 10. ‘Sand’, which typified one station.

3.7.18 Of the 44 stations investigated, 25 had very poorly sorted sediments, 15 had extremely poorly sorted sediments, two had poorly sorted sediment, one had moderately sorted sediment and one had moderately well sorted sediment.

SEDIMENT CHEMISTRY

3.7.19 Eight samples within the ECC area have been analysed for contaminants. The results from the contaminant analyses are presented in the following sections.

METALS

3.7.20 Of the eight metals used as the standard measures for sediment quality analysis (Cefas Guideline Action Levels; Canadian SQG’s), four reported levels under these threshold guidelines, including CAL1. The four metals for which the thresholds were exceeded were:

- Arsenic; at four stations both CAL1 and TEL were exceeded, whilst two of the stations exceed PEL;
- Cadmium; at one station where the concentration exceeded CAL1;
- Chromium; at one station, where the concentrations exceeded CAL1 and
- Nickel; at four stations which exceeded CAL1.

3.7.21 The full suite of metal concentrations for each of the sediment sample locations are presented in Table 3.9, alongside the Cefas Guideline Action Levels and Canadian SQG’s.

ORGANOTINS

3.7.22 Both DBT and TBT were analysed for in the sediment samples and both returned concentrations less than their respective LoD. The LoD for both DBT and TBT is below CAL1, consequently DBT and TBT concentrations were below CAL1.

POLYCYCLIC AROMATIC HYDROCARBONS

3.7.23 Along the offshore ECC, concentrations of total PAHs ranged from <25.8 µg/kg at station FE4_02_50 m, along the offshore section of the offshore ECC, to 911.7 µg/kg at station FE7b_02, along the nearshore section of the offshore ECC. In general,

concentrations of total PAHs were higher at stations along the nearshore section of the offshore ECC; however, all concentrations of individual PAHs were below their respective SQGs (Table 3.10). FE7b_02 exceeded CAL1 for C1-naphthalenes and C2-naphthalenes (Table 3.10).

3.7.24 The Gorham-Test approach to PAH assessment indicates that the sum of LMW and HWM PAHs did not exceed the ERL (CAL1) at any site.

TOTAL HYDROCARBON CONTENT

3.7.25 Along the offshore ECC, THC content generally showed a pattern of decreasing concentrations with distance offshore.

Table 3.9: Summary of the offshore ECC sediment metal analysis

Individual metals	Station (mg/kg)								Cefas Action Levels (mg/kg)		Canadian SQGs (mg/kg)	
	FE4_02_50 m	FE4_05	FE5_09	FE7b_02	FE7b_04	FE7c_04	FE7e_02	FE7g_03	CAL1	CAL2	TEL	PEL
As	73.3*	40.0	46.1*	14.2	39.3	10.7	13.9	9.7	20	100	7.24	41.6
Cd	0.28	0.50	0.28	0.14	0.31	0.09	0.13	0.10	0.4	5.0	0.7	4.2
Cr	23.2	16.5	42.9	19.9	20.7	13.9	20.1	12.1	40	400	52.3	160
Cu	11.4	6.7	31.3	15.1	21.5	9.6	13.0	9.5	40	400	18.7	108
Hg	0.03	0.02	0.05	0.07	0.10	0.05	0.04	0.04	0.3	3.0	0.13	0.7
Ni	58.2	20.9	55.9	16.0	56.0	11.3	14.2	9.4	20	200	-	-
Pb	8.8	6.3	15.6	17.3	17.1	12.7	13.3	12.3	50	500	30.2	112
Zn	43.8	28.2	85.6	53.4	62.3	37.6	55.7	38.1	130	800	124	271

Shaded cells indicate exceedance of CAL1
(*) Exceedance of PEL

Table 3.10: Summary of the offshore ECC Polycyclic Aromatic Hydrocarbons analysis

Individual PAHs	Station (ug/kg)								Cefas Action Levels (µg/kg)		Canadian SQGs (CCME, 2022) (ug/kg)	
	FE4_02_50 m	FE4_05	FE5_09	FE7b_02	FE7b_04	FE7c_04	FE7e_02	FE7g_03	CA L1	CA L2	TEL	PEL
Acenaphthene	< 1	< 1	< 1	5.27	1.73	2.8	2.95	2.04	100	N/A	6.71	88.9
Acenaphthylene	< 1	< 1	< 1	4.48	1.97	4.19	5.24	1.87	100	N/A	5.87	128
Anthracene	< 1	< 1	< 1	10.1	5.06	8.23	8.9	5.17	100	N/A	46.9	245
Benzo[a]anthracene	< 1	< 1	1.11	24.9	9.32	17.9	23.6	11.9	100	N/A	74.8	693
Benzo[a]pyrene	< 1	1.28	< 1	32.1	10.5	16.7	28.3	12.5	100	N/A	88.8	763
Benzo[b]fluoranthene	< 1	1.59	1.78	33.2	15.3	25.7	33.9	18	100	N/A	-	-
Benzo[e]pyrene	1.23	1.82	1.98	46.5	18.9	29.1	32.4	19.5	100	N/A	-	-
Benzo[ghi]perylene	1.31	1.69	< 1	33.7	14.6	21.2	31.6	15.5	100	N/A	-	-
Benzo[k]fluoranthene	< 1	1.14	1.38	28.1	8	18.7	18.8	13.5	100	N/A	-	-
C1-naphthalenes	2.05	2.83	5.93	129	44.9	81.3	53.3	53.9	100	N/A	-	-
C1-phenanthrene	1.47	1.78	4.17	72.1	27.2	44.9	41.9	33	100	N/A	-	-
C2-naphthalenes	2.11	3.03	7.36	101	37.7	61.8	46	44.7	100	N/A	-	-

Individual PAHs	Station (ug/kg)								Cefas Action Levels (µg/kg)		Canadian SQGs (CCME, 2022) (ug/kg)	
C3-naphthalenes	1.41	1.94	4.22	79.9	28.8	48.8	47.4	36.4	100	N/A	-	-
Chrysene	< 1	1.17	1.46	33.6	16.5	28	27.4	18.5	100	N/A	108	846
Dibenzo[ah]anthracene	< 1	< 1	< 1	3.4	1.5	2.78	3.56	1.5	10	N/A	6.22	135
Fluoranthene	1.49	2.11	4.38	59.6	24.9	39.7	52.7	28.7	100	N/A	113	1494
Fluorene	< 1	< 1	< 1	9.16	3.59	5.93	6.35	3.85	100	N/A	21.2	144
Indeno[1,2,3-cd]pyrene	< 1	1.53	< 1	25.4	8.31	14.9	24.8	10.2	100	N/A	-	-
Naphthalene	1.07	1.31	2.31	42.8	14.7	30.5	19.3	20.1	100	N/A	34.6	391
Perylene	< 1	< 1	< 1	17.9	9.25	12.9	13.8	9.33	100	N/A	-	-
Phenanthrene	1.18	1.52	3.81	64.9	22.2	39.2	45.7	27.2	100	N/A	86.7	544
Pyrene	1.46	1.95	4.61	54.6	26.1	38.4	45.2	27.9	100	N/A	153	1398

Green shading indicates those values which exceeded CAL1.

POLYCHLORINATED BIPHENYLS

3.7.26 The concentrations of individual PCB congeners analysed were below the LoD (< 0.00008 mg/kg) at the following sampling locations:

- central ECC: FE5_09;
- offshore ECC: FE4_02_50 and FE4_05; and
- nearshore ECC: FE7g_03.

3.7.27 At the remaining stations, all of which are along the nearshore section of the ECC, the concentration of selected PCB congeners was greater than the LoD. As such, sum of the 25 congeners was between <0.00200 mg/kg and <0.00244 mg/kg. These values were all below CAL1.

3.7.28 Where samples measured were reported as below the LoD, the LoD value was applied as a worst-case scenario. In this case, the sum of ICES 7 PCBs for the intertidal and ECC area were all below CAL1.

SEDIMENT ORGANOCHLORINE PESTICIDES

3.7.29 Along the ECC, most values were less than the LoD, with concentrations of dieldrin and DDT lower than CAL1.

INTERTIDAL

SEDIMENT CHARACTERISATION

3.7.30 Surficial sediments have been collected from within the intertidal at 23 locations. Sand was the predominant sediment fraction across the intertidal survey area, with a content of 35.66 % (station I_TR07_HW) to 100.00 % (I_TR04_LW) and a mean of 80.32 %. Gravel was absent at station I_TR04_LW, and, at the remaining stations, gravel content ranged from 0.01 % (station I_TR07_LW) to 64.34 % (station I_TR07_HW). Fines were absent from the intertidal samples at the time of the survey.

3.7.31 Three sediment classes were identified through the Folk (BGS modified) classification including:

- 1. ‘Sand’, which typified nine stations;
- 2. ‘Gravelly sand’, which typified eight stations; and
- 3. ‘Sandy gravel’, which typified six stations.

3.7.32 Of the 23 stations investigated, nine had well sorted sediment, seven had poorly sorted sediment, five had very poorly sorted sediment and two had moderately sorted sediment.

SEDIMENT CHEMISTRY

METALS

3.7.33 Three intertidal (at High Water; Mid Water; Low Water) samples were taken for contaminant analysis, the metal concentrations analysed were below their respective CAL1 and SQGs (Table 3.11).

Table 3.11: Summary of the intertidal sediment metal analysis.

Metal	Station (mg/kg)			Cefas Guideline Action Levels (mg/kg)		Canadian Sediment Quality Guidelines (mg/kg)	
	I_TR05_HW	I_TR05_MW	I_TR05_LW	AL1	AL2	TEL	PEL
As	4	6.2	5.4	20	100	7.24	41.6
Cd	< 0.04	0.08	< 0.04	0.4	5	0.7	4.2
Cr	2.9	5.4	3.1	40	400	52.3	160
Cu	5.8	6.7	6.1	40	400	18.7	108
Hg	< 0.01	0.04	0.02	0.3	3	0.13	0.7
Ni	3.8	6.4	4.2	20	200	-	-
Pb	3.4	3.6	6.7	50	500	30.2	112
Zn	16.2	13.1	12	130	800	124	271

ORGANOTINS

3.7.34 The organotins analysed included DBT and TBT, the concentrations of which were below their respective LoD and below the CAL1 at all stations across the intertidal survey area.

POLYCYCLIC AROMATIC HYDROCARBONS

3.7.35 All concentrations of individual PAHs were below their respective SQGs and CAL1 (Table 3.12).

TOTAL HYDROCARBON CONTENT

3.7.36 Within the intertidal area, the THC concentration at all the sampling locations was below CAL1.

POLYCHLORINATED BIPHENYLS

3.7.37 The concentrations of all individual PCB congeners analysed were below the LoD. The sum of the 25 congeners and sum of ICES 7 were below the CAL1.

SEDIMENT ORGANOCHLORINE PESTICIDES

3.7.38 The concentration of all organochlorine pesticides analysed were below their respective LoD. Concentrations of dieldrin and DDT were below the respective CAL1 at all stations across the intertidal survey area.

Table 3.12: Summary of the intertidal sediment Polycyclic Aromatic Hydrocarbon analysis.

Analyte	Station (µg/kg)			Cefas Action Levels (µg/kg)		Canadian SQGs (CCME, 2022) (µg/kg)	
	I_TR05_HW	I_TR05_MW	I_TR05_LW	CAL 1	CAL 2	TEL	PEL
Acenaphthene	< 1	< 1	< 1	100	N/A	6.71	88.9
Acenaphthylene	< 1	< 1	< 1	100	N/A	5.87	128
Anthracene	1.27	< 1	< 1	100	N/A	46.9	245
Benzo[a]anthracene	5.6	2.97	1.67	100	N/A	74.8	693
Benzo[a]pyrene	6.29	3.63	2.86	100	N/A	88.8	763
Benzo[b]fluoranthene	5.88	3.11	2.74	100	N/A	-	-
Benzo[e]pyrene	5.1	3.08	2.64	100	N/A	-	-
Benzo[ghi]perylene	4.4	2.49	2.25	100	N/A	-	-
Benzo[k]fluoranthene	3.85	2.48	1.81	100	N/A	-	-
C1-naphthalenes	< 1	< 1	< 1	100	N/A	-	-
C1-phenanthrene	2.14	1.53	< 1	100	N/A	-	-
C2-naphthalenes	1.5	< 1	1.49	100	N/A	-	-
C3-naphthalenes	< 1	< 1	< 1	100	N/A	-	-
Chrysene	5.9	3.63	2.61	100	N/A	108	846
Dibenzo[ah]anthracene	< 1	< 1	< 1	10	N/A	6.22	135
Fluoranthene	16.1	7.91	3.61	100	N/A	113	1494
Fluorene	< 1	< 1	< 1	100	N/A	21.2	144
Indeno[1,2,3-cd]pyrene	4.47	2.35	2.13	100	N/A	-	-
Naphthalene	< 1	< 1	< 1	100	N/A	34.6	391
Perylene	1.72	1.22	< 1	100	N/A	-	-
Phenanthrene	6.84	4.14	1.21	100	N/A	86.7	544
Pyrene	13.2	6.59	3.27	100	N/A	153	1398

3.7.39 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 Thames (Cefas, 2016).

3.7.40 The VE array areas are located close to the Thames Estuary, an area characterised by naturally high levels of turbidity, primarily in response to the input of fine grained sediments from fluvial sources, erosion of soft cliff coasts and the frequent re-suspension of mobile material from shallow seabed settings. The project is situated on the boundary between the turbid Thames Estuary and the clearer North Sea, in a region known as the East Anglian Plume (Cefas, 2016). The East Anglian Plume extends from the East coast of the UK across the southern North Sea towards the Danish coastline and has an important role in transporting sediment across the North Sea (Dyer and Moffat, 1998).

3.7.41 Monthly averaged satellite imagery of SPM relative to VE is presented in Figure 3.4. These data indicate that within the VE array areas average SPM is approximately 7 mg/l, increasing during winter months to values of approximately 11 mg/l (Cefas, 2016), occasionally reaching up to 18 mg/l.

3.7.42 As presented in Figure 3.4, the VE ECC shows variation along its length, with the highest values in the southern extents near the coast. The ECC shows a greater seasonality than the array areas, increasing in the winter months to mean SPM values between 30 to 120 mg/l.

3.7.43 Within both the array and ECC, higher SPM values are anticipated during spring tides and storm conditions, with the greatest concentrations encountered close to the seabed.

3.7.44 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 intertidal relative to the ZoI are the following stations, the locations of which are shown on Figure 3.1:

- Blackwater Wfd Intercalibration 01;
- North Sea At 51-46.0 N 01-11.2 E No.63;
- Holland Lso 100 M D/S Flood; and
- R. Orwell Foot Buoy Felixstowe.

3.7.45 A total of 28 parameters have been analysed at the R. Orwell monitoring point, of which the following are most relevant to the MW&SQ assessment:

- Water temperature;
- Turbidity (in-situ);
- Salinity (in-situ);
- Dissolved oxygen (% saturation); and
- Dissolved oxygen (as O_2).

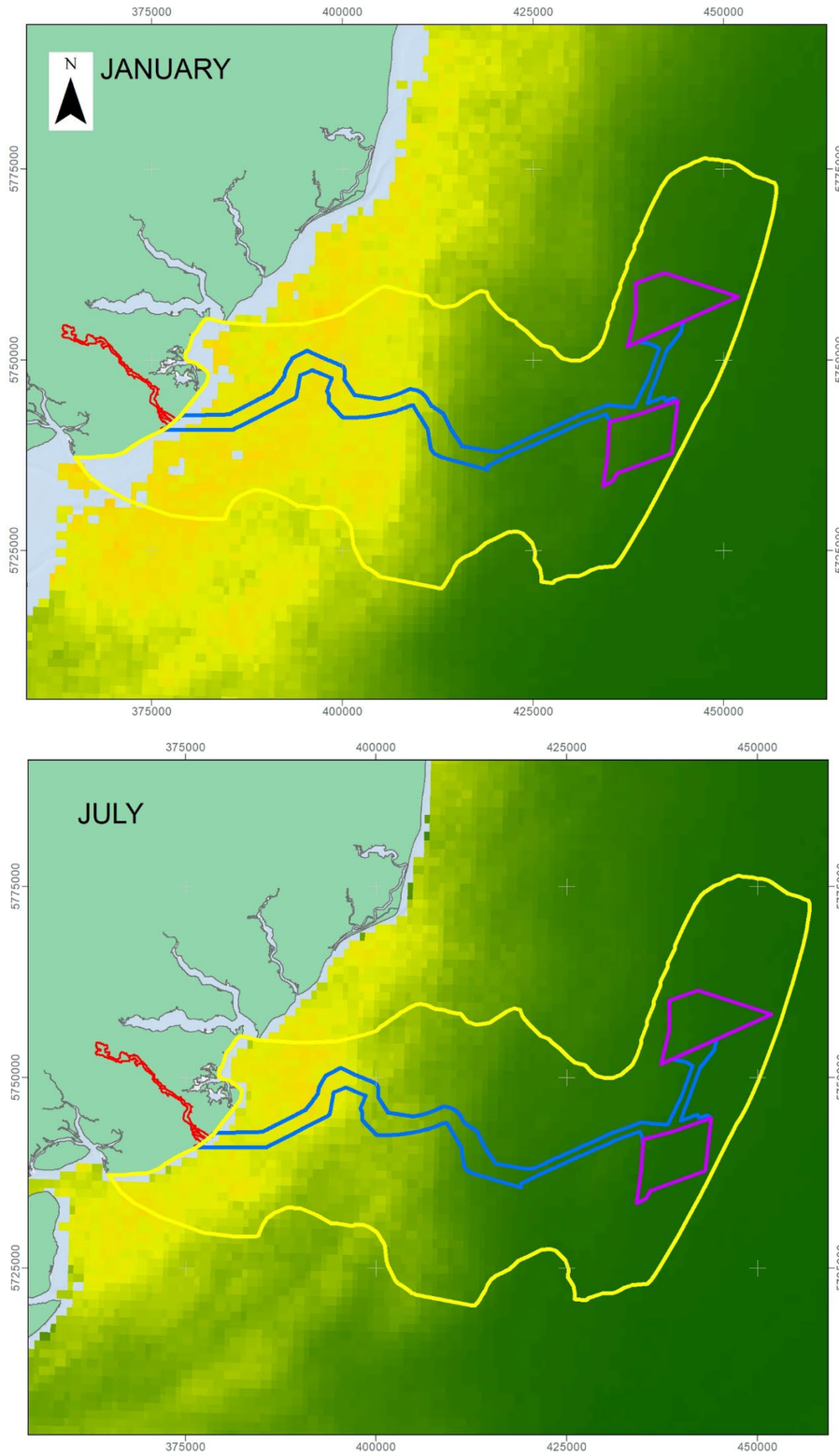
3.7.46 The remaining three monitoring points each analysed 22 parameters.

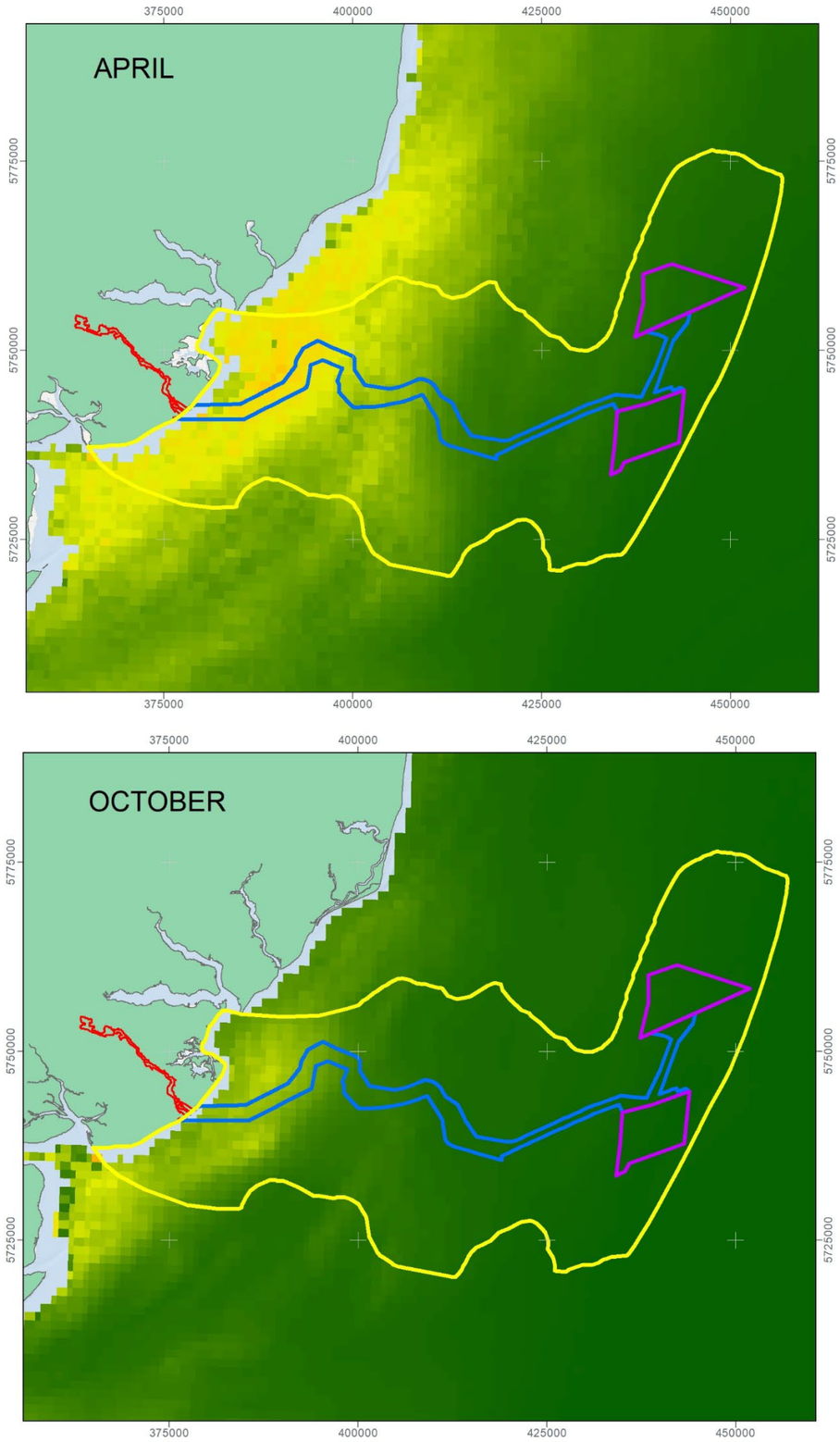
3.7.47 A summary of these parameters at the relevant monitoring stations is provided in Table 3.13.

Table 3.13 Summary of Environment Agency monitoring data (2018 to 2022) in coastal areas of the ECC study area (EA, 2022d).

Parameter	Details			
Sampling Point ID	Blackwater Wfd Intercalibration 01	North Sea At 51-46.0 N 01-11.2 E No.63	Holland Lso 100 M D/S Flood	R. Orwell Cliff Foot Buoy Felixstowe
Temperature of Water (°C)	$\bar{X}$=12.37 (9.4-14.6; n=3)	$\bar{X}$=12.93 (10.4-15; n=3)	$\bar{X}$=12.17 (2.3-21.5; n=33)	$\bar{X}$=12.3 (9.5-14.8; n=3)
Turbidity (in situ) (ftu)	$\bar{X}$=77.03 (35.5-142.1; n=3)	$\bar{X}$=43.03 (31.2-59.6; n=3)	$\bar{X}$=46.62 (4.5-115; n=30)	$\bar{X}$=68.23 (31.5-117.5; n=3)
Salinity (in situ) (ppt)	$\bar{X}$=34.39 (33.71-34.86; n=3)	$\bar{X}$=34.66 (34.46-34.84; n=3)	$\bar{X}$=34.30 (32.93-35.2; n=33)	$\bar{X}$=34.27 (33.75-34.65; n=3)
Dissolved Oxygen (Saturation) (%)	$\bar{X}$=95.23 (93-96.7; n=3)	$\bar{X}$=97.10 (97-97.2; n=3)	$\bar{X}$=97.26 (83.3-125; n=33)	$\bar{X}$=95.17 (92.2-97.4; n=3)
Dissolved Oxygen (as Oxygen) (mg/l)	$\bar{X}$=8.24 (7.95-8.61; n=3)	$\bar{X}$=8.29 (7.93-8.75; n=3)	$\bar{X}$=8.59 (6.04-11.5; n=33)	$\bar{X}$=8.25 (7.87-8.52; n=3)

This table presents data for monitoring stations in the vicinity of array area and cable route, used for baseline characterization. $\bar{X}$ is the average value calculated from the spread of results, with the minimum and maximum values shown in brackets, and the number of samples from each site shown by n.





LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Zone of Influence

SPM
180
150
120
90
60
30
0

0 15 30 60
Kilometres

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Analysed satellite SPM data (Cefas, 2016)

VER	DATE	REMARKS	Drawn	Checked
1	22/02/2023	For Issue	SWM	FM

DRAWING NUMBER:

3.4

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:750,000	A3	WGS84	UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

Z:\GIS\GIS_Projects\0144 Five Estuaries\GIS\Figures\PEIR\MWSQ\VE_MWSQ_SPM_Fig3_4_V1.mxd

DESIGNATED SITES

3.7.48 The offshore cable route transverses through the following WFD coastal water bodies (Figure 3.1):

- Essex coastal water body (ID: GB650503520001);
- Harwich Approaches coastal water body (ID: GB650503190000).

Both water bodies are 'heavily modified' due to flood protection works and currently (based on the 2019 (Cycle 3) classification) at moderate overall status, based on moderate ecological potential and failing chemical status. A summary of the current water body status (overall, ecological and chemical) and associated parameters is provided in Table 3.14.

Table 3.14: Summary (2019; Cycle 3) of the coastal water bodies relevant to MW&SQ (EA, 2022b; 2022c).

Parameter	Essex Coastal Water Body	Harwich Approaches Coastal Water Body
Water Body ID	GB650503520001	GB650503190000
Surface Area	1,196 km^2	23.99 km^2
Hydromorphological Designation (Reasons)	Heavily modified (flood protection)	Heavily modified (flood protection; navigation, ports and harbours)
Protected Area Designations	Special Protection Area; Ramsar Site; Special Area of Conservation, Shellfish Water Directive; Bathing Water Directive	Special Protection Area; Ramsar Site; Bathing Water Directive
Overall Status	Moderate	Moderate
Ecological Potential	Moderate	Moderate
Chemical Status	Fail	Fail
Parameters Currently Failing to Achieve Good Status/Potential	Dissolved Inorganic Nitrogen; Mitigation Measures Assessment; Mercury and its Compounds; Polybrominated diphenyl ethers (PBDE)	Mercury and its Compounds; Polybrominated diphenyl ethers (PBDE)
Higher Sensitivity Habitats (total habitat size within water body)	Intertidal seagrass (47.13 ha); Mussel beds (1.27 ha); Polychaete reef (28246.23 ha); Saltmarsh (458.66 ha); Subtidal kelp beds (0.01 ha)	Mussel beds (18.06 ha); Polychaete reef (130.20 ha); Saltmarsh (60.73 ha); Subtidal kelp beds (9.57 ha)
Lower Sensitivity Habitats (total	Cobbles, gravel and shingle (1153.58 ha); Intertidal soft sediment (5649.78 ha); Rocky	Cobbles, gravel and shingle (7.83 ha); Intertidal soft sediment (165.46 ha); Rocky

Parameter	Essex Coastal Water Body	Harwich Approaches Coastal Water Body
habitat size within water body)	shore (1.29 ha); Subtidal rocky reef (4.10 ha); Subtidal soft sediments (588957.42 ha)	shore (26.05 ha); Subtidal rocky reef (32.01 ha); Subtidal soft sediments (1955.66 ha)
Phytoplankton Status	High	High
History of Harmful Algae	Yes	Not monitored

3.7.49 There are eight designated bathing waters located within the MW&SQ study area (Table 3.15), of which Holland is located within the VE's ECC.

Table 3.15: Bathing Water summary (EA, 2022a).

Parameter	Classification			
	2018	2019	2021	2022
Dovercourt	Excellent	Excellent	Excellent	Excellent
Walton	Good	Excellent	Good	Excellent
Frinton	Good	Good	Good	Excellent
Holland	Excellent	Excellent	Excellent	Excellent
Clacton	Excellent	Excellent	Excellent	Excellent
Clacton (Groyne 41)	Excellent	Poor	Not classified	Not classified
Clacton Beach Martello Tower	Good	Good	Good	Good
Jaywick	Good	Good	Good	Good

Data was not collected in 2020 due to COVID-19

3.7.50 There is one Shellfish Water Protected Areas within the ZoI, Walton Backwaters, which is designated for production of wild Manila clam *Tapes philippinarum*, wild and farmed Pacific oyster *Crassostrea gigas* and farmed native oyster *Ostrea edulis* (MMO, 2021). Of note is that, according to the Cefas' Shellfish Classification Zone Maps (Cefas, 2022), Walton Backwaters is not currently classified nor subject to any current sampling plans/ monitoring (*E.coli*).

3.7.51 Further, there is no Coastal Sensitive Area (Eutrophic) designated within the ZoI.

3.7.52 The wider study area encompassed three Shellfish Water Protected Areas, which are designated due to the presence of certain bivalve molluscs. This ties into the River Basin Management Plan to improve shellfish growing waters. The shellfish production waters within the study area are shown below in Table 3.16.

Table 3.16: Shellfish production waters within the MW&SQ study area (Food Standards Agency, 2022).

Classification Zone	Species	Classification (*)
Thames Estuary		
Maplin East	*C. edule, Tapes* spp.	Seasonal A/B (Class A from 01 June to 31 October)
Barrows (Zone 12)	*C. edule*	Seasonal A/B (Class A from 01 June to 31 October)
East Barrows	*C. edule*	Seasonal A/B (Class A from 01 June to 31 October)
West Barrows (Zone 9)	*C. edule*	Seasonal A/B (Class A from 01 June to 31 October)
Black Deep	*Ensis* spp.	A
Blackwater		
Buxey Sands and Dengie Flats	*C. edule*	Seasonal A/ B (Class A from 01 November to 31 July)
St Peters & Batchelor	*C. gigas, O. edulis*	A
Ray Channel	*C. gigas, O. edulis*	A
St Peter's Flats	*C. gigas*	A
Colne		
Brightlingsea Creek Inner	*O. gigas, O. edulis*	B-LT
Brightlingsea Creek Outer	*C. gigas, O. edulis*	B-LT
Main Channel Central	*O. gigas, O. edulis*	B-LT
Main Channel Outer	*C. gigas, O. edulis*	B-LT

(*) Classification Date 06 December 2022 (effective until 31 August 2023)
Where classifications are based on *E. coli* concentration in shellfish flesh. Class A (80% of samples ≤ 230 *E. coli*/100g; all samples must be less than 700 *E. coli*/100g), Class B-LT (90% of samples must be ≤ 4600 *E. coli*/100g; all samples must be less than 46000 *E. coli*/100g- long-term classification).

EVOLUTION OF THE BASELINE

3.7.53 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 require that *"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"* is included within the ES (EIA Regulations, Schedule 4, Paragraph 3). From the point of assessment, over the course of the development and operational lifetime of VE (operational lifetime anticipated to be 25 years from first power), long-term trends mean that the condition of the baseline environment is expected to evolve.

3.7.54 Predictions of suspended particulate matter (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 2, Chapter 2: Marine Geology, Oceanography and Physical Processes);
- anthropogenic uses/ changes (Volume 2, Chapter 13: Other Marine Users and Activities); and
- increased precipitation over land and associated run-off (Volume 3, Chapter 6: Hydrology and Flood Risk).

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

3.7.56 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 reduce since 2010; this is expected to continue due to improved regulation and diffuse pollution control initiatives (OSPAR Commission, 2017).

3.7.57 Seawater chemistry, such as reductions in pH and to 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. In the absence of VE being constructed, no alterations to the evolving baseline environment, in respect of MW&SQ, are anticipated to occur.

3.8 KEY PARAMETERS FOR ASSESSMENT

3.8.1 This section identifies the maximum design scenario (MDS) of relevance to the assessment of impacts on MW&SQ, defined by the project design envelope (Volume 2, Chapter 1: Offshore Project Description). The method adopted is in accordance with the requirements of the Rochdale Envelope approach to environmental assessment as set out in the PINS Advice note nine: 'Using the Rochdale Envelope' (PINS, 2017), and as detailed in Volume 1, Chapter 1: Introduction.

3.8.2 The MDSs assessed for MW&SQ are described in Table 3.17. These scenarios will be taken forward to assess the realistic worst-case scenario for each of the identified potential impacts.

3.8.3 Each of the MDS (Table 3.17) which describe the construction and maintenance of the export cables are associated with the radial connection option. All references to infrastructure and activities in the array areas are applicable and form the realistic worst case for both the radial and offshore connection options.

Table 3.17: Maximum Design Scenario for the project alone.

Potential effect	Maximum design scenario assessed	Justification
Construction		
Impact 1: Deterioration in water quality due to suspension of sediments	**Total subtidal sediment volume = 106,249,775 m^3** **Seabed preparation for foundations (1,193,600 m^3):** > 79 small GBS (Wind Turbine Generator (WTG)) foundations for WTG = 1,137,600 m^3; and > 2 GBS foundations for OSP = 56,000 m^3. **Sandwave clearance for cable installation (99,750,000 m^3):** > Sandwave clearance for 100 km of inter-array cables resulting in the suspension of 35,000,000 m^3 of sediment; and > Sandwave clearance for 185 km of export cables resulting in the suspension of 64,750,000 m^3 of sediment. **Cable trenching (5,306,175 m^3):** > Installation of 200 km of inter-array cables by jetting resulting in the suspension of 3,150,000 m^3 of sediment; and > Installation of 370 km of export cables by jetting resulting in the suspension of 2,156,175 m^3 of sediment.	This design scenario results in the greatest sediment volumes being disturbed for all construction activities. > for foundation installation the MDS results from the largest volume suspended from seabed preparation and presents the worst-case for WTG installation; > for cable installation, the MDS results from the greatest volume from sandwave clearance and installation. This also assumes the largest number of cables and the

Potential effect	Maximum design scenario assessed	Justification
		greatest burial depth.
Impact 2: Deterioration in water clarity due to the release of drilling mud	**Total intertidal sediment volume = 38,575 m^3** > Five offshore HDD exit pits require excavation of 9,375 m^3 which will be side-cast onto the adjacent seabed. Backfilling of exit pits will recover a similar amount from the surrounding seabed, as required. It has not been confirmed whether exit pits will occur in the subtidal or intertidal; and > Drilling mud loss and drill cuttings of 24,700 m^3 and 4,500 m^3 respectively	The maximum bentonite volume of which could be released as part of the landfall activities is considered. It is assumed the method does not allow for the capture of bentonite and as such it is released directly into the marine environment.
Impact 3: Release of sediment-bound contaminants from disturbed sediments	The MDS and associated justification for sediment disturbance is presented in Impact 1.	
Impact 4: Accidental releases or spills of materials or chemicals	> Up to 35 construction vessels on-site simultaneously; > Up to 5,110 vessel round trips; > Up to 530 return trips by two helicopters with refuelling only taking place on an onshore base; and > There is the potential for synthetic compound, heavy metal and hydrocarbon contamination resulting from the construction of the WTGs and OSS: > A large WTG is expected to contain 1,736 litres of grease, 3,278 litres of hydraulic oil, 6,437 litres of gear oil, 210,207 litres of liquid nitrogen, 20,000 litres per kg of silicone oil, 1,000 litres of diesel fuel, 180 kg SF6 gas, 4,100 kg of batteries and 45,513 litre of glycol/ coolants; and	These parameters are considered to represent the maximum adverse scenario with regards to vessel movement during the construction period. These parameters present the maximum volumes of compounds which could be associated with the project infrastructure.

Potential effect	Maximum design scenario assessed	Justification
	> A typical OSP is expected to contain 3,000 litres of hydraulic oil, 1,000 litres of gear oil, 340,000 litre/kg of transformer silicon/ ester oil, 120,000 litre of diesel fuel, 10,000 kg SF6 gas, 90,000 litres of glycol/ coolant, 350,000 kg of batteries, 5,000 litres of grey water and 3,000 litres of black water. Minimal amount of grease, and nitrogen may also be within the OSPs.	
Operation		
Impact 5: Deterioration in water quality due to suspension of sediments from O&M activities	> Up to 276,656 m^2 of the seabed may be disturbed due to inter-array cable repairs; > Up to eight inter-array cable repairs/replacements (up to 5 km) may require reburial/ remedial works that involve seabed disturbance; > Up to 259,280 m^2 of the seabed may be disturbed due to export cable repairs; and > Up to 16 export cable repairs/replacements (up to 5 km) may require reburial/ remedial works that involve seabed disturbance.	The maximum lengths of cables which may require maintenance and repair works have been considered in this assessment to provide a reasonable worst-case for the purposes of this assessment.
Impact 6: Deterioration in water quality due to suspension of sediments from scour	> Defined from the outputs of the scour assessment. For assessment purposes, it is assumed that scour protection around foundations is not installed.	This design configuration of foundations and foundation types are most likely to result in the development of scour pits one the seabed. In addition, the worst-case cable protection and crossings designs which could result in scour have been considered.
Impact 7: Accidental releases or spills of	> Up to 27 operation and maintenance vessels on-site simultaneously; > Up to 1,776 vessel annual round trips;	These parameters are considered to represent the maximum adverse

Potential effect	Maximum design scenario assessed	Justification
materials or chemicals	> Up to 125 return trips per year within the O&M phase by two helicopters with refuelling only taking place on an onshore base; > There is the potential for synthetic compound, heavy metal and hydrocarbon contamination resulting from accidental events involving the WTGs and OSS: > A large WTG is expected to contain 1,736 litres of grease, 3,278 litres of hydraulic oil, 6,437 litres of gear oil, 210,207 litres of liquid nitrogen, 20,000 litres per kg of silicone oil, 1,000 litres of diesel fuel, 180 kg SF6 gas, 4,100 kg of batteries and 45,513 litres of glycol/ coolants; and > A typical OSP is expected to contain 3,000 litres of hydraulic oil, 1,000 litres of gear oil, 340,000 litre/kg of transformer silicon/ ester oil, 120,000 litre of diesel fuel, 10,000 kg SF6 gas, 90,000 litres of glycol/ coolant, 350,000 kg of batteries, 5,000 litres of grey water and 3,000 litres of black water. Minimal amount of grease, and nitrogen may also be within the OSPs.	scenario with regards to vessel movement during the Operation and Maintenance period. These parameters present the maximum volumes of compounds which could be associated with the project infrastructure.
Decommissioning		
Impact 8: Deterioration in water quality due to re-suspension of sediments	> The decommissioning phase will last up to three-years. > Buried cables to be 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*; > Landfall infrastructure to (but to be determined in consultation with key stakeholders as part of the	This scenario represents the maximum design scenario for the decommissioning of VE at the time of writing.

Potential effect	Maximum design scenario assessed	Justification
	decommissioning plan and following best practice at the time); and > Structures in the array to be cut off at or below the seabed.	

Impact 9: Accidental releases or spills of materials or chemicals	> Up to 35 construction vessels on-site simultaneously;
	> Up to 5,110 vessel round trips;
	> Up to 530 return trips by two helicopters with refuelling only taking place on an onshore base; and
	> There is the potential for synthetic compound, heavy metal and hydrocarbon contamination resulting from the decommissioning of the WTGs and OSS:
	  > A large WTG is expected to contain 1,736 litres of grease, 3,278 litres of hydraulic oil, 6,437 litres of gear oil, 210,207 litres of liquid nitrogen, 20,000 litres per kg of silicone oil, 1,000 litres of diesel fuel, 180 kg SF6 gas, 4,100 kg of batteries and 45,513 litre of glycol/ coolants; and
	  > A typical OSP is expected to contain 3,000 litres of hydraulic oil, 1,000 litres of gear oil, 340,000 litre/kg of transformer silicon/ ester oil, 120,000 litre of diesel fuel, 10,000 kg SF6 gas, 90,000 litres of glycol/ coolant, 350,000 kg of batteries, 5,000 litres of grey water and 3,000 litres of black water. Minimal amount of grease, and nitrogen may also be within the OSPs.
		These parameters are considered to represent the maximum adverse scenario with regards to vessel movement during the decommissioning period.
		These parameters present the maximum volumes of compounds which could be associated with the project infrastructure.

3.9 EMBEDDED MITIGATION

3.9.1 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

3.9.2 Table 3.18. General mitigation measures, which would apply to all parts of the project, are set out first. Thereafter mitigation measures that would apply specifically to MW&SQ issues associated with the array, offshore ECC and landfall are described separately.

3.9.3 The embedded mitigation contained in

3.9.4 Table 3.18 are mitigation measures or commitments that have been identified and adopted as part of the evolution of the project design of relevance to the topic, these include project design measures, compliance with elements of good practice and use of standard protocols.

Table 3.18: Embedded mitigation relating to MW&SQ.

Project phase	Mitigation measures embedded into the project design
General	
Project design	The development boundary selection was made following a series of constraints analyses, with the array area and offshore ECC route selected to ensure the impacts on the environment and other marine users are minimised as far as reasonably practicable.
Pollution prevention	A PEMP is proposed to be produced to ensure that the potential for contaminant release is strictly controlled. The PEMP will include a Marine Pollution Contingency Plan (MPCP) and will also incorporate plans to cover accidental spills, potential contaminant release and include key emergency contact details (e.g., Environment Agency, Natural England, Maritime Coastguard Agency and the project site co-ordinator). The PEMP will be secured as a condition in the deemed Marine Licence(s). Typical measures will include: > Storage of all chemicals in secure designated areas with impermeable bunding (generally to 110% of the volume); and > Double skinning of pipes and tanks containing hazardous materials. The purpose of these measures is to ensure that potential for contaminant release is strictly controlled and provides protection to marine life across all phases of the life of the wind farm.

Project phase	Mitigation measures embedded into the project design
Pollution prevention	VE OWFL commits to the disposal of sewage and other waste in a manner which complies with all regulatory requirements, including but not limited to the IMO MARPOL requirements[2].
Construction	
Cable Specification and Installation Plan (CSIP)	Development of, and adherence to, a Cable Specification and Installation Plan (CSIP) post consent. The CSIP will set out appropriate cable burial depth in accordance with industry good practice, minimising the risk of cable exposure. The CSIP will also ensure that cable crossings are appropriately designed to mitigate environmental effects, these crossings will be agreed with relevant parties in advance of CSIP submission. The CSIP will include a detailed Cable Burial Risk Assessment (CBRA) to enable informed judgements regarding burial depth to maximise the chance of cables remaining buried whilst limiting the amount of sediment disturbance to that which is necessary. The CSIP will be conditioned in the Marine Licence.
Operation	
Project design	Where burial depth cannot be achieved, cable armouring will be implemented (e.g., mattressing, rock placement etc). The suitability of installing rock or mattresses for cable protection will be investigated, based on (inter alia) the seabed current data at the location of interest, the assessed risk of impact damage and navigational water depth requirements.
Project design	In areas where there is potential for scour pits to develop around the foundations of structure, then scour protection will be implemented.
Scour Protection Management Plan	Development of a Scour Protection Plan (SPP) which will consider the need for scour protection where there is the potential for scour to develop around wind farm infrastructure, including turbine and substation/ platform foundations and cables. The plan will be secured via a condition in the deemed Marine Licence.
Decommissioning	
Decommissioning Programme	A Decommissioning Programme will be developed to cover the decommissioning phase as required under Chapter 3 of the Energy Act 2004. As the decommissioning phase will be a similar process to the construction phase but in reverse (i.e., increased project vessels on-site, partially deconstructed structures) the embedded mitigation measure will be similar to those for the construction

[2] https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-%28MARPOL%29.aspx

Project phase	Mitigation measures embedded into the project design
	phase. The Decommissioning Plan will be secured as a condition in the DCO.

3.10 ENVIRONMENTAL ASSESSMENT: CONSTRUCTION PHASE

3.10.1 The effects of construction on VE have been assessed on MW&SQ receptors within the VE MW&SQ study area (Section 3.4). The environmental impacts arising from construction of VE are listed in Table 3.17, along with the design envelope against which each construction phase impact has been assessed.

3.10.2 An assessment of the potential SSC increases is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes of this PEIR report for all project phases. The conclusions of this MW&SQ are primarily based upon this sediment plume assessment, the full details of which, including the methodological approach used to assess the characteristics of sediment plumes and associated bed level changes are given in Volume 4, Annex 2.1: Physical Processes Technical Baseline.

3.10.3 For ease of reference, this section provides a summary of the key results regarding the potential effects upon SSC that have been used to inform this MW&SQ assessment.

3.10.4 Four main zones of effect are predicted for each of the seabed disturbance activities. Within each of these, the SSC elevations are primarily controlled by the sediment volume, the resuspension height/ release above the seabed, and the ambient current speed and direction at the time:

- **0 to 50 m** – zone of highest SSC increase and greatest likely thickness of deposition. All gravel sized sediment likely deposited in this zone, also a large proportion of sands that are not resuspended high into the water column, and also most or all dredge spoil in the active phase:
  - At the time of active disturbance – very high SSC increase (tens to hundreds of thousands of mg/l) lasting for the duration of the active disturbance, plus up to 30 minutes following end of disturbance;
  - One hour after the cessation of active disturbance – no SSC change.
- **50 to 500 m** – zone of measurable SSC increase. Mainly sands that are released or resuspended higher in the water column and resettling to the seabed whilst being advected by ambient tidal currents:
  - at the time of active disturbance – high SSC increase (hundreds to low thousands of mg/l) lasting for the duration of active disturbance plus up to 30 minutes following end of disturbance.
  - more than one hour after end of active disturbance – no SSC change.
- **500 m to the tidal excursion buffer distance** - zone of lesser, but measurable SSC increase. Mainly fines that are maintained in suspension for more than one tidal cycle and are advected by ambient tidal currents:

- at the time of active disturbance – low to intermediate SSC increase (tens to low hundreds of mg/l) as a result of any remaining fines in suspension, only within a narrow plume (tens to a few hundreds of metres wide, SSC decreasing rapidly by dispersion to ambient values within one day after the end of active disturbance.
- one to six hours after end of active disturbance – decreasing to low SSC increase (tens of mg/l);
- six to 24 hours after end of active disturbance – decreasing gradually through dispersion to background SSC (no measurable local increase). No measurable change from baseline SSC after 24 to 48 hours following cessation of activities.

- **Beyond the tidal excursion buffer distance** or anywhere not tidally aligned to the active sediment disturbance activity – there is no expected impact or change to SSC nor a measurable sediment deposition.

IMPACT 1: DETERIORATION IN WATER QUALITY DUE TO SUSPENSION OF SEDIMENTS

3.10.5 Those offshore construction activities associated with VE that have the potential to result in elevated SSC through the generation of sediment plumes include seabed preparation activities for foundations, sandwave clearance, and cable trenching (Table 3.17). An increase in SSC, and so turbidity, may result in a decrease in the depth to which natural light can penetrate into the water column. This in turn may result in a reduction in primary productivity and/or an increase in bacterial growth. Seabed disturbance may also release of additional nutrients, which were sediment-bound, into the water column consequentially increasing associated concentrations.

3.10.6 Fish and many other organisms need dissolved oxygen in the water to survive. Dissolved oxygen levels can decrease due to various factors, including rapid changes in temperature and salinity, 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.

MAGNITUDE OF THE EFFECT

3.10.7 Neither phytoplankton nor dissolved oxygen are anticipated to be affected by the proposed project activities; any release of seabed nutrients is anticipated to remain within natural variation, the maxima of which occur during storm events. All effects are anticipated to be temporary in nature, given the short-term discrete nature of the project activities. This is confirmed within Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes which fully details the short-term nature of sediment suspension from seabed preparation activities. In addition to the absence of significant nutrient releases, there are no outfalls or discharges associated with the project. Therefore, the proposed activities are not expected to cause a reduction in the dissolved oxygen in 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.

3.10.8 As previously noted, the maximum SSC anticipated after one day of cessation of the seabed disturbance will be less than 100 mg/l. This would be classified as '*intermediate*' in the UKTAG (2014) water turbidity ranking. After two days, the sediment plumes would be immeasurable in practice and may be classified as '*clear*' (UKTAG, 2014).

3.10.9 Bacterium mortality within the water column, including that of *E.coli* and IE, is strongly influenced by the levels of UV light penetrating the water column. Under higher UV scenarios, bacterium mortality is higher. Therefore, the reduced water clarity due to works within the coastal zone, including the intertidal, could result in temporary increases in bacterial counts within the water column. This would result from reduced UV levels and a decreased bacterial mortality alongside the potential release of sediment bound bacteria (including *E.coli* and IE). These elevated bacterial counts could theoretically 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 3.15). A reduction in the water quality at the Shellfish Protected Area identified may result in a compliance failure with the microbial standard specified in the Shellfish Waters Protected Areas (England and Wales) Directive.

3.10.10 Given the predicted dilution levels (Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes), the temporary nature of the project's seabed activities, and SSC dispersion from tidal currents it is anticipated that any bacterial increases in the water column would be in the order of days, i.e., as long as the plumes persisted. Following the dispersion of the sediment plumes alongside the 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. These potential changes are within the natural variation of the marine environment during high energy low frequency events.

3.10.11 Of note is that any seabed disturbance activities which occur within the array are not predicted to impact upon designated WFD waterbodies (Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes).

3.10.12 Any elevated SSC levels and associated reductions in bacterium mortality are shown to be localised, temporary and within the range of natural variability. The magnitude of the impact is considered to be **low** adverse for potential impacts to water quality.

SENSITIVITY OF THE RECEPTOR

3.10.13 The sensitivity of the identified Bathing Waters is considered to be **low** adverse, for potential increased bacterial counts (with a moderate capacity to accommodate the changes within natural variation).

3.10.14 The sensitivity of the identified Shellfish Water Protected Areas to reductions in water clarity and release of sediment bound contaminants is considered to be **low** adverse.

3.10.15 The sensitivity of the Essex and Harwich Approaches coastal water bodies is considered **low** adverse, with respect to water quality reductions.

3.10.16 The sensitivity of the non-designated waters are considered resistant to temporary reductions in water clarity. Therefore, the sensitivity of non-designated waters is judged to be **negligible adverse**.

SIGNIFICANCE OF THE EFFECT

3.10.17 The magnitude of the increases to the SSC and associated decrease in bacterial mortality is considered **low** adverse. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: **minor adverse** (not significant in terms of EIA Regulations);
- Shellfish Water Protected Areas: **minor** adverse (not significant in terms of EIA Regulations);
- Essex and Harwich Approaches coastal water bodies: **minor** adverse (not significant in terms of EIA Regulations);
- Non-designated waters: **negligible** adverse (not significant in terms of EIA Regulations).

3.10.18 No additional mitigation to that already identified in

3.10.19 Table 3.18 is considered necessary. Therefore, no significant adverse residual effects have been predicted for MW&SQ receptors.

IMPACT 2: DETERIORATION IN WATER CLARITY DUE TO THE RELEASE OF DRILLING MUD

3.10.20 Drilling mud, such as bentonite (or another inert mud), will be used to undertake HDD and make landfall. This will consequently result in the release of drilling mud within the intertidal area at the punch out point under the MDS assessed (Table 3.17).

3.10.21 Bentonite is a non-toxic, inert, natural clay mineral (<63 µm particle diameter) included in the List of Notified Chemicals approved for use and discharge into the marine environment. Classified as a Group E substance under the Offshore Chemical Notification Scheme for which it is least likely to cause environmental harm being *"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) .

3.10.22 This assessment has been based on the maximum bentonite volume which could be released into the environment (Table 3.17). The principal issue, for MW&SQ receptors, relating to bentonite release to the water column comprises the potential for an increase in SSC (and so turbidity) within the water column and thus a potential reduction in bacterial mortality, as detailed in *Impact 1: deterioration in water quality due to suspension of sediment.* With the exception of the potential for increased turbidity from a bentonite release, no other potential deterioration in water quality, such as the introduction of contaminants or nutrients, is anticipated following the release of drilling mud.

MAGNITUDE OF THE EFFECT

3.10.23 Bentonite is a clay-based substance and as such may persist in suspension for hours to days following release, becoming diluted to very low concentrations (indistinguishable from natural background levels and variability). The majority of the plume will be advected in the direction of the ambient tidal currents, which are broadly aligned to the coast. The transport direction will depend upon the tidal state (flood/ ebb) during release and it is expected that the plume would be dispersed to relatively low concentrations within hours of release and to background concentrations within a few tidal cycles.

3.10.24 As previously described, a relationship exists between increased turbidity/ SSC and decreased bacterial mortality within the water column. Given the predicted dilution levels, the temporary nature of the activities and SSC dispersion by tidal currents, it is expected that any bacterial increases within the water column would be in the order of days. Following the dispersion of the bentonite plumes, and subsequent increases in UV light, the bacterial counts in the water column will return to "do-nothing" baseline conditions. The resultant reduction in water clarity is considered to be analogous to storm events and as such these potential changes remain within the marine environment's natural variation.

3.10.25 The SSC elevation and potential decrease in bacterial mortality as a consequence of the release of inert drilling mud, such as bentonite, would be temporary, localised and within the range of natural variability. The magnitude of these elevated concentrations and potential bacterial counts on water quality receptors is considered to be **low** adverse.

SENSITIVITY OF THE RECEPTOR

3.10.26 The sensitivity of the identified Bathing Waters is considered to be **low** adverse, for potential increased bacterial counts (with a moderate capacity to accommodate the changes within natural variation).

3.10.27 The sensitivity of the identified Shellfish Water Protected Areas to reductions in water clarity is considered to be **low** adverse.

3.10.28 The sensitivity of the Essex and Harwich Approaches coastal water bodies is considered **low** adverse, with respect to water quality reductions.

3.10.29 The sensitivity of the non-designated waters is considered resistant to temporary reductions in water clarity. Therefore, the sensitivity of non-designated waters is judged to be **negligible** adverse.

SIGNIFICANCE OF THE EFFECT

3.10.30 The magnitude of the increases to the SSC and associated decrease in bacterial mortality is considered **low adverse**. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: **minor adverse** (not significant in terms of EIA Regulations);
- Shellfish Water Protected Areas: **minor adverse** (not significant in terms of EIA Regulations);
- Essex and Harwich Approaches coastal water bodies: **minor adverse** (not significant in terms of EIA Regulations);
- Non-designated waters: **negligible adverse** (not significant in terms of EIA Regulations).

3.10.31 If the drilling fluid were captured within a cofferdam(s), the magnitude of the impact would be reduced to **negligible adverse**. The significance of the effect on the Bathing Waters, Shellfish Protected Waters, WFD waterbodies and the receiving environment more broadly can be concluded to be **negligible adverse**, which is not significant in terms of the EIA Regulations. Therefore, no significant adverse residual effects have been predicted in respect of MW&SQ receptors.

IMPACT 3: RELEASE OF SEDIMENT-BOUND CONTAMINANTS FROM DISTURBED SEDIMENTS

3.10.32 The construction activities associated with the project have the potential to increase SSC in the marine environment through the generation of sediment plumes (Table 3.17). 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 THE EFFECT

3.10.33 Details relating to the sediment contamination levels within the array and ECC are presented in Table 3.8. through to Table 3.12. The project specific surveys indicate that the contamination within the array and the intertidal are low:

- Array: no samples exceeded CAL1. At all stations, the arsenic concentration exceeded the Canadian TEL but were below the PEL; and
- Intertidal: no samples exceeded CAL1 nor the Canadian TEL.

3.10.34 Within the ECC, the following contaminations become relevant for this assessment:

- higher levels of metal contamination have been identified at the same four sample stations, specifically:
  - Arsenic; all four stations exceed CAL1 and TEL. Of these, two exceed PEL but not CAL2. Both these stations are in the offshore section of the ECC, circa 43 km offshore and 9 km from the shoreward boundary of the array.
  - Cadmium; one station exceeds CAL1 only in the offshore section of the ECC;

- Chromium; one station exceeds CAL1 only in the offshore section of the ECC;
- Nickel; three offshore stations and one nearshore (circa 2.5 km offshore) exceeds CAL1 only.

- For PAH, the Gorham-Test approach indicates that the sum of LMW and HWM PAHs do not exceed the ERL (equivalent to CAL1) at any station.

3.10.35 The tidal regime has been shown to be relatively energetic (peak current speeds on a mean spring tide are circa 0.8 to 1.3 m/s (Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes). As such, the discharge location has no restricted dilution or dispersion. Thus, it is expected that, whilst there may be some contaminant (metal) release predominately within the offshore area of the ECC, 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 2, Chapter 2: Marine Geology, Oceanography and Physical Processes.

3.10.36 Typically, whilst very small 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) Environmental Quality Standards (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.

3.10.37 Moreover, given the short-term nature of the works and presence of the sediment plumes, any small uplift in the water concentrations of EQS substances would be anticipated to return to background levels very quickly.

3.10.38 It should be noted that any activities disturbing sediment within the array area are not anticipated to impact on the designated WFD waterbodies. The project specific modelling indicates that no works undertaken in the array have measurable changes in SSC within the WFD water bodies.

3.10.39 The magnitude of this potential impact is considered to be **low** adverse 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

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

3.10.41 The sensitivity of the identified Shellfish Water Protected Areas to the release of sediment bound contaminants is considered to be **low** adverse.

3.10.42 The sensitivity of the Essex and Harwich Approaches coastal water bodies is considered **low** adverse, with respect to the release of sediment bound contaminants.

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

SIGNIFICANCE OF THE EFFECT

3.10.44 The magnitude of the release of sediment bound contaminants is considered **low** adverse. Based on the sensitivity of the different receptors presented in the preceding section, the significance(s) is considered to be:

- Bathing Waters: **minor** adverse (not significant in terms of EIA Regulations);
- Shellfish Water Protected Areas: **minor** adverse (not significant in terms of EIA Regulations);
- Essex and Harwich Approaches coastal water bodies: **minor** adverse (not significant in terms of EIA Regulations);
- Non-designated waters: **negligible** adverse (not significant in terms of EIA Regulations).

3.10.45 No additional mitigation to that already identified in

3.10.46 Table 3.18 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of MW&SQ receptors.

IMPACT 4: ACCIDENTAL RELEASES OR SPILLS OF MATERIALS OR CHEMICALS

3.10.47 Substances such as grease, oil, fuel, anti-fouling paints and grouting materials may be accidentally released or spilt into the marine environment. VE is committed to the use of best practice, due diligence and pollution prevention guidelines at all times. As outlined in

3.10.48 Table 3.18, a MPCP (likely to be embedded within the PEMP) would be in place and agreed (through Conditions in the Marine Licence) in line with the Integrated Pollution Prevention and Control (IPPC) Directive (Directive 2008/1/EC or equivalent at that time) such that any potential risk is minimised. Any planned discharges would be permitted small volumes, intermittent and would dilute and disperse quickly.

3.10.49 This commitment ensures the use of appropriate preventative measures and serves as an embedded mitigation against this type of pollution incidence (see

3.10.50 Table 3.18). If an accidental spill occurs, all relevant parties would be informed as required in the MPCP.

MAGNITUDE OF THE EFFECT

3.10.51 No discharges (continuous or intermittent) are proposed during the construction phase of VE with the exception of drilling mud (see Impact 2). The MDS for the volumes of chemicals and materials used in the construction/ infrastructure associated with VE are presented in Table 3.17.

3.10.52 Any quantities of accidentally released materials are likely to be small. Associated lateral and vertical dispersion rates are expected to be high. The potential impacts will be temporary in nature and project controls will be in place. The magnitude of this potential impact is considered to be **negligible** adverse, as it is not anticipated to affect the waterbodies performance against their EQSs.

SENSITIVITY OF THE RECEPTOR

3.10.53 Bathing Waters status is dependent on the monitoring of the bacterial counts. No source-receptor-pathway has been identified which could affect bacterial counts at the Bathing Waters from accidental spills and consequently is considered to be of **negligible** adverse sensitivity.

3.10.54 The sensitivity of the identified Shellfish Water Protected Areas to accidental spills is considered to be **low** adverse.

3.10.55 The Essex and Harwich Approaches coastal water bodies are internationally designated sites under the WFD but judged to have a high ability to accommodate a small accidental spill (if it were to occur). The sensitivity of the water bodies to the proposed change is deemed to be **low** adverse.

3.10.56 The sensitivity of non-designated waters is judged to be **negligible** adverse. There is no applicable quality status which may be affected by a small accidental spill event.

SIGNIFICANCE OF THE EFFECT

3.10.57 The magnitude of an accidental spill event is considered *negligible*. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: **negligible** adverse (not significant in terms of EIA Regulations);
- Shellfish Water Protected Areas: **negligible** adverse (not significant in terms of EIA Regulations);
- Essex and Harwich Approaches coastal water bodies: **negligible** adverse (not significant in terms of EIA Regulations);
- Non-designated waters: **negligible** adverse (not significant in terms of EIA Regulations).

3.10.58 No additional mitigation to that already identified in

3.10.59 Table 3.18 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of MW&SQ receptors.

3.11 ENVIRONMENTAL ASSESSMENT: OPERATIONAL PHASE

3.11.1 The effects of VE project activities within the O&M phase have been assessed on MW&SQ receptors within the VE MW&SQ study area (Section 3.4). The potential identified environmental impacts arising from the O&M of VE are listed in Table 3.17, along with the design envelope against which each O&M phase impact has been assessed.

3.11.2 A description of the significance of effect upon MW&SQ receptors caused by each identified impact is also provided below.

IMPACT 5: DETERIORATION IN WATER QUALITY DUE TO SUSPENSION OF SEDIMENTS FROM O&M ACTIVITIES

3.11.3 As presented in Table 3.17, if a section of the cable became exposed or damaged it would require reburial and/ or replacement. Reburial (and/ or replacement) would be undertaken using similar techniques to that set out in the assessment of SSC and bed level changes associated with cable installation activities (see Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes). 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.

3.11.4 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 2, Chapter 2: Marine Geology, Oceanography and Physical Processes.

MAGNITUDE OF THE EFFECT

3.11.5 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 **low** adverse for the potential deterioration in water quality.

SENSITIVITY OF THE RECEPTOR

3.11.6 The sensitivity of the identified Bathing Waters is considered to be **low** adverse, for potential increased bacterial counts (with a moderate capacity to accommodate the changes within natural variation).

3.11.7 The sensitivity of the identified Shellfish Water Protected Areas to reductions in water clarity and release of sediment bound contaminants is considered to be **low** adverse.

3.11.8 The sensitivity of the Essex and Harwich Approaches coastal water bodies is considered **low** adverse, with respect to water quality reductions.

3.11.9 The sensitivity of the non-designated waters are considered resistant to temporary reductions in water clarity. Therefore, the sensitivity of non-designated waters is judged to be **negligible** adverse.

SIGNIFICANCE OF THE EFFECT

3.11.10 The magnitude of the increases to the SSC and associated decrease in bacterial mortality is considered **low adverse**. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: **minor adverse** (not significant in terms of EIA Regulations);
- Shellfish Water Protected Areas: **minor** adverse (not significant in terms of EIA Regulations);
- Essex and Harwich Approaches coastal water bodies: **minor adverse** (not significant in terms of EIA Regulations);
- Non-designated waters: **negligible** adverse (not significant in terms of EIA Regulations).

3.11.11 No additional mitigation to that already identified in

3.11.12 Table 3.18 is considered necessary. Therefore, no significant adverse residual effects have been predicted for MW&SQ receptors.

IMPACT 6: DETERIORATION IN WATER QUALITY DUE TO SUSPENSION OF SEDIMENTS FROM SCOUR

3.11.13 The term scour refers here to the development of pits, troughs or other depressions in the seabed sediments around the base of the project infrastructure. Scour results from sediment removal over time due to the complex three-dimensional interaction between the foundation and ambient flow regime (currents and/ or waves).

3.11.14 Scour assessment for EIA purposes is considered within Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes for monopile, multi-leg jacket and gravity base foundations in addition to scour around cable protection measures. Seabed scour will lead to sediment re-suspension before an equilibrium of scour pit development is reached. These impacts are considered associated with the O&M phase of the proposed development and primarily within the array.

3.11.15 Under waves or combined waves and currents an equilibrium scour depth for the conditions existing at that time may be achieved over a period of minutes, whilst typically under tidal flows alone equilibrium scour conditions may take several months to develop.

MAGNITUDE OF THE EFFECT

3.11.16 The magnitude of any change to the seabed topography will vary depending upon the infrastructure type (including different foundation types), the local baseline oceanographic and sedimentary environments and the type of scour protection implemented (if needed). Whilst the modified sediment character within a scour pit may be comparable to the surrounding seabed, changes relating to bed slope and elevated flow speed and turbulence close to the foundation are still likely to apply.

3.11.17 Any SSC elevation as a consequence of scour is shown in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes to be short-lived, localised and within the range of natural variability. Therefore, magnitude of the potential to release sediment-bound contaminants as a result of seabed scour is considered to be **negligible** adverse.

SENSITIVITY OF THE RECEPTOR

3.11.18 The sensitivity of the identified Bathing Waters is considered to be **low** adverse, for a deterioration in water quality resulting from scour and the consequential potential increased bacterial counts (with a moderate capacity to accommodate the changes within natural variation).

3.11.19 The sensitivity of the identified Shellfish Water Protected Areas to reductions in water clarity and release of sediment bound contaminants is considered to be **low** adverse.

3.11.20 The sensitivity of the Essex and Harwich Approaches coastal water bodies is considered **low** adverse, with respect to water quality reductions resulting from scour.

3.11.21 The sensitivity of the non-designated waters are considered resistant to temporary reductions in water clarity resulting from scour. Therefore, the sensitivity of non-designated waters is judged to be **negligible** adverse.

SIGNIFICANCE OF THE EFFECT

3.11.22 The magnitude of elevated SSC resulting from scour is considered *negligible*. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: **negligible** adverse (not significant in terms of EIA Regulations);
- Shellfish Water Protected Areas: **negligible** adverse (not significant in terms of EIA Regulations);
- Essex and Harwich Approaches coastal water bodies: **negligible** adverse (not significant in terms of EIA Regulations);
- Non-designated waters: **negligible** adverse (not significant in terms of EIA Regulations).

3.11.23 No additional mitigation to that already identified in

3.11.24 Table 3.18 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of MW&SQ receptors.

IMPACT 7: ACCIDENTAL RELEASES OR SPILLS OF MATERIALS OR CHEMICALS

3.11.25 There is a potential risk of the accidental spillage or release of materials such as grease and oils during maintenance work and from vessels associated with the windfarm. As noted above, VE is committed to the use of best practice and pollution prevention guidelines at all times. These commitments will be secured through Conditions in the Marine Licence. Any permitted discharges would be small volumes, intermittent and dilute and disperse quickly.

MAGNITUDE OF THE EFFECT

3.11.26 No discharges (continuous or intermittent) are proposed during the O&M phase of VE. The MDS for the volumes of chemicals and materials used in the construction/ infrastructure associated with VE are presented in Table 3.17.

3.11.27 Any quantities of accidentally released materials are likely to be small. Associated lateral and vertical dispersion rates are expected to be high. The potential impacts will be temporary in nature and project controls will be in place. The magnitude of this potential impact is considered to be **negligible** adverse, as it is not anticipated to affect the waterbodies performance against their EQSs.

SENSITIVITY OF THE RECEPTOR

3.11.28 Bathing Waters status is dependent on the monitoring of the bacterial counts. No source-receptor-pathway has been identified which could affect bacterial counts at the Bathing Waters from accidental spills and consequently is considered to be of **negligible** adverse sensitivity.

3.11.29 The sensitivity of the identified Shellfish Water Protected Areas to accidental spills is considered to be **low** adverse.

3.11.30 The Essex and Harwich Approaches coastal water bodies are internationally designated sites under the WFD judged to have a high ability to accommodate a small accidental spill (if it were to occur) owing to the overall status of Moderate. The sensitivity of the waterbody to the proposed change is deemed to be **low** adverse.

3.11.31 The sensitivity of non-designated waters is judged to be **negligible** adverse. There is no applicable quality status which may be affected by a small accidental spill event.

SIGNIFICANCE OF THE EFFECT

3.11.32 The magnitude of an accidental spill event is considered *negligible*. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: **negligible** adverse (not significant in terms of EIA Regulations);
- Shellfish Water Protected Areas: **negligible** adverse (not significant in terms of EIA Regulations);
- Essex and Harwich Approaches coastal water bodies: **negligible** adverse (not significant in terms of EIA Regulations);
- Non-designated waters: **negligible** adverse (not significant in terms of EIA Regulations).

3.11.33 No additional mitigation to that already identified in

3.11.34 Table 3.18 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of MW&SQ receptors.

3.12 ENVIRONMENTAL ASSESSMENT: DECOMMISSIONING PHASE

3.12.1 The effects of decommissioning on VE have been assessed on MW&SQ receptors within the VE MW&SQ study area (Section 3.4). The environmental impacts arising from the decommissioning of VE are listed in Table 3.17, along with the design envelope against which each decommissioning phase impact has been assessed.

3.12.2 As presented in Table 3.17, 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, these have been assessed based on the worst-case construction impacts and are presented in the following sections.

IMPACT 8: DETERIORATION IN WATER QUALITY DUE TO RE-SUSPENSION OF SEDIMENTS

3.12.3 As outlined in Table 3.17, the VE project infrastructure will be decommissioned in accordance with the decommissioning plan, and the best environmental practice/ option at the time of decommissioning. This may indicate infrastructure such as cables should be retained *in situ*. For the purposes of undertaking a MDS assessment, it is assumed that the decommissioning would be a reversal of the construction process if infrastructure were removed.

MAGNITUDE OF THE EFFECT

3.12.4 The impacts during decommissioning are considered to be similar, or less, than during construction. Therefore, the magnitude of the impact is considered to be **low** adverse for the potential changes in water clarity, microbiology and release of sediment-bound contaminants.

SENSITIVITY OF THE RECEPTOR

3.12.5 The sensitivity of the identified Bathing Waters is considered to be **low** adverse, for potential increased bacterial counts (with a moderate capacity to accommodate the changes within natural variation).

3.12.6 The sensitivity of the identified Shellfish Water Protected Areas to reductions in water clarity and release of sediment bound contaminants is considered to be **low** adverse.

3.12.7 The sensitivity of the Essex and Harwich Approaches coastal water bodies is considered **low** adverse, with respect to water quality reductions.

3.12.8 The sensitivity of the non-designated waters are considered resistant to temporary reductions in water clarity. Therefore, the sensitivity of non-designated waters is judged to be **negligible** adverse.

SIGNIFICANCE OF THE EFFECT

3.12.9 The magnitude of the increases to the SSC and associated decrease in bacterial mortality 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: **minor** adverse (not significant in terms of EIA Regulations);
- Shellfish Water Protected Areas: **minor** adverse (not significant in terms of EIA Regulations);
- Essex and Harwich Approaches coastal water bodies: **minor** adverse (not significant in terms of EIA Regulations);
- Non-designated waters: **negligible** adverse (not significant in terms of EIA Regulations).

3.12.10 No additional mitigation to that already identified in

3.12.11 Table 3.18 is considered necessary. Therefore, no significant adverse residual effects have been predicted for MW&SQ receptors.

IMPACT 9: ACCIDENTAL RELEASES OR SPILLS OF MATERIALS OR CHEMICALS

3.12.12 The potential impacts during decommissioning are considered to be similar or less than during construction for accidental spills and releases. As previously stated, VE is committed to the use of best practice and pollution prevention guidelines at all times.

MAGNITUDE OF THE EFFECT

3.12.13 The magnitude of this potential impact is considered to be **negligible** adverse as a result of the controls and best practice measures that will be captured within the PEMP. Furthermore, it is not anticipated that any accidental release or spill would affect the waterbody's performance against its EQSs as the potential impacts will be temporary in nature.

SENSITIVITY OF THE RECEPTOR

3.12.14 Bathing Waters status is dependent on the monitoring of the bacterial counts. No source-receptor-pathway has been identified which could affect bacterial counts at the Bathing Waters from accidental spills and consequently is considered to be of **negligible** adverse sensitivity.

3.12.15 The sensitivity of the identified Shellfish Water Protected Areas to accidental spills is considered to be **low** adverse.

3.12.16 The Essex and Harwich Approaches coastal water bodies are internationally designated sites under the WFD but judged to have a high ability to accommodate a small accidental spill (if it were to occur) owing to the overall status of Moderate. The sensitivity of the waterbody to the proposed change is deemed to be **low** adverse.

3.12.17 The sensitivity of non-designated waters is judged to be **negligible** adverse. There is no applicable quality status which may be affected by a small accidental spill event.

SIGNIFICANCE OF THE EFFECT

3.12.18 The magnitude of an accidental spill event is considered *negligible*. Based on the sensitivity of the different receptors presented in the pre-ceding section, the significance(s) is considered to be:

- Bathing Waters: **negligible** adverse (not significant in terms of EIA Regulations);
- Shellfish Water Protected Areas: **negligible** adverse (not significant in terms of EIA Regulations);
- Essex and Harwich Approaches coastal water bodies: **negligible** adverse (not significant in terms of EIA Regulations);
- Non-designated waters: **negligible** adverse (not significant in terms of EIA Regulations).

3.12.19 No additional mitigation to that already identified in

3.12.20 Table 3.18 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of MW&SQ receptors.

3.13 ENVIRONMENTAL ASSESSMENT: CUMULATIVE EFFECTS

3.13.1 This cumulative impact assessment for MW&SQ has been undertaken in accordance with the methodology provided in Volume 1, Chapter 3, Annex 3.1: Cumulative Effects Assessment Methodology.

3.13.2 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. The longlist of projects and plans is then broken down further into three different tiers (Tier 1, 2 and 3) depending on at what stage the project is at. A full description of the tiers can be found in Table 3.19 and Volume 1, Annex 3.1: Cumulative Effects Assessment Methodology. 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 VE on MW&SQ in the region, the cumulative effect assessment technical note submitted through the EIA Evidence Plan and forming Technical Annex 1.3.1 of this PEIR screened in a number of projects and plans as presented in Table 3.20.The location of these known plans and projects are shown in Figure 3.5.The cumulative MDS is presented in Table 3.21.

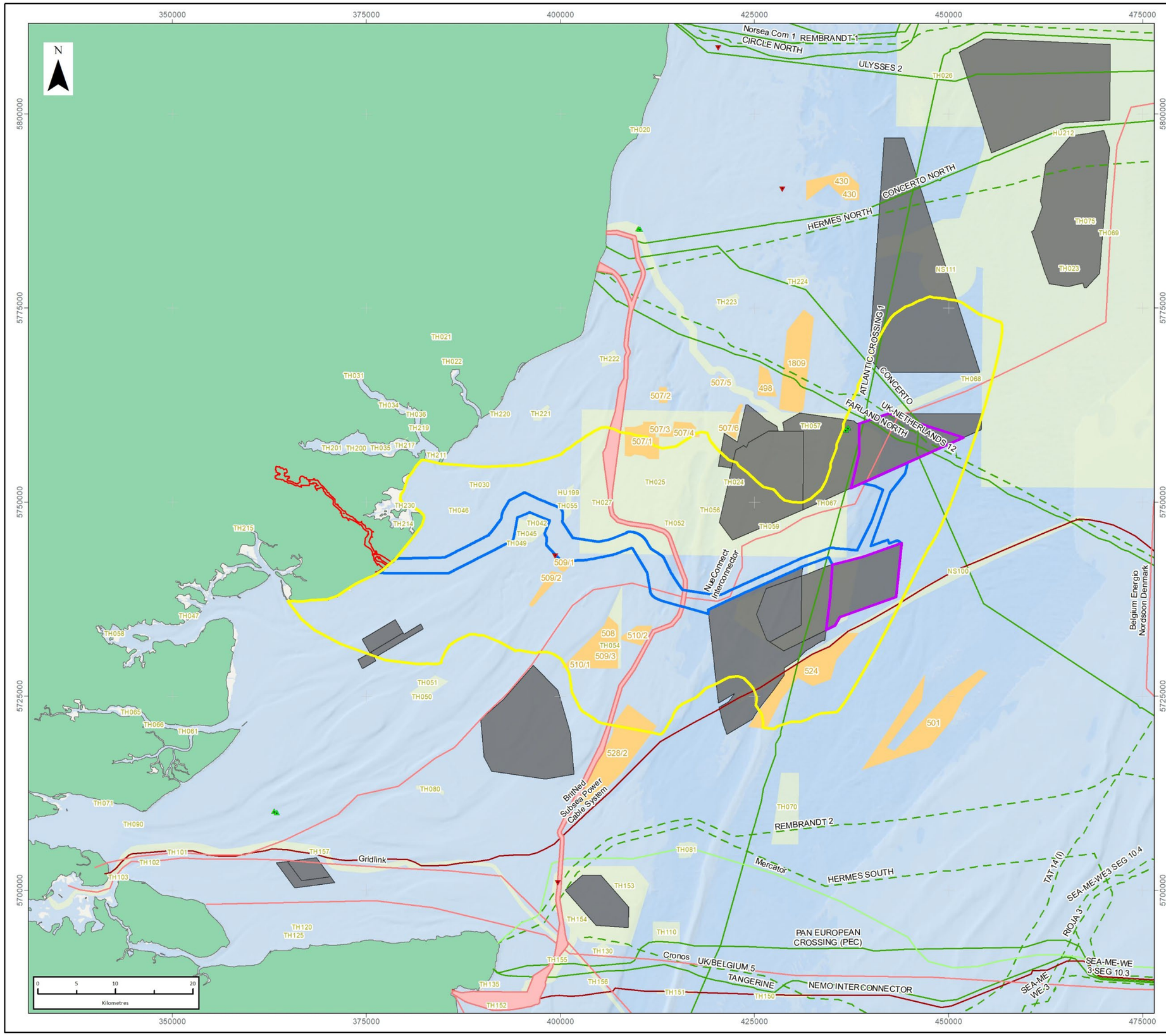
Table 3.19: Description of Tiers of other developments considered for CEA.

Tiers	Development Stage
Tier 1	Projects under construction.
	Permitted applications, whether under the Planning Act 2008 or other regimes, but not yet implemented.
	Submitted applications, whether under the Planning Act 2008 or other regimes, but not yet determined.
Tier 2	Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has been submitted.
	Projects under the Planning Act 2008 where a PEIR has been submitted for consultation.
Tier 3	Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has not been submitted.
	Identified in the relevant Development Plan (and emerging Development Plans with appropriate weight being given as they move closer to adoption) recognising that much information on any relevant proposals will be limited.
	Identified in other plans and programmes (as appropriate) which set the framework for future development consents/ approvals, where such development is reasonably likely to come forward.

Table 3.20: Projects considered within the MW&SQ cumulative effect assessment.

Development type	Project	Status	Data confidence assessment/ phase	Tier
Offshore Wind Farms	East Anglia Two	Consented	High - Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate. The operational period will overlap with VE construction and operation.	Tier 1
	North Falls	Pre-planning Application	High - Third party project details published in the public domain and confirmed as being 'accurate' by The Crown Estate. If consent is granted the project will be constructed at the same time as VE and will be operational by 2030	Tier 2
Aggregate Production Area	Tarmac Marine Ltd (509/1)	Operation	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
	Tarmac Marine Ltd (509/2)	Operation	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1

Development type	Project	Status	Data confidence assessment/ phase	Tier
	CEMEX UK Marine Ltd (510/2)	Operation	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
	Tarmac Marine Ltd (509/3)	Operation	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
	CEMEX UK Marine Ltd (510/1)	Operation	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
	Britannia Aggregates Ltd (508)	Operation	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
	DEME Building Materials Ltd (524)	Operation	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
	CEMEX UK Marine Ltd (507/1)	Operation	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
Sea Disposal Site	Inner Gabbard East (TH056)	Open	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
	Inner Gabbard (TH052)	Open	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
	Harwich Haven (TH027)	Open	Medium - Third party project details published in the public domain and confirmed as being 'accurate'	Tier 1
Interconnector	Neuconnect	Consented	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'	Tier 1
	Nautilus MPI	Proposed	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'	Tier 3
	Sea Link	Proposed	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'	Tier 3



LEGEND

- Array Areas
- Offshore Export Cable Corridor
- Onshore Red Line Boundary
- Zone of Influence
- Oil and Gas (Surface Infrastructure)
- Oil and Gas (Subsurface Infrastructure)
- Offshore Wind Farm
- Aggregates Site
- Disposal Sites

Subsea Cable (Type - Status)

- Power - Active
- Power - Disused
- Power - Proposed
- Telecom - Active
- Telecom - Disused
- Telecom - Proposed
- SeaLink Interconnector

Data Source:
Basemap: Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

PROJECT TITLE:

FIVE ESTUARIES OFFSHORE WINDFARM

DRAWING TITLE:

Location of cumulative projects relative to the MW&SQ study area

VER	DATE	REMARKS	Drawn	Checked
1	23/02/2023	For Issue	SWM	CH

DRAWING NUMBER:

3.5

SCALE:	PLOT SIZE:	DATUM:	PROJECTION:
1:500,000	A3	WGS84	UTM31N

FIVE ESTUARIES
OFFSHORE WIND FARM

Z:\GIS\GIS_Projects\0144 Five Estuaries\GIS\Figures\PEIR\MWSQ\VE_MWSQ_CEA_Fig3_5_V1.mxd

Table 3.21: Cumulative Maximum Design Scenario.

Impact	Scenario	Justification
Impact 10: Cumulative effects resulting in the deterioration in water quality from the suspension of sediments Impact 11: Cumulative effects from the release of sediment bound contaminants from disturbed sediments	Tier 1: > Aggregate production Tarmac Marine Ltd (509/1); Tarmac Marine Ltd (509/2); CEMEX UK Marine Ltd (510/2); Tarmac Marine Ltd (509/3); CEMEX UK Marine Ltd (510/1); Britannia Aggregates Ltd (508); DEME Building Materials Ltd (524); CEMEX UK Marine Ltd (507/1) > Sea disposal sites Inner Gabbard East (TH056); Inner Gabbard (TH052); Harwich Haven (TH027) > Operation and maintenance of East Anglia Two including cables > The construction of the Neuconnect interconnector Tier 2: > The construction of the North Falls offshore windfarm Tier 3: > The construction of the Nautilus MPI and Sea Link interconnectors	If these intermittent activities overlap temporally with either the construction or O&M of VE, there is potential for cumulative SSC and sediment deposition to occur within the modelled plume footprints.

IMPACT 10: CUMULATIVE EFFECTS RESULTING IN THE DETERIORATION OF WATER QUALITY FROM THE SUSPENSION OF SEDIMENTS

3.13.3 Due to uncertainty associated with the exact timings of other plans and projects, there is 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 be undertaking routine maintenance work, in particular asset reburial or repairs, as these are infrequent occurrences during the lifetime of developments.

3.13.4 A detailed cumulative assessment for the temporary increase in SSC (and associated deposition) resulting from VE and other projects within the study area is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes. Given the high levels of sediment dispersion as demonstrated by the project specific sediment assessment, alongside the location 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.

3.13.5 In addition, it is noted that in line with UNCLOS (The United Nations Convention on the Law of the Sea) cable installation vessels typically request a one nautical mile (c. 1.85 km) vessel safety zone when installing or handling cables.

3.13.6 Sediment plumes generated by other projects, are anticipated to behave in a similar pattern as the sediments being disturbed for VE. 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 clarity and microbial growth are deemed to be comparable to VE alone and as such are considered not significant in terms of the EIA Regulations. No additional mitigation to that already identified in

3.13.7 Table 3.18 is considered necessary. Therefore, no significant adverse residual effects have been predicted in respect of MW&SQ receptors.

IMPACT 11: CUMULATIVE EFFECTS FROM THE RELEASE OF SEDIMENT BOUND CONTAMINANTS FROM DISTURBED SEDIMENTS

3.13.8 For the same rationale as provided in Impact 3, it is anticipated that any contaminants will be rapidly dispersed from the point of disturbance with high levels of dilution and dispersion achieved. Therefore, the potential cumulative effects from contaminants released into the water column are deemed to be equivalent to VE alone and not significant in terms of the EIA Regulations.

3.14 INTER-RELATIONSHIPS

3.14.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- 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 (e.g. subsea noise effects from piling, operational WTGs, vessels and decommissioning); and
- Receptor-led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on benthic ecology such as direct habitat loss or disturbance, sediment plumes, scour, JUVs use etc., may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short-term, temporary or transient effects, or incorporate longer term effects.

3.14.2 A description of the likely inter-related effects arising from VE on MW&SQ is provided in Volume 2, Chapter 14: Inter-relationships, with a summary of assessed inter-relationships provided below.

3.14.3 Potential inter-relationships exist between MW&SQ and:

- Fish and Shellfish - impacts to shellfish and fish ecology as a result of increased contaminant concentrations;
- Benthic Subtidal and Intertidal Ecology - impacts benthic, subtidal and intertidal ecology as a result of increased contaminant concentrations;

- Marine Geology, Oceanography and Physical Processes - the physical processes controlling SSC, SPM and scour are directly related to the resuspension of contaminated sediments; and
- Impacts on socio-economics and tourism from changes to Bathing Water Quality.

3.15 TRANSBOUNDARY EFFECTS

3.15.1 No transboundary impacts are predicted to result from the construction, O&M and decommissioning phases of VE in terms of MW&SQ receptors. In line with the stakeholder consultation (Table 3.2) and transboundary screening (Volume 1, Chapter 3, Annex 3.2: Transboundary Screening), no potentially significant transboundary effects are predicted for MW&SQ. Therefore, a transboundary effects assessment is not considered necessary in this chapter.

3.16 SUMMARY OF EFFECTS

3.16.1 This PEIR chapter has investigated the potential effects on MW&SQ receptors arising from VE. The range of potential impacts and associated effects has been informed by Scoping responses and consultation responses (including those submitted during the Evidence Plan Process) from stakeholders, alongside reference to existing legislation and guidance.

3.16.2 The potential for VE to interact directly and indirectly with MW&SQ receptors 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 worst-case potential effects of VE have been considered thereby providing a highly conservative assessment.

3.16.3 A summary of the effects of the proposed development during construction, O&M and decommissioning phases on MW&SQ are presented in Table 3.22.

Table 3.22: Summary of impacts for MW&SQ.

Description of Impact	Impact	Additional mitigation measures	Residual impact
Construction			
Impact 1	Deterioration in water quality due to suspension of sediments	If the drilling fluid were captured within a cofferdam(s), the magnitude of the impact would be reduced to negligible.	No significant adverse residual effects
Impact 2	Deterioration in water clarity due to the release of drilling mud	Not Applicable – no additional mitigation identified.	No significant adverse residual effects

Description of Impact	Impact	Additional mitigation measures	Residual impact
Impact 3	Release of sediment-bound contaminants from disturbed sediments	If any disturbed sediments within the localised area of the ECC identified as having elevated, but less than CAL2 levels of sediment contamination were retained upon the TSHD(s), the magnitude of the impact would be reduced to negligible.	No significant adverse residual effects
Impact 4	Accidental releases or spills of materials or chemicals	Not Applicable – no additional mitigation identified.	No significant adverse residual effects
Operation			
Impact t 5	Deterioration in water quality due to suspension of sediments from O&M activities	Not Applicable – no additional mitigation identified.	No significant adverse residual effects
Impact 6	Deterioration in water quality due to suspension of sediments from scour	Not Applicable – no additional mitigation identified.	No significant adverse residual effects
Impact 7	Accidental releases or spills of materials or chemicals	Not Applicable – no additional mitigation identified.	No significant adverse residual effects
Decommissioning			
Impact 8	Deterioration in water quality due to re-suspension of sediments	Not Applicable – no additional mitigation identified.	No significant adverse residual effects
Impact 9	Accidental releases or spills of materials or chemicals	Not Applicable – no additional mitigation identified.	No significant adverse residual effects

Description of Impact	Impact	Additional mitigation measures	Residual impact
Cumulative effects			
Impact 10	Cumulative effects resulting in the deterioration in water quality from the suspension of sediments	Not Applicable – no additional mitigation identified.	No significant adverse residual effects
Impact 11	Cumulative effects from the release of sediment bound contaminants from disturbed sediments	If any disturbed sediments within the localised area of the ECC identified as having elevated, but less than CAL2 levels of sediment contamination were retained upon the TSHD(s), the magnitude of the impact would be reduced to negligible.	No significant adverse residual effects

3.17 NEXT STEPS

3.17.1 The following steps will be undertaken in order to progress the MW&SQ assessment from PEIR stage to DCO Application stage.

- Further consultation and engagement will be undertaken through the Marine Ecology and Processes ETG. All feedback post-PEIR will be used to inform and update the MW&SQ assessment, including the cumulative assessment, and will be presented within the ES, where necessary.
- Preparation of WFD assessment following the Environment Agency's 'Clearing the Waters for All' guidance to determine compliance of proposed VE activities against the objectives of relevant WFD water bodies.

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