Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Environmental Statement Volume 2

Chapter 3: Marine Water and Sediment Quality

June 2018, Revision A

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Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Volume 2

Chapter 3: Marine Water and Sediment Quality

June 2018

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3 Water Quality and Sediment Quality

3.1 Introduction

3.1.1 This chapter has been prepared by GoBe Consultants Ltd and assesses the potential effect on marine water and sediment quality of the offshore works (including construction, Operations and Maintenance (O&M) and decommissioning) associated with Thanet Extension Offshore Wind Farm (Thanet Extension).

3.1.2 This chapter has drawn on information from information and assessment provided in the following chapters:

- Volume 2, Chapter 1: Project Description (Offshore) (Document Ref: 6.2.1);
- Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2);
- Volume 4, Annex 2-1: Physical Processes Technical Report (Document Ref: 6.4.2.1);
- Volume 2, Chapter 5: Benthic Subtidal and Intertidal Ecology (Document Ref: 6.2.5); and
- Volume 2, Chapter 6: Fish and Shellfish (Document Ref: 6.2.6).

3.1.3 The following sections of this chapter include:

- A summary of relevant legislation and planning policy;
- A description of the methodology for the assessment including details of the study area and the approach to the assessment of effects;
- A summary of consultation with stakeholders;
- A review of baseline (existing) conditions;
- Details of the measures proposed as part of the project to avoid or reduce environmental effects, including mitigation and design measures that form part of the project (embedded mitigation);
- An assessment of the likely effects for the construction, O&M and decommissioning phases of the project, taking into account the measures proposed;
- Identification of any further mitigation measures or monitoring required in relation to likely significant effects; and
- Assessment of any cumulative effects with other proposed developments.

3.1.4 The assessment of the impacts is based on the understanding of the proposed development in terms of the likely impacts and effects, and on a characterisation of the receiving environment as defined in detail within the Benthic Subtidal and Intertidal Ecology, and Physical Processes Technical Reports (6.4.5.1, 6.4.5.2 and 6.4.2.1 respectively).

3.2 Statutory and policy context

3.2.1 This section identifies legislation and national and local policy of relevance to marine water and sediment quality. The Planning Act 2008, Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 and Environment Act 1995 are considered along with the legislation relevant to marine water and sediment quality.

3.2.2 In undertaking the assessment, the following legislation has been considered:

- The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017;
- The Water Framework Directive (WFD);
- The revised Bathing Water Directive (rBWD); and
- The revised Shellfish Water Directive.

3.2.3 Guidance on the issues to be assessed for offshore renewable energy developments has been obtained through reference to the Overarching National Policy Statement (NPS) for Energy (NPS EN-1; Department for Energy and Climate Change (DECC), 2011a), the National Policy Statement for Renewable Energy Infrastructure (NPS EN-3, DECC, 2011b), the NPS for Electricity Networks Infrastructure (NPS EN-5; DECC, 2011c),the UK Marine Policy Statement (MPS; HM Government, 2011), and the relevant Marine Plans.

3.2.4 Table 3.1 presents NPS EN-3 and EN-1 guidance on what matters are to be included in an applicant's assessment for this chapter.

Table 3.1: Summary of NPS EN-3 policy relevant to marine water and sediment quality and consideration of Thanet Extension

Policy/ legislation	Key provisions	Section where provision addressed
NPS EN-3	Paragraph 5.15.2 states that "where the project is likely to have effects on the water environment, the applicant 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 Environmental Statement or equivalent."	Sections 3.10 to 3.14 of this chapter present the assessment of the proposed development on water quality. An assessment of the physical characteristics is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2). An assessment of fresh water resources and quality is presented in Volume 3, Chapter 6: Ground Conditions, Land Use and Flood Risk (Document Ref: 6.3.6).
NPS EN-1	Paragraph 5.15.3 states "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." "Existing physical characteristics of the water environment (including quantity and dynamics of flow) affected by the proposed project and any impact of physical modifications to these characteristics; and any impacts of the proposed project on waterbodies or protected areas under the Water Framework Directive."	A baseline of the existing water quality for the area which may be affected by the proposed activities in presented in section 3.7 of this chapter. The impacts of the proposed activities on marine water quality are assessed in sections 3.10 to 3.14 of this chapter. There will be no proposed changes or new discharges as a result of the proposed development. A full WFD assessment is presented in Volume 4, Annex 3-1: Water Framework Directive (Document Ref: 6.4.3.1) which details the impacts on coastal and transitional waterbodies and protected areas under WFD. Potential changes to the physical environment, including hydrodynamics, waves and sediment pathways, are presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2).

3.3 Consultation and Scoping

3.3.1 As part of the Environmental Impact Assessment (EIA) for Thanet Extension, 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 Secretary of State (SoS) following submission of the Scoping Report (VWPL, 2016). The Scoping Opinion (the Planning Inspectorate (PINS), 2017) was issued in January 2017 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, to be published with the final application.

3.3.2 A draft Environmental Statement (ES) chapter was provided as part of the Preliminary Environmental Information Report (PEIR) in November 2017 in order to seek formal consultation responses. The consultation responses received under Section 42 are also included within Table 3.2.

Table 3.2: Summary of consultation relating to marine water and sediment quality

Consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion	As part of the assessment of water quality affects as outlined in Table 2.5 (in the Scoping Report), the SoS would expect to see specific consideration of the proposed development's construction effects upon bathing waters.	In line with current guidance the potential impacts associated with the proposed Thanet Extension project are considered for all Bathing Waters (BWs) within 2 km of the Red Line Boundary (RLB). The key findings are presented in sections 3.10 to 3.14 of this chapter. A full assessment of the potential impacts associated with the proposed Thanet Extension project in relation to WFD waterbodies are presented in Volume 4, Annex 3-1: Water Framework Directive Assessment (Document ref: 6.4.3.1).
Scoping Opinion	The release of contaminated sediments during construction not scoped out; further analysis of contaminated sediments to be considered.	The release of sediments for all activities including construction is considered in this assessment in section 3.10 of this chapter, inclusive of a summary of the relevant contaminated sediment surveys undertaken to characterise the receiving environment.

Consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion	An assessment of the accidental release of contaminants during construction, operation and decommissioning scoped out but in order to provide confidence to the assessment the ES should specify with details the measures to be employed and how they are secured by the DCO.	A full assessment on water quality due to the accidental release of contaminants for all stages of the development are considered in sections 3.10 to 3.14. Information about the proposed prevention measures are outlined in section 3.15.
Scoping Opinion	Reference is made to potential release of contaminants from the former hoverport in landfall option 1 (Pegwell Bay) being considered as part of the onshore assessment of water resources (section 3.4 of the Scoping Report) and the SoS would also expect to see specific consideration of this as part of the offshore marine water and sediment quality assessment.	The potential release of contaminants from the former hoverport and the wider Pegwell Bay intertidal zone is considered in section 3.9.
Scoping Opinion	The SoS considers that 'changes to water quality' during construction, operation and decommissioning remain scoped in to the EIA process.	The potential for changes in water quality are assessed for each of the stages of the development (construction, O&M and decommissioning) in sections 3.10 to 3.14 of this Chapter.
Scoping Opinion	Cumulative effects. The SoS does not agree that marine water and sediment quality effects during construction can be scoped out of the EIA. In particular, these should be considered in conjunction with the other activities as listed in section 2.14.1 of the Scoping Report.	Cumulative effects resulting from the proposed activities from Thanet Extension are presented in section 3.13 of this chapter.
Evidence Plan	Proposed that the WFD assessment should be a standalone document and include priority habitats (including saltmarsh). Sediment disturbance and potential impacts on BW will need to be assessed.	In line with current guidance the potential impacts associated with the proposed Thanet Extension project are considered for all BWs with 2 km of the red line boundary. The key findings are presented in sections 3.10 to 3.14 of this chapter. A full assessment of the impacts of the proposed activities for Thanet extension in terms of WFD are presented in Volume 4, Annex 3-1: Water Framework Directive Assessment (Document Ref: 6.4.3.1). Please see this Annex for full details.
Evidence Plan	The Environment Agency (EA) requested that invasive non-native species are considered in the assessment, in particular the stepping stone effect from North to South Kent.	A full assessment of invasive non-native species spread or introduction as a result of the proposed activities for Thanet Extension are presented in Volume 4, Annex 3-1: Water Framework Directive Assessment and the Benthic Ecology Chapter (Volume 2, Chapter 5) Assessment (Document Refs: 6.4.3.1 and 6.2.5).
S42	The MMO agree that the chapter presents "sufficient data to support the conclusions made regarding release of sediment contaminants".	N/A
S42	The MMO agrees with the conclusions reached in the PEIR.	N/A
S42	The MMO requested clarification on the extent and nature of any proposed dredging activities and sea bed preparation. Noting "the MMO accepts that the requirement for, and quantity of, any dredging is not yet known in detail."	Table 3.10 has been updated and clarified with the revised project description. In addition, please refer to Volume 2, Chapter 1: Project Description – Offshore (Document Ref: 6.2.1) for the revised project description.

Consultation phase/ type	Consultation and key issues raised	Section where comment addressed
S42	The MMO noted that "consideration must be given to all relevant in-combination effects on the marine environment including the proposed 132kV cable replacement project for the existing Thanet OWF."	The Thanet Cable Replacement project is no longer being pursued and as such a cumulative impact assessment is not required.
S42	The MMO and Natural England requested a map presenting the locations of the contamination testing sites and to detail the number of sites the assessment is based on within the chapter.	See Figure 3.6 and paragraph 3.7.7 *et seq*.
S42	"Whilst the scheme is not one for navigational dredging the number and location of samples should follow the OSPAR guidance if dredged material is to be disposed into the marine environment." (MMO)	See Disposal Site Characterisation Report (Document Ref: 8.14)
S42	The MMO recommended to interpret the contamination results in further context, not just the Cefas Action Levels such as by effect range and background ranges.	Further analysis and context has been included to assess the contaminant analysis against the Canadian marine sediment quality guidelines. Context of the baseline of contaminant above a threshold have been added into section 3.7.
S42	"The MMO notes that all contaminants were recorded at levels below Cefas action level 2 and are at levels which may be expected in offshore marine sediments, including the high levels of arsenic identified in the reports which the MMO agrees are within typical ranges."	Noted
S42	The MMO notes that interpretation of analysis is given for metals only, in section 3.7, and requested that the other contaminants are summarised.	Additional interpretation of non-metal contaminants has been included in paragraph 3.10.17.
S42	The Environment Agency confirmed they have no comments on the Water Quality and Sediment Quality assessment.	Noted
S42	Natural England have requested the potential for leachate contamination from the historic landfill to be assessed during construction.	The potential impact has been included in this assessment see Table 3.10, Table 3.14 and paragraphs 3.10.17 *et seq*.
S42	Natural England stated that the maximum design scenario assessed with the maximum design parameters have been adequately identified.	Table 3.10 has been updated with the additional potential impact and with the revised project description. In addition, please refer to Volume 2, Chapter 1: Project Description – Offshore (Document Ref: 6.2.1) for the revised project description.
S42	"Natural England agrees with the EIA conclusions presented in the summary table. Based on the information presented in the chapter and subject to the project being constructed within the Rochdale envelope, no LSE can be concluded for the topics of Marine Water and Sediment Quality."	Noted

3.4 Scope and methodology

Study Area

3.4.1 The study area for the marine water and sediment quality assessment is a 13 km buffer of the project boundary, which is approximately equivalent to the maximum spring tidal excursion. The study area for this assessment is presented in Figure 3.1.

3.4.2 The assessment of impacts on the marine physical environment has been considered over two spatial scales. These are:

- Far-field. Defined as the area surrounding the Thanet Extension array area and Offshore Export Cable Corridor (OECC) over which indirect changes may occur (i.e. the study area); and
- Near-field. Defined as the footprint of the Thanet Extension array area and OECC.

3.4.3 The characterisation presented in this chapter provides a regional overview before focusing on the study area. The study area encompasses the Thanet Extension array area as well as the OECC, up to and including the intertidal zone in Pegwell Bay, defined as ending at Mean High Water Springs (MHWS). The immediate RLB, and tidal ellipse buffer area effectively characterises the predicted zone of potential primary (direct) and secondary (indirect) impacts of the development on water and sediment receptors respectively. The study area has been broken down into three sections, and these sections have been assessed individually in terms of their potential impacts on marine water and sediment quality for each stage of the proposed development. The sections considered within this chapter comprise the following:

- Array area (including Wind Turbine Generators (WTGs), Offshore Substation (OSS) and inter-array cables);
- OECC area; and
- The seabed and water column surrounding these areas that may be influenced by changes to physical processes due to the proposed development.

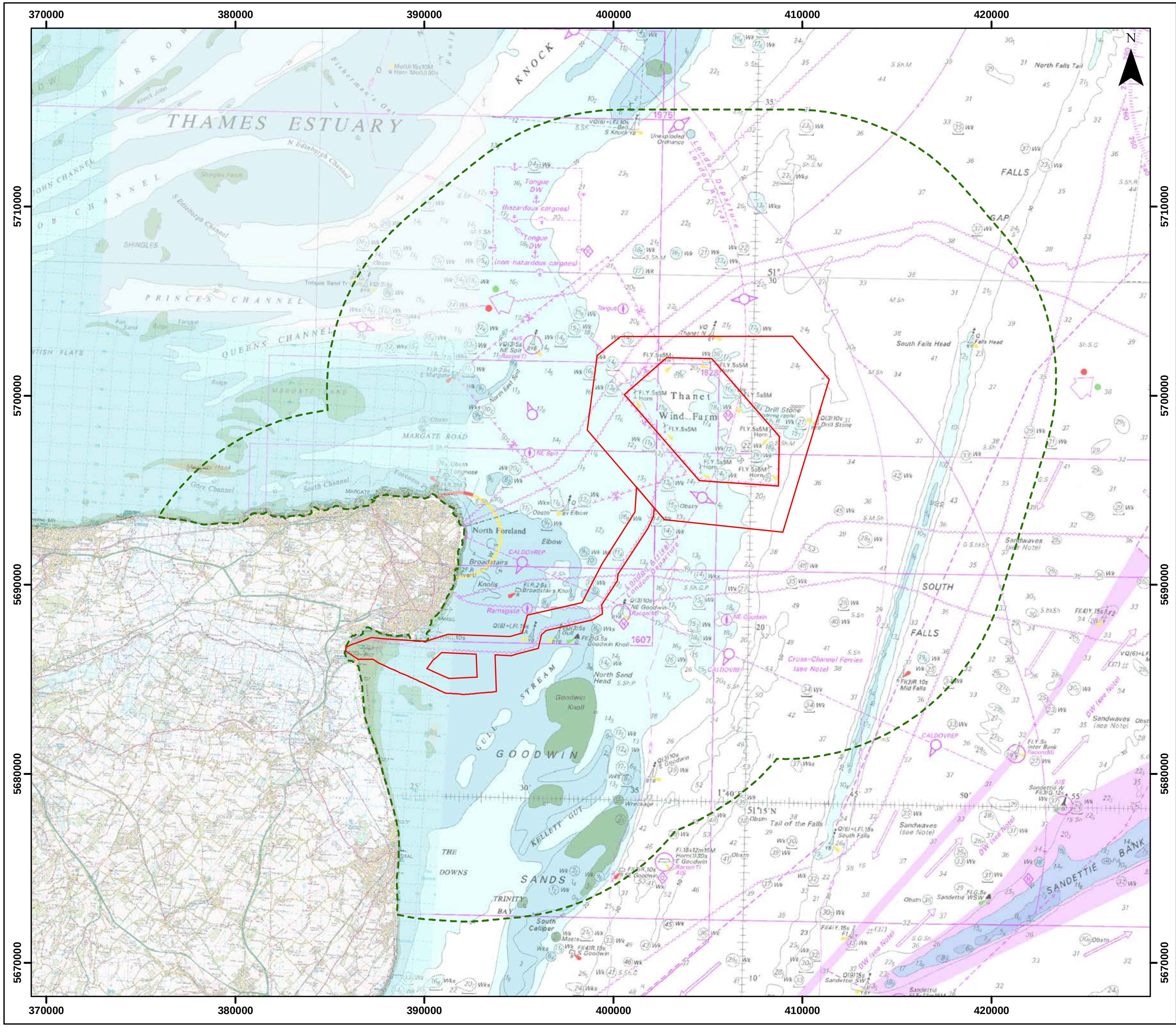
Data Sources and Gap Analysis

3.4.4 Site specific geophysical surveys for Thanet Extension have been undertaken to characterise the benthic ecology throughout the array and the OECC (Volume 4, Annex 5-1 and Volume 4, Annex 5-2 (Document Refs: 6.4.5.1 and 6.4.5.2)). This survey comprised of a full geophysical survey of the array and OECC, supplemented with drop-down camera data and grab samples to allow a characterisation of the sediment features composition within the study area. The survey additionally included sediment Particle Size Analysis (PSA) and contaminant analysis using the grab samples.

3.4.5 A site specific extended Phase 1 intertidal survey (Document Ref: 6.4.5.3) was carried out at the proposed landfall location for the OECC at Pegwell Bay, in Kent, in July 2017. The scope was agreed under the Evidence Plan and provides adequate coverage for the purposes of EIA. Further sediment samples were taken for PSA and contaminant analysis.

3.4.6 Where relevant, data from surveys undertaken for Thanet Offshore Wind Farm (TOWF) has been used in the characterisation of the Thanet Extension study area, complemented by the primary sources of information including site specific surveys undertaken for Thanet Extension.

3.4.7 EA's BW classification data, based on water samples/ monitoring data at Sandwich Bay, Ramsgate Western Undercliffe and Ramsgate Sands BW from 2004 to 2016 have been included in this assessment. Further detail is provided in the WFD assessment (Volume 4, Annex 3-1).



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THANET EXTENSION OFFSHORE WIND FARM

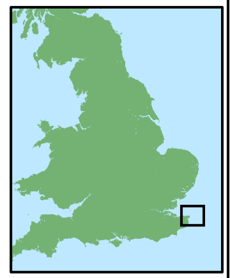
Figure 3.1

Marine Water and Sediment Quality Study Area.

Legend

- Offshore Red Line Boundary
- Marine Water and Sediment Quality Study Area

Datum: ETRS 1989
Projection: UTM31N



1:200,000 — 0 2 4 km; 0 1 2 nm

Drg No	TEOW_WQ_Fig.3.1			Figure 3.1
Rev	0.1	Date	25/05/2018	
By	PN	Layout	N/A	

Assessment Methodology

Cefas Action Levels

3.4.8 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 Action Levels for the disposal of dredge material. This may be used to provide evidence for decision makers about the disposal of dredge material, they are not however statutory. The Cefas Action Levels are presented in Table 3.3. These levels are used in this assessment to determine whether further assessment is required rather than a pass/ fail criterion.

3.4.9 For dredging projects, contaminants below the Action Level 1 are not considered to be of concern and are approved for disposal at sea. Contaminant levels above Action Level 2 are not considered suitable for disposal at sea without further consideration. In this assessment if levels of contaminants in the sediment samples are between Level 1 and Level 2 then further assessment will be undertaken, see section 3.10.

Table 3.3: Cefas Action Levels

Contaminant/ Compound	Action Level 1	Action Level 2
	mg/ kg Dry Weight (ppm)	mg/ kg Dry Weight (ppm)
Arsenic	20	100
Mercury	0.3	3
Cadmium	0.4	5
Chromium	40	400
Copper	40	400
Nickel	20	200
Lead	50	500
Zinc	130	800
Orgotins; 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
*DDT	*0.001	N/A
*Dieldrin	*0.005	N/A

* Levels set in 1994

3.4.10 It is noted that this is not a proposed dredging scheme but as in keeping with common practice, contaminants will be contextualised against the Cefas Action Levels to provide an indicative risk to the environment.

3.4.11 The Cefas 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.

Canadian Marine Sediment Quality Guidelines

3.4.12 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.

3.4.13 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.

3.4.14 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.

3.4.15 Table 3.1 presents the guidelines for the TELs and PELS.

Table 3.4: Canadian Marine Sediment Quality Guidelines

Substance	Units	TEL	PEL
Metals			
Arsenic	mg kg^{-1}	7.24	41.6
Cadmium	mg kg^{-1}	0.7	4.2
Chromium	mg kg^{-1}	52.3	160
Copper	mg kg^{-1}	18.7	108
Lead	mg kg^{-1}	30.2	112
Mercury	mg kg^{-1}	0.13	0.7
Zinc	mg kg^{-1}	124	271
Polychlorinated byphenyls (PCB)			
PCBs: total PCBs	mg kg^{-1}	21.5	189
Polyaromatic hydrocarbons (PAH)			
Acenaphthene	µg kg^{-1}	6.71	88.9
Acenaphthylene	µg kg^{-1}	5.87	128
Anthracene	µg kg^{-1}	46.9	245
Benz(a)anthracene	µg kg^{-1}	74.8	693
Benzo(a)pyrene	µg kg^{-1}	88.8	763
Chrysene	µg kg^{-1}	108	846
Dibenz(a,h)anthracene	µg kg^{-1}	6.22	135
Fluoranthene	µg kg^{-1}	113	1494
Fluorene	µg kg^{-1}	21.2	144
2-Methylnaphthalene	µg kg^{-1}	20.2	201
Naphthalene	µg kg^{-1}	34.6	391
Phenanthrene	µg kg^{-1}	86.7	544
Pyrene	mg kg^{-1}	153	1398

3.4.16 Water quality is closely linked to that of the associated sediments. Disturbed sediments may release contaminants into the water column from the sediments and thus has the potential to reduce the water quality locally. Consequently, reduction of water quality will be assessed in terms of the presence of contaminants in the sediment.

3.4.17 The European Union (EU) WFD (2000/60/EC) was established in 2000 in order to provide a single framework for the protection of surface waterbodies (including rivers, lakes, coasts (up to 1 nautical mile (nm)) and estuaries) and groundwater. Each waterbody has an assigned ecological status. The ecological status is assigned by considering the biological, hydromorphological, chemical and specific chemicals. The different statuses are:

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

3.4.18 The WFD's objective of a "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.

3.4.19 This assessment will consider the potential to affect both the ecological and chemical status of any affected WFD waterbodies as a result of activities for Thanet Extension. This assessment should be read in conjunction with Volume 4, Annex 3-1: Water Framework Directive Assessment (Document Ref: 6.4.3.1).

3.4.20 The European Union's rBWD (2006/7/EC) came into force in March 2006 and replaces the Bathing Water Directive (BWD) (76/1160/EEC). The rBWD provides more stringent standards than the BWD and places an emphasis on providing information to the public.

3.4.21 The rBWD has four different classifications of performance, these are:

- Excellent – the highest, cleanest class;
- Good – generally good water quality;
- Sufficient – the water meets minimum standards; and
- Poor – the water has not met the minimum required standards.

3.4.22 Full details of how the classifications are calculated are presented in Volume 4, Annex 3-1: Water Framework Directive Assessment (Document Ref: 6.4.3.1).

3.4.23 Water quality at BW will be contextualised against the baseline performance of each BW relative to the rBWD. Further assessment will be required if there is the potential for the BW to have reduced performance against the rBWD as a direct or indirect result of the proposed Thanet Extension activities.

3.4.24 The WFD incorporates the Shellfish Water Directive which aims to protect and improve water quality and support the growth of healthy shellfish (bivalve and gastropod molluscs) and contribute to good quality edible shellfish.

3.4.25 The original Directive 'Council Directive 79/923/EEC of 30 October 1979 on the quality required of shellfish waters (SFWs) as amended by Council Directive 91/692/EEC (further amended by Council Regulation 1882/2003/EC), known as the Shellfish Waters Directive, was designed to protect the aquatic habitat of bivalve and gastropod molluscan species of shellfish. It sets out standards for various parameters that should be monitored in designated shellfish areas. It has since been superseded by 'Directive 2006/113/EC of the European Parliament and of the Council of 12 December 2006 on the quality required of shellfish waters'.

3.4.26 The Directive establishes parameters applicable to designated SFWs, as well as indicative values, mandatory values, reference methods of analysis and the minimum frequency for taking samples and measurements. These parameters are set for pH, temperature, salinity and the presence or concentration of certain substances (dissolved oxygen, hydrocarbons, metals, organohalogenated substances etc.).

3.4.27 The competent authorities for each Member State must take samples from the waters to verify their conformity with the criteria set by the Directive. The following proportions of samples must conform to the established values:

- 100% of the samples for the parameters 'organohalogenated substances' and 'metals';
- 95% of the samples for the parameters 'salinity' and 'dissolved oxygen';
- 75% of the samples for the 'other' parameters; and
- No evidence of harm to the shellfish from organohalogenated compounds.

3.4.28 Additionally, the Directive stipulates that a discharge should not cause increase of suspended solids to exceed 30% above background levels, as shellfish can be adversely affected by the smothering effects of sediment settling.

3.4.29 Water quality at SFWs has been assessed for the potential of reduced performance against the Shellfish Waters Directive as a direct or indirect result of the proposed Thanet Extension activities. The SFW assessment should be read in conjunction with both Volume 2, Chapter 6: Fish and Shellfish and Volume 4, Annex 3-1: Water Framework Directive Assessment (Document Refs: 6.2.6 and 6.4.3.1). This assessment will primarily focus on organohalogenated substances and metals.

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 (Document Ref: 6.1.3).

3.5.2 Sensitivity/ importance of the environment are defined in Table 3.5 and the magnitude of identified impacts are defined in Table 3.6.

3.5.3 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.

3.5.4 As set out in Volume 1, Chapter 3: EIA Methodology (Document Ref: 6.1.3) 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. Table 3.5 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 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 marine water and sediment quality receptors. Various actions may result in impacts: for instance, the installation of the export cable, causing a localised and short-term change to Suspended Sediment Concentrations (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 status. The descriptions of magnitude are specific to the assessment of marine water quality impacts and are considered against the magnitude descriptions presented in Table 3.6. 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.

3.5.6 For the purposes of this assessment, any effect that is of major or moderate significance is considered to be significant in EIA terms, whether this be adverse (red and orange respectively) or beneficial (green and turquoise), see Table 3.7. 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 3.10 - 3.14.

3.5.7 Where relevant, mitigation measures that are incorporated as part of the project design process and/ or can be considered to be industry standard practice (referred to as 'embedded mitigation') are considered throughout the chapter and are reflected in the outcome of the impact assessment. Mitigation is prescribed only to reduce 'significant' effects. Under EIA guidelines, 'Moderate' and Major' effects are regarded as being significant (see Table 3.7). Mitigation measures that were identified and adopted as part of the evolution of the project design (embedded into the project design) are described separately, in section 3.9 of this chapter.

Table 3.5: Sensitivity/ importance of the environment

Receptor sensitivity/ importance	Description/ reason
High	Very low capacity to accommodate the proposed form of change; and/ or receptor designated and/ or of national level importance. Likely to be rare with minimal potential for substitution. May also be of high socio-economic importance.
Medium	Moderate to low capacity to accommodate the proposed form of change; and/ or receptor designated and/ or of regional level importance. Likely to be relatively rare. May also be of moderate socio-economic importance.
Low	Moderate to high capacity to accommodate the proposed form of change; and/ or receptor not designated but of district level importance.
Negligible	High capacity to accommodate the proposed form of change; and/ or receptor not designated and of local level importance.

Table 3.6: Magnitude of impact

Magnitude	Definition
High	The waterbody is of international or national importance and: • The waterbody is defined as being of 'High' or 'Good' chemical and ecological status. The waterbody would be reduced to a 'Moderate' status and would be a permanent impact; • A reduction of BW quality below 'Sufficient' classification; or • A permanent reduction in the quality of shellfish in the designated SFWs is anticipated.
Medium	The waterbody is of international or national importance and: • The waterbody is defined as being of 'High' or 'Good' chemical and ecological status. The waterbody would perform at a reduced WFD status temporarily; • A reduction of BW quality temporarily; or • A reduced quality of shellfish in the designated SFWs is anticipated temporarily.
Low	The waterbody is of international or national importance and decreases in performance/quality temporarily but do not result in a reduced WFD status of the waterbody/ BW/ SFW; or The waterbody is of local importance and/ or there will be temporary decreases in water or sediment quality.
Negligible	Changes which are not discernible from background conditions.

Table 3.7: Significance of potential effects

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

Note: shaded cells are defined as significant effects in respect of the EIA.

3.6 Uncertainty and technical difficulties encountered

3.6.1 Grab sampling and video surveys, while providing detailed information on the infauna and epifauna present, cannot cover wide swaths of the seabed and consequently represent point samples that must be interpreted in combination with the other appropriate datasets such as the RBMP quality element data to provide sufficient characterisation of a wider area.

3.6.2 There is some uncertainty associated with the assessment of sediment plumes and accompanying changes to bed levels due to construction related activities. This arises due to uncertainty regarding how the seabed geology will respond to 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 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 (Document Ref: 6.2.2). 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.

3.6.3 However, despite the above uncertainties, it should be noted that there is robust data available on the sediment types and contaminants present within the study area. The seabed in the area is well studied and surveyed, including for TOWF and also for the Nemo Interconnector Cable that has a landfall also within Pegwell Bay. 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

3.7.1 The marine water and sediment study area encompasses the Thanet Extension array area as well as the OECC, up to and including the intertidal zone in Pegwell Bay, defined as ending at MHWS. The immediate RLB, and 13 km buffer area effectively characterises the predicted zone of potential primary (direct) and secondary (indirect) impacts of the water and sediment receptors respectively (see Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2)).

3.7.2 Full details of the existing baseline for the following parameters relevant to this assessment are available in the following Chapters:

- Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2); and
    - Water levels;
    - Currents;
    - Wind and wave climate;
    - Sediments and geology; and
    - Seabed bathymetry and geomorphology.
- Volume 2, Chapter 6: Fish and Shellfish (Document Ref: 6.2.6).
    - Shellfish ecology.

The study area

3.7.3 Thanet Extension is situated at the boundary between the southern North Sea and the English Channel. This area is dominated by primarily coarse sediments, and is broadly lacking in hard substrate, except where the substratum is exposed (e.g. Brown *et al*., 1998; Thanet Offshore Wind Limited, 2005). Sand banks are known to form in places, with some reaching 40 m above the seabed, the area is considered to support 5.8% of the submerged sandbank habitat in Europe (Jones *et al*., 2004a) however these are outwith the proposed development area.

3.7.4 The study area is typical of the southern North Sea, comprising of coarse heterogenous sediments, primarily sands, interspersed with coarser sediments (gravels) and some small areas of sandy muds and muddy sands. The net movement of any fine grained material persisting in suspension would generally be in an approximate southerly (south-easterly through south-westerly) direction across most of the array area in accordance with the direction of residual flow in this area.

3.7.5 For sediment quality, the physical properties of the seabed are important to provide an indication as to contamination risk. For example, the potential for contamination increases with the proportion of fine sediment present since it is these smaller particles which bind contaminants, due to their larger surface area to volume ratios and higher organic carbon content. Sediments consisting of coarser sand and gravel is generally accepted to carry a much lower contamination risk. Information regarding particle sizes is an important step in assessing the contamination risk to the marine environment.

3.7.6 The sediments throughout the array site and wider study area are generally highly heterogeneous, although the site-specific surveys (Volume 4, Annex 2-1: Benthic Characterisation (Document Ref: 6.4.2.1)) showed that sediments in the south-west are relatively coarser, with finer, sandier sediments being found further offshore. Outcroppings of the underlying chalk bedrock occur in distinct locations to the north-west and south of the array area. Further hummocky or rugged seabed areas were identified in the north-east sector of the survey area, generally coinciding with the chalk outcroppings, with only a thin veneer of mobile sediments. Large dunes were identified to the north-east, with gradients between 20 and 32 degrees.

3.7.7 Two site specific surveys have been undertaken to assess the sediment quality, presence of contaminants, within the OECC and array area. These are:

- 2016 survey undertaken by Fugro Emu; and
- 2017 survey undertaken by MESL Ltd.

3.7.8 Figure 3.6 presents the survey locations for contaminant analysis undertaken by the two survey campaigns. The 2016 survey, consisted of 19 samples within and surrounding the array and two samples within the OECC. The 2017 survey contained four samples within the intertidal area of Pegwell Bay. Full details of the 2016 and 2017 surveys are presented in Volume 4 Annex 2-4 and Volume 4, Annex 5-1 (Document Refs: 6.4.2.4 and 6.4.5.1 respectively).

3.7.9 The distribution of contaminants in sediments is generally similar to that of surface water. The sediment type is an important factor when considering the potential presence of contaminants within sediments. Sediments with a finer particle size, such as clays and muds, can act as adsorption surfaces for contaminants that may be released into the water column if the sediment is disturbed (Cefas, 2001). Sediments with larger particle sizes (e.g. sands) are not associated with anthropogenic contaminants. Hydrocarbons in particular are closely linked to the spatial distribution of sediment types, decreasing from the northern to the southern North Sea where coarser sediments are more prevalent.

3.7.10 The concentrations of metals 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 (Cefas, 1998). Particularly high concentrations are observed in estuaries with historic or current industry, although these may also be the result of the presence of clay rich sediments.

WFD waterbodies

3.7.11 The proposed OECC lies within the Kent North coastal waterbody (GB650704510000) and the Stour (Kent) transitional waterbody (GB520704004700). The current status of these waterbodies is presented in Table 3.8, full details are provided in Volume 4, Annex 3-1: Water Framework Directive Assessment (Document Ref: 6.4.3.1).

3.7.12 Within 2 km of the proposed boundary are three designated BWs, these are:

- Ramsgate Western Undercliffe;
- Ramsgate Sands; and
- Sandwich Bay.

3.7.13 Figure 3.2 presents the RLB and each of the WFD waterbodies and WFD receptors (BWs and SFWs). The Stour Estuary (Kent) SFW intersects the OECC.

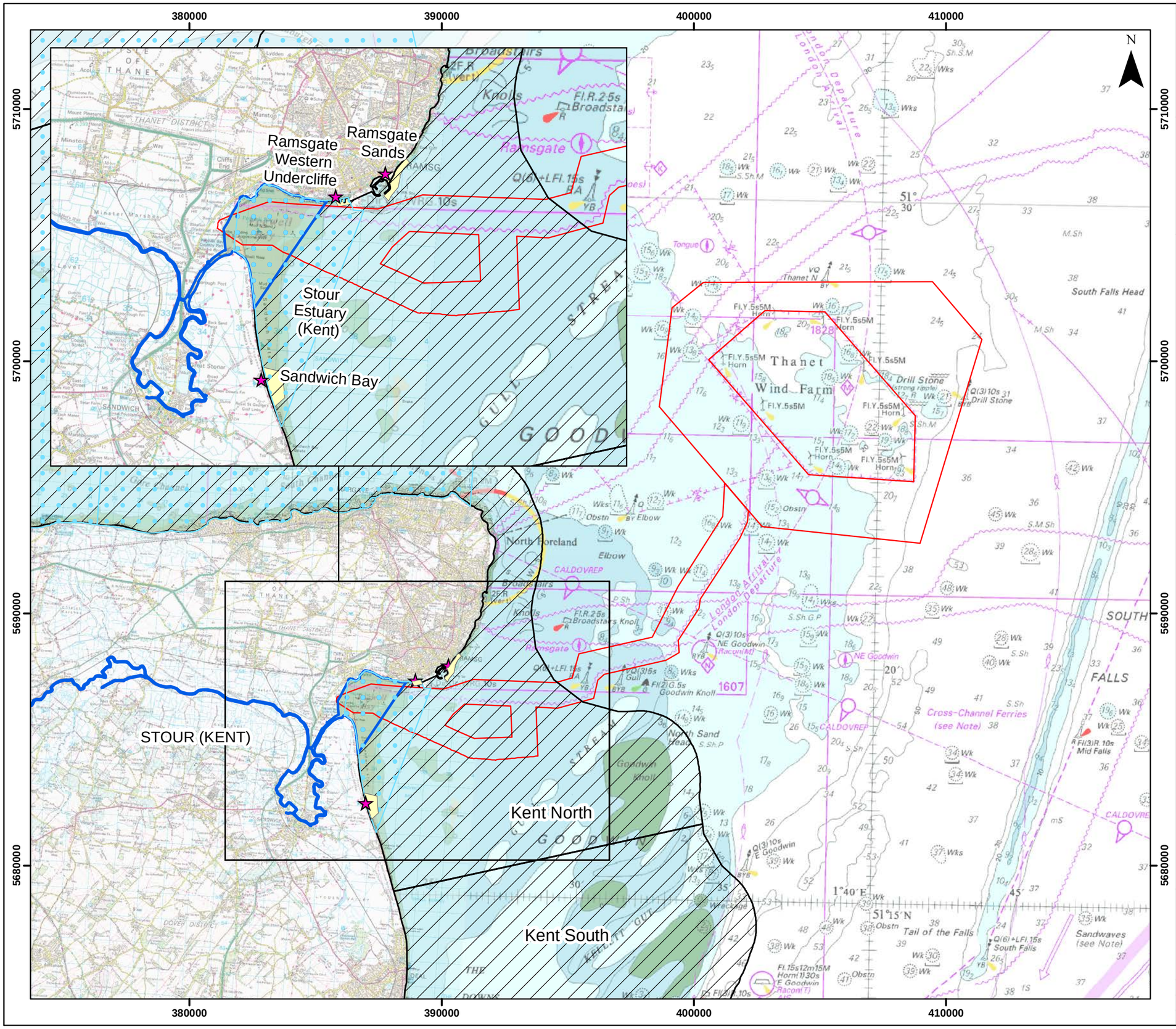
Table 3.8: Presents the status of the intersected waterbodies

Waterbody	Kent North	Stour (Kent)
ID	GB650704510000	GB520704004700
Type	Coastal	Transitional
Distance from OECC (km)	0.0	0.0
Distance from array (km)	6.0	14.7
Overall Current Status	Moderate	Poor
Current Status (Ecological)	Moderate	Poor
Current Status (Chemical)	Good	Good
Target Status	Moderate (2015)	Moderate (2027)
Is the waterbody heavily modified (HMWB)?	Yes	Yes
Reason for HMWB	Coastal Protection	Flood Protection
Hydro-morphology status	-	Supports Good
WFD phytoplankton classification	Good	Poor
History of harmful algae	Not Monitored	No

Table 3.9: Presents the current status of the identified BWs and SFWs

Waterbody	Ramsgate Western Undercliffe	Ramsgate Sands	Sandwich Bay	Stour Estuary (Kent)
ID	UK12900	UK12850	UK13000	123
Type	Bathing Water	Bathing Water	Bathing Water	Shellfish Water
Distance from OECC (km)	0.1	0.2	0.6	0.0
Distance from array (km)	14.2	12.4	18.5	14.1
Current Classification	Excellent	Good	Excellent	Not currently classified*

* Source: Cefas classification zone maps web page



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THANET EXTENSION OFFSHORE WIND FARM

Figure 3.2
WFD Waterbodies and Designations

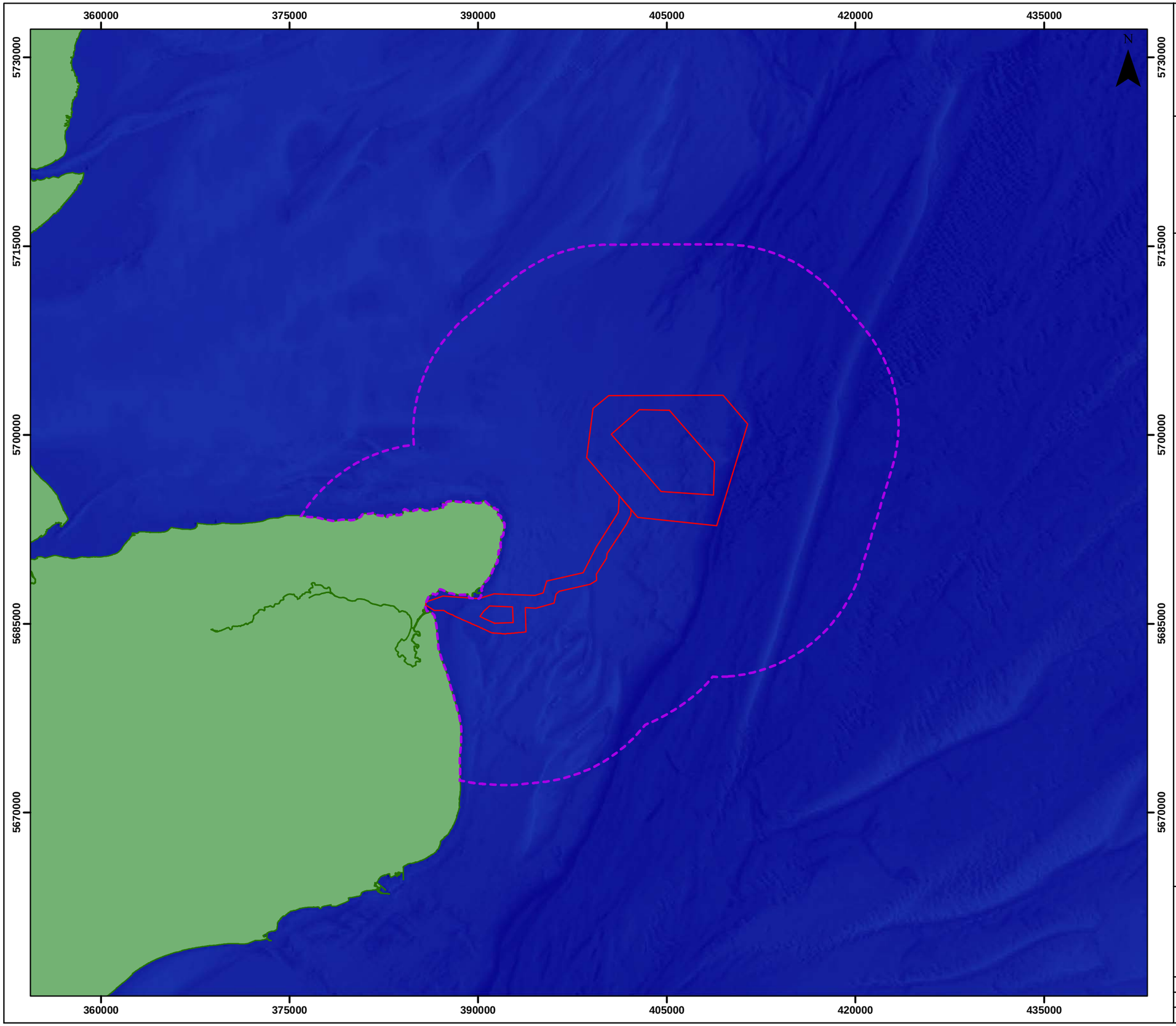
Legend

- Offshore Red Line Boundary
- BW Monitoring Locations
- BW Designated Polygons
- WFD - Shellfish Waters
- WFD - Transitional Waterbodies
- WFD - Coastal Waterbodies

Datum: ETRS 1989
Projection: UTM31N

1:150,000 0 1.5 3 km 0 0.85 1.7 nm

Drg No	TEOW_WQ_Fig.3.2			**Figure 3.2**
Rev	0.1	Date	25/05/2018	
By	PN	Layout	N/A	



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THANET EXTENSION OFFSHORE WIND FARM

Figure 3.3

Broadscale Bathymetry in the Study Area and Wider Region.

Legend

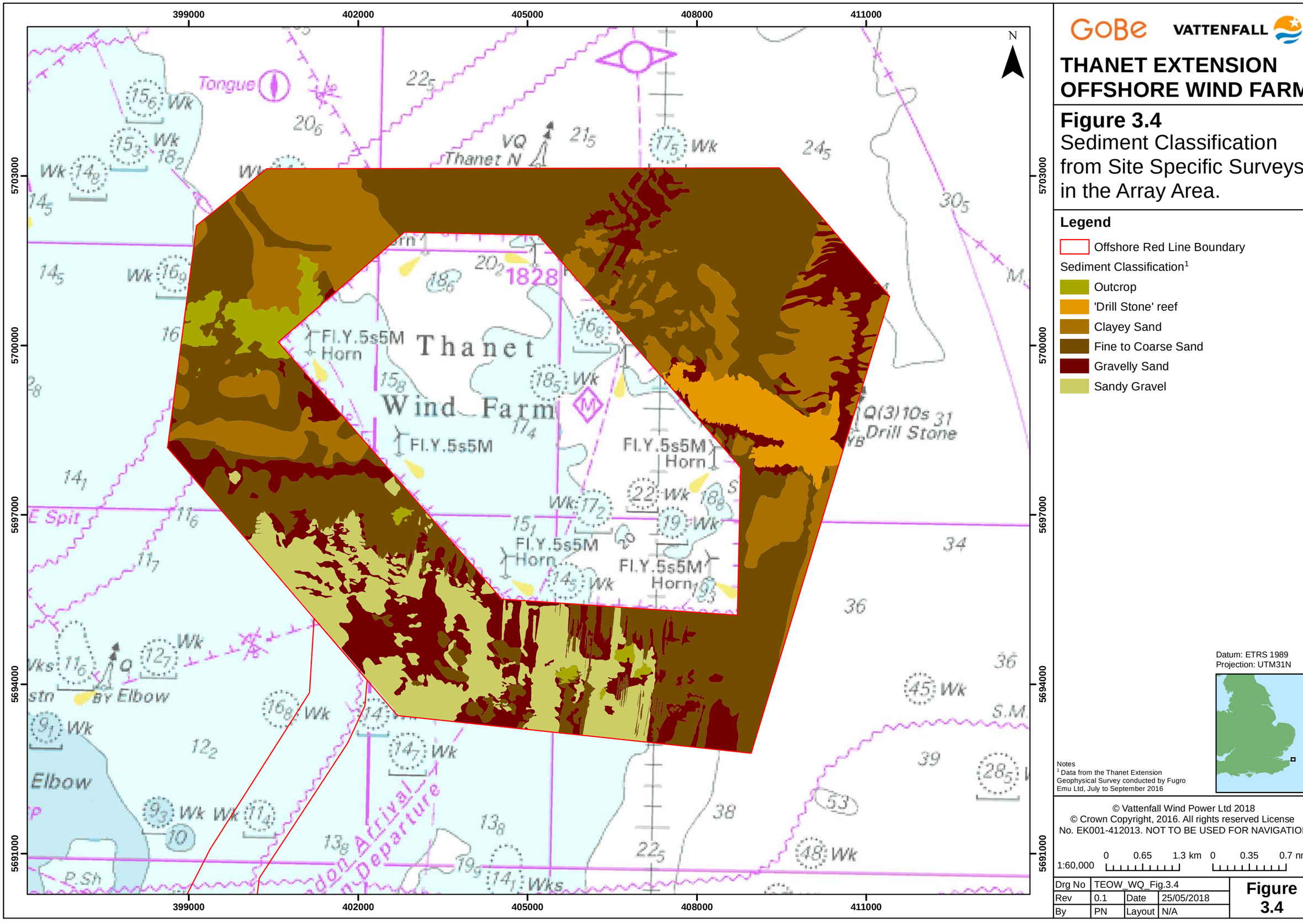
- Offshore Red Line Boundary
- Marine Water and Sediment Quality Study Area

Datum: ETRS 1989
Projection: UTM31N

1:300,000 0 3 6 km 0 1.5 3 nm

Drg No	TEOW_WQ_Fig.3.3		
Rev	0.1	Date	25/05/2018
By	PN	Layout	N/A

Figure 3.3



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THANET EXTENSION OFFSHORE WIND FARM

Figure 3.4

Sediment Classification from Site Specific Surveys in the Array Area.

Legend

- Offshore Red Line Boundary

Sediment Classification[1]

- Outcrop
- 'Drill Stone' reef
- Clayey Sand
- Fine to Coarse Sand
- Gravelly Sand
- Sandy Gravel

Datum: ETRS 1989
Projection: UTM31N

Notes
[1] Data from the Thanet Extension Geophysical Survey conducted by Fugro Emu Ltd, July to September 2016

1:60,000 0 0.65 1.3 km 0 0.35 0.7 nm

Drg No	TEOW_WQ_Fig.3.4		
Rev	0.1	Date	25/05/2018
By	PN	Layout	N/A

Figure 3.4

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Figure 3.5
Sediment Classification from Site Specific Surveys in the OECC.

Legend

- Offshore Red Line Boundary

Sediment Classification[1]

- Outcrop
- Clayey Sand
- Fine to Coarse Sand
- Gravelly Sand
- Sandy Gravel

Datum: ETRS 1989
Projection: UTM31N

Notes
[1] Data from the Thanet Extension Geophysical Survey conducted by Fugro Emu Ltd, July to September 2016

1:60,000 0 0.65 1.3 km 0 0.35 0.7 nm

Drg No	TEOW_WQ_Fig.3.5			**Figure 3.5**
Rev	0.1	Date	25/05/2018	
By	PN	Layout	N/A	

THANET EXTENSION OFFSHORE WIND FARM

Figure 3.6
Site Specific Survey Locations.

Legend

- Offshore Red Line Boundary
- Fugro Sample Locations
- MESL Ltd Sample Locations

WF47 WF41 WF04 WF25 WF01 WF37 WF32 WF02 WF19 WF07 WF14 WF06 WF22 WF03 WF08 WF29 WF27 WF12 WF05 CR03 CR10 PB07 T1 PB04 T2 PB11 T3 PB01 T4 PB14 T5

Datum: ETRS 1989
Projection: UTM31N

1:100,000 0 1 2 km 0 0.55 1.1 nm

Drg No	TEOW_WQ_Fig.3.6		
Rev	0.1	Date	25/05/2018
By	PN	Layout	N/A

Figure 3.6

The array

3.7.14 Bathymetry within the array area was determined from the geophysical surveys undertaken in 2016. Water depths throughout the survey area range between approximately 11.5 m below Lowest Astronomical Tide (LAT) and 49 m LAT. Generally, the shallower areas are to the west and south-west, with deeper areas to the north-east and particularly the very east of the survey area, where the North Sea deepens as it approaches the English Channel (see Figure 3.3).

3.7.15 On the basis of the available grab sample data (Fugro, 2017, Document Ref: 6.4.2.4) and interpreted multi-beam backscatter and side-scan sonar data (Fugro 2016a; TOWL, 2005), it has been determined that sediments within Thanet Extension array area mainly consist of sand and gravel with variable contributions silt and/ or clay (see Figure 3.4). The north-west of the array consists of mainly fine to medium sand, with clayey/ silty sand also present. Close to the TOWF array, the presence of sub-cropping tertiary sediments results in an irregular and poorly sorted seabed with cobble and boulder clusters frequently present. The north and east of Thanet array area consists of fine to coarse sand of varying proportions, with individual pockets of clay/ silt and sand/ gravel. Often the surficial sediments are present as thin veneers immediately overlying larger geological features.

Contaminants

3.7.16 Contaminant analysis was undertaken by Fugro EMU (Fugro, 2017; Document Ref: 6.4.5.2) in the array area. The results of the metals analysis showed that metal concentrations in sediment samples were below both Cefas Action 1 and TEL all metals with the only exception being arsenic, concentrations of which were between Cefas Action Level 1 and 2. The arsenic concentrations (Fugro, 2017; Document Ref: 6.4.5.1) were within the range reported for the southern North Sea: < 0.5 mg kg-1 to 135 mg kg-1 of dry weight arsenic (Whalley et al., 1999).

3.7.17 Sediment hydrocarbon concentrations, were below the limit of detection in samples from three out of the seven stations investigated and, where quantifiable, concentrations were below the Canadian marine sediment quality guidelines and so unlikely to pose a threat to the marine environment, i.e. consistently below the TEL threshold.

3.7.18 Polychlorinated biphenyls and organotins levels were consistently below the limit of detection in all samples.

Suspended Sediment

3.7.19 The Thanet Extension array area is 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. It is situated at 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).

3.7.20 Monthly averaged satellite imagery of Suspended Particulate Matter (SPM) suggests that within Thanet Extension array area average (surface) SPM is generally greater than 10 mg/l, increasing markedly throughout winter months to values between 30 and 80 mg/l (Eggleton et al. 2011; Cefas, 2016), occasionally reaching up to 100 mg/l. Higher values are anticipated during spring tides and storm conditions, with the greatest concentrations encountered close to the bed.

3.7.21 Further details of the physical environmental baseline in Thanet Extension array area are presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2).

The offshore export cable corridor

3.7.22 *Surficial and sub-seabed sediments*: As for the Thanet Extension array area, information has been provided from available grab sample data (Fugro, 2017) and interpreted side-scan sonar data (Fugro 2016b; TOWL, 2005).

3.7.23 Seabed sediments along the corridor are predominantly characterised by sands and gravels with varying contributions of each (Fugro 2016b) (Figure 3.4). The north-eastern extent of the OECC (close to the Thanet Extension array area) comprises mixed sand/ gravel. Increasing contributions of sand and clay occurs within mid sections, with further fine sand and clay contributions within inshore and nearshore areas. The surficial sediment layer varies in thickness throughout the corridor, although predominantly acts as a mobile surface layer on top of underlying geological features.

3.7.24 Sediments in Pegwell Bay comprise fine to very fine sands (Rees Jones, 1998; Dussart and Rodgers, 2002). Within the bay, fine surface sediments are re-suspended, moved around in the water column as the tide ebbs and flows and eventually deposited elsewhere.

Contaminants

3.7.25 Contaminant analysis was undertaken by Fugro EMU (Fugro, 2017; Document Ref: 6.4.5.2) in the OECC. The results of the metals analysis showed that metal concentrations in sediment samples were below both Cefas Action Level 1 and TEL all metals with the only exception being arsenic which is in keeping with the contaminant analysis in the array.

3.7.26 The highest arsenic concentration (60.1 mg kg^{-1}), recorded at the shallow near shore station CR10 (see Figure 3.6) concentrations of which were between Cefas Action Level 1 and 2. The arsenic concentrations (Fugro, 2017; Document Ref: 6.4.5.1) were within the range reported for the southern North Sea: < 0.5 mg kg-1 to 135 mg kg-1 of dry weight arsenic (Whalley et al., 1999).

3.7.27 Sediment hydrocarbon concentrations were below the Canadian marine sediment quality guidelines and consistently below the TEL threshold within the 2016 survey.

3.7.28 Polychlorinated biphenyls and organotins levels were consistently below the limit of detection in all samples within the 2016 survey.

3.7.29 Chemical contaminant samples were acquired from the mid-shore station at each transect at Pegwell Bay and Sandwich Bay by Marine Ecological Surveys Limited (MESL Ltd) (see Figure 3.6). Samples were collected in accordance with the instructions of the analytical lab and were stored in containers provided by ALS Environmental, to identify levels of tributyltin, heavy metals, Polycylic Aromatic Hydrocarbons (PAH) and organic matter in the areas of interest

3.7.30 None of the samples analysed showed metals, hydrocarbons or organic pollutants above the Cefas Action Level 1. Full details of the survey are presented in Volume 4, Annex 5-1 (MESL Ltd, 2017, Document Ref: 6.4.5.1).

3.7.31 A disused hoverport is located onshore to the north of the OECC. The hoverport was built circa 1973 and was visible on maps of the area until the 2006 map. The area of the hoverport appears to have been constructed into Pegwell Bay by reclaiming an area of land. Historical records indicate the area may have been reclaimed using colliery shale waste materials.

3.7.32 Ground contamination had been reported in the site through ground investigations using borehole and spike samples. There is evidence of former fuel storage and vehicle maintenance areas from elevated concentrations of hydrocarbons detected in the ground water. The site has formerly been considered likely to be classified as Contaminated Land under Part 2a of the Environment Act due to the risks associated with groundwater contamination discharging to coastal waters. The hoverport lies some 500 m north of the proposed landfall, and to the periphery of the OECC.

Suspended Sediments

3.7.33 Suspended sediment concentrations are found to increase with greater proximity to the coast and are at their highest within nearshore and inshore areas of the OECC. This is likely due to a combination of enhanced re-suspension from wave activity within shallower water and fluvial input of sediment. In general average (surface) SPM remains above 10 to 20 mg/l throughout summer months and above 40 mg/l during winter (Eggleton *et al.*, 2011).

3.7.34 Further details of the physical environmental baseline in the Thanet Extension OECC are presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2).

Landfall

3.7.35 Details of the historic Cliffsend landfill are presented within Volume 3, Chapter 6: Ground Conditions, Flood Risk and Land Use and Volume 5, Annex 6-1: Phase 1 Geo-environmental Desk Study (Document Refs: 6.3.6 and 6.5.6.1 respectively).

3.7.36 The historic Cliffsend landfill is located on-site to the east of the Sandwich Road in the Pegwell Bay Country Park, the last input to this landfill was in 1972. It was filled with household and inert waste and also non-degradable and slowly degradable waste, scrap metal, putrescible waste, hazardous waste and household waste. Based on the information received from TDC, it may have been partly capped.

3.7.37 VWPL have commissioned site investigation works within the historic landfill in order to determine the feasibility of burying cables and to provide information on the potential contaminants present. These studies would typically be undertaken post-consent to inform the detailed design of the project, however these surveys have been brought forwards as a response to stakeholder consultation. The findings of these studies are not available at the time of writing this ES, therefore a Rochdale Envelope approach has been adopted within this assessment.

3.8 Key parameters for assessment

3.8.1 This section identifies the maximum adverse scenario of relevance to the assessment of impacts on water and sediment quality, defined by the project design envelope (Volume 2, Chapter 1: Offshore Project Description (Document Ref: 6.2.1)). 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, 2012), and as detailed in Volume 1, Chapter 3 EIA Methodology (Document Ref: 6.1.3).

3.8.2 The maximum design scenarios assessed for sediment and water quality are described in Table 3.10. These scenarios will be taken forward to assess the realistic worst-case scenario for each of the identified potential impacts.

Table 3.10: Maximum design scenario assessed

Potential effect	Maximum adverse scenario assessed	Justification
Construction		
Deterioration in water quality due to re-suspension of sediments due to dredging for seabed preparation prior to foundation installation	*Greatest volume of sediment disturbed and released from a single foundation location* • Largest WTG quadropod suction caisson foundation (12 MW*) and associated bed preparation will result in a maximum spoil volume per foundation of 9,600 m^3; • Disposal of material on the seabed within the array area; • Dredging carried out using a representative trailer suction hopper dredger. Multiple dredgers to be working simultaneously; and • Material to be deposited 'close' to the installation works. *Greatest volume of sediment disturbed and released across the entire array area* • Project comprising 28 large (12 MW) quadropod suction caisson foundations and associated seabed preparations will create a maximum spoil volume for entire array area of 268,800 m^3; • One OSS quadropod suction caisson foundation with an associated total spoil volume of 9,600 m^3; • Disposal of material on the seabed within the array area; • Dredging carried out using a representative trailer suction hopper dredger; and • Offshore construction phase lasting up to 28 months (but anticipated to be around 12 working months spread over a minimum of two summer seasons).	Seabed preparation works would only be required prior to installation of quadropod suction caisson foundations (if at all). Two maximum adverse scenarios are identified, corresponding to the greatest volume of sediment disturbance locally (from a single foundation) and across the entire array (from all foundations). The greatest sediment disturbance from a single quadropod suction caisson foundation location is associated with the largest diameter caisson cans whereas the greatest volume of sediment release for the entire array area is associated with a layout comprising a smaller number of large (12 MW) WTG foundations.
Deterioration in water quality due to re-suspension of sediments due to the release of drill arisings during foundation installation	*Greatest volume of sediment disturbed and released from a single foundation location* • Largest WTG monopile foundations (12 MW), drill risings volume per foundation 1,325 m^3; • Drilling rate of up to 5 m/ hour (based on six hours to each foundation); and • Disposal of drill arisings at or above water surface. *Greatest volume of sediment disturbed and released across the entire array area* • Project comprising 28 (12 MW) monopile foundations, up to 50% of foundations may be drilled, spoil volume for entire array area 22,531 m^3; • One OSS monopile foundation, total drill rising volume 1,000 m^3; • Drilling rate of up to 5 m/hour (based on six hours to each foundation); • Disposal of drill arisings at or above water surface; and • Construction phase lasting up to 28 months.	Although the volumes of material released via drilling are less than for seabed preparation via dredging, drilling has the potential to release larger volumes of relatively finer sediment. Two maximum adverse scenarios are identified, corresponding to the greatest volume of sediment disturbance locally (from a single foundation) and across the entire array (from all foundations). The greatest volume of drill arisings from a single foundation location is associated with the largest diameter monopile foundation whereas the greatest volume of drill arisings for the entire array area is associated with a layout comprising a smaller number of large (12 MW) quadropod foundations.
Deterioration in water quality due to re-suspension of sediments due to cable installation within the Thanet Extension array area and within the OECC	*Inter-array cables* • Installation method: jetting; • Total length 64 km; • V-shape trench; 0.3 km^2; • Burial of up to 3 m below mean seabed level;	Cable installation may involve (*inter alia*) jetting, ploughing, trenching, cutting and/ or jetting excavation installation techniques. Of these, jetting will most energetically disturb the greatest volume of sediment in the trench profile and as such is considered to be the maximum adverse scenario for sediment dispersion.

Potential effect	Maximum adverse scenario assessed	Justification
	• Assumed installation rate of up to approximately 450 m/hr; and • Construction phase lasting up to 28 months. *Sand wave clearance* • Sandwave clearance via dredging • Assume 20% of HVAC export cable route (total length 24 km); • Pre-sweeping dredging width of corridor of 20 m; • Pre-sweeping area of 0.48 km^2; and • Pre-sweeping volume of dredging corridor will be up to 1,440,000 m^3. *Export cable installation* • Installation method: jetting; • Up to four export cable trenches; each up to 30 km in length from array area boundary to landfall (120 km in total); • V-shape trench; width = 10 m; depth = 3 m; • Volume of disturbance = 1.2 km^2 (0.3 km^2 per cable); • Minimum spacing between (pairs) of cables 120 m; • Assumed installation rate of up to approximately 450 m/hr; and • Construction phase lasting up to 28 months.	
Accidental releases or spills of construction materials or chemicals	Synthetic compound, heavy metal and hydrocarbon contamination resulting from the construction of up to 34 turbines, one met mast and one OSS. A typical 12 MW turbine is expected to contain approximately 2,000 litres of grease, 2,000 litres of synthetic or hydraulic oil, 200 litres of liquid nitrogen, 2,000 kg of silicone oil and 100 kg SF6 gas. The OSS is expected to contain approximately 200,000 litres of diesel, 1,000 litres of grey water, 1,000 litres of black water, 600,000 litres of transformer coolant water, 20,000 litres of fire suppressant material, 1,500 kg of SF6, 5 m^3 of engine oil and 5 m^3 of HVAC coolant (glycol).	These parameters are considered to represent the maximum adverse scenario with regards to vessel movement during the construction period.
Contamination from leachate from the historic landfill	Each of the three landfall designs pose a risk of leachate from the historic landfill, however embedded mitigation has been included to prevent this from materialising. Option 3 is considered the worst-case for the potential of leachate from the historic landfill. This option would involve removing the sea wall and trenching through the historic landfill. A cofferdam (165 m x 25 m) will be used to capture all leachate and contaminated materials will be disposed of as considered appropriate through consultation with the relevant authorities post-consent.	These parameters are considered to represent the maximum adverse scenario with regards to works to the sea wall at the boundary of the historic landfill.

Potential effect	Maximum adverse scenario assessed	Justification
	The maximum working area associated with the landfall alone within the saltmarsh will be 4,702 m^2. The total duration of the landfall works is anticipated to be 18 months.	
Release of bentonite from HDD at the landfall	This effect is only applicable to landfall Option 1 – HDD. • A temporary working area of 60 x 50 m will contain the HDD apparatus; • Up to four ducts will be installed by HDD from the TJB locations, under the sea wall, to exit at least 100 m from the sea wall; • Up to four (one per duct) 20 x 20 m offshore containment areas in order to contain the water based drilling mud (usually inert clay based Bentonite). A common methodology that may be employed is the creation of a temporary mud lagoon installed in the landward drilling entry pit which will use a closed-circuit mud management system where the mud is constantly pumped out of the pit for processing. At the exit pit containment area, which may be excavated or surface based, some bentonite will collect in the exit pit and subsequently be removed. The total duration of the landfall works is anticipated to be 18 months.	These parameters are considered to represent the maximum adverse scenarios for volumes of bentonite which could be released to the environment from the use of a HDD at the landfall.
O&M		
Deterioration in water quality due to re-suspension of sediments due to scour of seabed sediments	• Maximum adverse scenario is defined on the basis of the outputs of the scour assessment (see Volume 4, Annex 2.1: Marine Geology, Oceanography and Physical Processes Technical Annex for results).	Each foundation type may produce different scour patterns for this reason monopiles and quadropod foundations have both been considered. The foundation type, size and number producing the greatest area and/ or volume of influence cannot be identified in advance of the assessment.
Deterioration in water quality due to re-suspension of sediments due to development of turbid wake features	• Array comprising the largest (12 MW) quadropod suction caisson foundations for WTGs (up to 28 structures with four 20 m suction cans), one met mast and one OSS; • Minimum foundation spacing of 480 x 716 m; and • O&M phase lasting 30 years†.	Different foundation types will produce differing patterns of turbulence and so potentially slightly different turbid wake footprints. However, suction caissons provide the greatest blockage and have the potential to cause greatest turbulence.
Accidental releases or spills of construction materials or chemicals	Synthetic compound, heavy metal and hydrocarbon contamination resulting from up to 34 WTGs and one OSS. Accidental pollution may also result from up to 1160 round-trips to port by O&M vessels (including crew supply vessels and jack-up vessels) per year over the 30-year design lifetime. A typical 12 MW turbine is expected to contain approximately 2,000 litres of grease, 2,000 litres of synthetic or hydraulic oil, 200 litres of liquid nitrogen, 2,000 kg of silicone oil and 100 kg SF6 gas.	These parameters are considered to represent the maximum adverse scenario with regards to vessel movement during the O&M period.

Potential effect	Maximum adverse scenario assessed	Justification
	The OSS (if required) is expected to contain approximately 200,000 litres of diesel, 1,000 litres of grey water, 1,000 litres of black water, 600,000 litres of transformer coolant water, 10 litres of UPS batteries, 20,000 litres of fire suppressant material, 1,500 kg of SF6, 5 m^3 of engine oil and 5 m^3 of HVAC coolant (glycol).	
Decommissioning		
Increases in SSC and deposition of disturbed sediment to the seabed within the Thanet Extension array area and the corridor	• Array comprising the largest number of foundations (34); • 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); and • Scour and cable protection left *in situ*. Decommissioning phase is expected to last approximately one year.	When removing foundations, the greatest disturbance will be associated with the layout containing the greatest number of structures.
Cumulative effects		
Cumulative temporary changes in SSC and bed levels as a result of Thanet Extension project construction and Nemo Link installation works	• Maximum adverse scenario for Thanet Extension Project construction phase (as previously defined); and • Nemo Link interconnector.	Meaningful sediment plume interaction generally only has the potential to occur if the activities generating the sediment plumes are located within one spring tidal excursion ellipse from one another and occur at the same time. Accordingly, only those activities located within one spring tidal excursion ellipse of the project have been considered within the assessment. Operational wind farms within the study area (Thanet and London Array) are not considered in the cumulative effects assessment as they are recognised as being part of the baseline environment and hence are taken into consideration within the project-alone assessment.
Cumulative temporary increases in SSC and bed levels as a result of Thanet Extension export cable installation and dredge disposal activities.	• Maximum adverse scenario for Thanet Extension Project construction phase (as previously defined); and • Two dredge disposal sites (Pegwell Bay – TH140 and Nemo Disposal Site C – TH152).	
Cumulative temporary increases in SSC and bed levels as a result of Thanet Extension export cable installation and aggregate dredging activities.	• Maximum adverse scenario for Thanet Extension Project construction phase (as previously defined); and • One aggregate extraction site dredge disposal site (Goodwin Sands – Area 521).	

* Subject to final design it is possible that an alternative, larger capacity, WTG (i.e. >12 MW) type may be selected. In this scenario the number of WTGs would be reduced, but the overall maximum project capacity will remain at 340 MW and the physical parameters such as maximum blade tip height, rotor diameter, and height of nacelle will remain within the maximum envelope described in this chapter.

†The operational life is expected to be 30 years, although this may be extended as the project nears decommissioning as technology and maintenance improve.

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 water and sediment quality are listed in Table 3.11. General mitigation measures, which would apply to all parts of Thanet Extension, are set out first. Thereafter mitigation measures that would apply specifically to marine water and sediment quality issues associated with the proposed activities, are described separately.

3.9.2 A Marine Pollution Contingency Plan (MPCP) would be implemented, as embedded mitigation, to reduce any potential risk of accidental spills and pollution.

Table 3.11: Embedded mitigation relating to marine water and sediment quality

Parameter	Mitigation measures embedded into the project design
General	
Definition of development boundaries	The development boundary selection was made following a series of constraints analyses, with the array area and OECC route selected to ensure the impacts on the environment and other marine users are minimised. The development boundary has been specifically kept south of the disused hoverport to prevent any interactions with this known source of contamination.
Construction	
Pollution prevention	A Project Environment Management Plan (PEMP) will be produced post-consent and implemented to cover the construction and O&M phases of Thanet Extension. The PEMP will include a MPCP to cover accidental spills, potential contaminant release and include key emergency contact details (e.g. Marine Management Organisation (MMO), Maritime Coastguard Agency and the project site co-ordinator). A Decommissioning Programme will be developed to cover the decommissioning phase.
	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.
Leachate prevention	For landfall options 2 and 3, prior to cable installation works commencing a temporary cofferdam would be installed at the seaward interface of the landfall works to act as a barrier to tidal inundation, and as a preventative barrier for the release of any contaminants associated with the landfill area. The cofferdam will be installed in such a way as to permit open trenching from the intertidal to the sea wall extension, allowing a dry working area below the high water mark on the saltmarsh in the area east of the Country Park. This cofferdam would be a maximum of 25 m seaward by 165 m wide, and would be constructed of sheet piles.
Bentonite capture	A common methodology that may be employed should HDD be used is the creation of a temporary mud lagoon installed in the landward drilling entry pit which will use a closed-circuit mud management system where the mud is constantly pumped out of the pit for processing. At the exit pit containment area, which may be excavated or surface based, some bentonite will collect in the exit pit and will be subsequently removed. Whilst the drilling mud will be water based, and will comprise an inert clay material (Bentonite), this approach will ensure that impacts to surrounding intertidal receptors will be kept to a minimum.
O&M	
Offshore cable	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 and the assessed risk of impact damage.
WTG foundations	Where scour protection is absent and where the hydrodynamic/ seabed geology allow, scour has the potential to form around WTG foundations. This may lead to the release of material into suspension (higher turbidity) and a change to seabed habitat immediately adjacent to the structure. This will be reduced with the introduction of scour protection, where necessary.

3.10 Environmental assessment: construction phase

3.10.1 A description of the significance of effect upon water and sediment receptors caused by each identified impact is provided below.

Deterioration in water quality due to re-suspension of sediments and release of contaminants

3.10.2 A full assessment of increased SSC, is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2). The findings of the assessment were that the magnitude of the maximum potential increase in SSC resulting from construction activities is within the natural range of SSC within the region and the impact will be short-term, intermittent, of localised extent and reversible. The magnitude of the impact is considered to be Negligible.

3.10.3 The sensitivity has been primarily determined based on the presence and absence of designations for the impacted waters given the predicted magnitude of the impacts. Therefore, the sensitivity for designated sites such as WFD waterbodies is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be low. Despite different sensitivities the significance of the effect for both is deemed to be of **Minor** adverse significance, which is not considered to be significant in EIA terms, see Table 3.7.

3.10.4 A full assessment of proposed activities on the water quality at the three screened in BW is presented in Volume 4, Annex 3-1: Water Framework Directive (Document Ref: 6.4.3.1). The changes to bacterial concentrations at the BWs as a result of the proposed activities for the phases of Thanet Extension (from re-suspended sediments) is considered to be Negligible in terms of magnitude. As these are international designated sites the sensitivity is deemed to be High. The significance of the effect is deemed to be of **Minor** adverse significance, which is not significant in EIA terms.

3.10.5 The impacts of increases in SSC and associated impacts on shellfish is assessed in Volume 2, Chapter 6: Fish and Shellfish (Document Ref: 6.2.6). The magnitude of the impact has been assessed as Low, with the sensitivity of receptors being Low. The significance of effect is deemed to be of **Minor** adverse significance, which is not considered to be significant in EIA terms.

3.10.6 As identified in Table 3.2 and assessed in the above section, construction activities will re-suspend sediments. While 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 effect on water quality receptors.

3.10.7 Contaminant analysis was undertaken by MESL Ltd for the intertidal area of Pegwell Bay (MESL Ltd; Volume 4, Annex 5-1). None of the samples analysed showed metals, hydrocarbons or organic pollutants above the Cefas Action Level 1.

3.10.8 All samples for organotins (including tributyltin), polychlorinated biphenyl's (PCB's) (sum of International Council for the Exploration of the Sea-7 (ICES 7)) and mercury, were below the levels of detection in all of the intertidal samples taken in 2017 in Pegwell Bay by MESL Ltd. Cadmium sampled were all recorded at the detection limit of the analysis which coincides with the Cefas Action Level 1.

3.10.9 Contaminant analysis was undertaken by Fugro EMU (Fugro, 2017; Document Ref: 6.4.5.1). The results of the metals analysis showed that metal concentrations in sediment samples were below the marine sediment quality guidelines for most of the metals included in the analysis. The only exception was arsenic, concentrations of which was between Cefas Alert Level 1 and 2 (AL1; AL2) present both within the array and OECC.

3.10.10 Sediment hydrocarbon concentrations were below the limit of detection in samples from three out of the seven stations investigated in the analysis undertaken but Fugro EMU and, where quantifiable, concentrations were below the Canadian marine sediment quality guidelines and are consequently unlikely to pose a threat to the marine environment. Polychlorinated biphenyls and organotins levels were considerably below the limit of detection in all samples.

3.10.11 Natural sources of arsenic in the marine environment include (but are not limited to) remobilisation and erosion of arsenic-rich rocks (Research Council of Norway, 2012), which vary naturally according to local geology. Anthropogenic sources include mining and smelting (Research Council of Norway, 2012) as well as the burning of fossil fuels (ICES, 2004). Due to the high natural occurrence of this metal, it is often difficult to precisely discern between natural and anthropogenic sources of this metal (OSPAR, 2005). However, high arsenic concentrations in the outer Thames Estuary, as well as the south-west Dogger Bank and Norfolk may be associated with a history of arsenical waste disposal in the Thames estuary (Whalley *et al.*, 1999).

3.10.12 The arsenic concentrations (Fugro, 2017; Document Ref: 6.4.5.1) were within the range reported for the southern North Sea: < 0.5 mg kg^{-1} to 135 mg kg^{-1} of dry weight arsenic (Whalley *et al*., 1999). Quantifiable, but below the standards, concentrations of cadmium and mercury at station WF47 (Volume 4, Annex 5-2) within the north-western end of the development site, may be associated with the high mud content at this station, as finer sediment offers a larger surface area to volume ratio for metals to adsorb (and conversely, to desorb) (Davies, 2004). Cadmium and mercury in the marine environment are predominantly of anthropogenic origin (United Nations Environment Programme, 1990), with rivers being the dominant sources compared to direct discharge (OSPAR, 2005).

3.10.13 The total area that is likely to be disturbed by construction activities, and so the potential volume of material disturbed, resulting in the potential release of sediment bound contaminants is small and localised in extent, see Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2). In addition, the nature of the subtidal sediments is predominantly coarse, typically with low levels of fines adhering to them. Following disturbance as a result of construction activities, the majority of re-suspended sediments are expected to be deposited in the immediate vicinity of the works. The release of contaminants from the small proportion of fine sediments is likely to be rapidly dispersed with the tide and/ or currents and so increased bio-availability resulting in adverse eco-toxicological effects are not expected. The levels found are all comparable to the wider regional background and not considered to be of a low quality and will not result in a significant effect-receptor pathway if made bioavailable.

3.10.14 The impacts to water quality receptors as a result of the release of sediment-bound contaminants are considered to be of Negligible magnitude. The sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium to High. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Despite different sensitivities the significance of the effect is deemed to be of **Minor to Negligible** adverse significance, which is not considered to be significant in EIA terms.

Accidental releases or spills of construction materials or chemicals

3.10.15 Substances such as grease, oil, fuel, anti-fouling paints and grouting materials may be accidentally released or spilt into the marine environment. Thanet Extension is committed to the use of best-practice techniques and due diligence throughout all construction, O&M and decommissioning activities. This commitment ensures the use of appropriate preventative measures and serves as an embedded mitigation against this type of pollution incidence.

3.10.16 Any quantities of accidentally released materials are likely to be small. Both the lateral and vertical dispersion rates are expected to be high. The magnitude of this potential impact is considered to be Negligible, as it is not anticipated to affect the waterbodies performance against their EQSs, the potential impacts will be temporary in nature and controls are anticipated to be in place. The sensitivity has been primarily determined based on the presence and absence of designations for the impacted waters given the predicted magnitude of the impacts. Therefore, the sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Despite different sensitivities the significance of the effect is deemed to be of **Minor** adverse significance, which is not considered to be significant in EIA terms.

Contamination from leachate from the historic landfill

3.10.17 The requirement to remove and replace the sea wall at the boundary of the Pegwell Bay Country Park introduces the risk of leachate from the historic landfill being released onto the saltmarsh and transported to the intertidal and offshore environment from the inundation of spring tides.

3.10.18 The content of the historic landfill is thought be both household and commercial waste.

3.10.19 The proposed embedded mitigation will be deployed in such a way as to control any foreseeable pathways of leachate to ensure that it is appropriately captured and disposed of. Prior to works commencing a temporary cofferdam would be installed at the seaward interface of the landfall works to act as a barrier to tidal inundation, and as a preventative barrier for the release of any contaminants associated with the landfill area.

3.10.20 Consequently, there will be no release of leachate into the marine environment as a result of the proposed activities from any of the proposed landfall options including trenching or HDD. So, the changes to concentrations of contaminants, including metals and non-metals, in the local waters will not be discernible from background conditions. Therefore, the magnitude of this impact is considered to be Negligible.

3.10.21 The sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Therefore, the significance of the effect is deemed to be of **Minor** adverse significance for designated sites and non-designated sites, which are not considered to be significant in EIA terms.

3.10.22 Therefore, the significance of the effect is deemed to be of **Minor** adverse significance for designated sites and **Negligible** adverse for non-designated sites, which are not considered to be significant in EIA terms.

Release of bentonite from HDD at the landfall

3.10.23 Bentonite (specifically sodium bentonite as the chemical species under discussion) is a non-toxic, inert, natural clay mineral (<63 µm particle diameter) that can be diluted with water and used as a drilling mud, lubricating the drill annulus and forming an impermeable filter cake that acts to control fluid loss. It has been used both for HDD works and in the oil and gas industry for the drilling of wells. As noted previously Bentonite is on the List of Notified Chemicals approved for use in the marine environment and is classed as OCNS[1] group E, which is the group least likely to cause environmental harm.

3.10.24 It is anticipated that bentonite will be mixed with water to create the drilling fluid.

[1] Offshore Chemical Notification Scheme operated by Cefas - https://www.cefas.co.uk/cefas-data-hub/offshore-chemical-notification-scheme/hazard-assessment/

3.10.25 The requirement for drilling mud, such as bentonite (or another inert mud), if the HDD option is selected for making landfall, could result in the release of drilling mud within the intertidal mudflats at the punch out point. The bentonite may then be dispersed and transported by tidal currents.

3.10.26 The principal issues relating to bentonite release to the water column comprise the potential for an increase in SSC within an area and/or deposition causing a risk of smothering benthic organisms should the material settle on the seabed, for example during low tidal flow states. The significance of such potential impacts relates to the degree to which SSC are elevated in an area and the depth and temporal extent of any deposition on the seabed.

3.10.27 Although no specific modelling of bentonite within the intertidal has been undertaken for the purposes of this assessment, numerous studies have been carried out regarding the fate of drilling muds and bentonite in the water column after release from oil and gas platforms. These oil and gas studies provide a good indication of the behaviour of bentonite after re-suspension by wave action, in particular the dispersal of bentonite within the marine environment. The impacts of bentonite on benthic species is considered in Volume 2, Chapter 5: Benthic Intertidal and Subtidal Ecology (Document Ref: 6.2.5).

3.10.28 Bentonite, when in suspension, can increase the suspended sediment concentration (SSC) in an area. However, as it is a clay-based substance it can be rapidly dispersed in high-energy environments and as such the local SSC would drop within one tidal cycle.

3.10.29 Offshore oil and gas drilling release large volumes of drilling mud (mostly bentonite), and the drill cuttings, directly next to the platform during exploration and operational drilling. While the heavier elements of this mixture such as the drill cuttings tend to settle around the platform, the lighter elements including the drill muds (bentonite) remain in suspension or are re-suspended by bottom currents. The initial plume from the drill mud and cuttings can produce a high SSC locally, however the dispersal and dilution of the drilling muds within the water column is very rapid and occurs over very small distances. Coats (1994) demonstrated that within 0.5km of an actively drilling oil and gas platform, only 2% of the SSC could be attributed to the drilling muds.

3.10.30 It is also noteworthy that the bentonite release from the oil and gas platform was situated in deep waters offshore, the current speeds were lower than those found in Pegwell Bay; as such, dispersal should be even more rapid within the higher energy environment of Pegwell Bay. Therefore, it can be expected that within one tidal cycle the contribution of the bentonite to the local background levels of SSC would be negligible.

3.10.31 Any elevation in SSC as a consequence of inert drilling mud, such as bentonite, would be localised, within the range of natural variability and temporary. The magnitude of these elevated concentrations on water quality receptors are considered to be Low.

3.10.32 The sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Therefore, the significance of the effect is deemed to be of **Minor** adverse significance for designated sites and non-designated sites, which are not considered to be significant in EIA terms.

3.10.33 However, the HDD will be deployed in such a way as to minimise release of drilling fluid/ mud. The HDD will exit into offshore containment areas in order to contain the water based drilling mud for subsequent removal.

3.10.34 Consequently, there will be no release of drilling muds into the marine environment as a result of the use of HDD activities, and so the magnitude of this impact is considered to be Negligible. Therefore, the significance of the effect is deemed to be of **Minor** adverse significance for designated sites and **Negligible** adverse for non-designated sites, which are not considered to be significant in EIA terms.

3.11 Environmental assessment: O&M phase

Deterioration in water quality due to re-suspension of sediments - scour

3.11.1 A full assessment of scour associated with the presence of WTGs, OSS foundations and cable protection measures used at cable crossings and areas where burial is not possible, will lead to re-suspended sediments from scour before an equilibrium is reached. This assessment is presented in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes. These impacts are considered associated with the O&M phase of the proposed development.

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

3.11.3 The magnitude of any change 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). In some cases, the modified sediment character within a scour pit may not be so different from the surrounding seabed; however, changes relating to bed slope and elevated flow speed and turbulence close to the foundation are still likely to apply.

3.11.4 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. Therefore, the impacts associated with increased SSC due to scour are considered to be temporary.

3.11.5 Any elevation in SSC as a consequence of scour will be short-lived, localised and within the range of natural variability, see Volume 2, Chapter 2: Marine Geology, Oceanography and Physical processes (Document Ref: 6.2.2). The magnitude of these elevated concentrations on water quality receptors are considered to be Negligible.

3.11.6 The sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Therefore, the significance of the effect is deemed to be of **Minor** adverse significance for designated sites and of **Negligible** adverse significance for non-designated sites, which are not considered to be significant in EIA terms.

Deterioration in water quality due to re-suspension of sediments - turbid wakes

3.11.7 Turbid wakes (wake features additionally characterised by an elevated level of turbidity relative to water immediately outside of their local footprint) have been observed at the Thanet, London Array and Greater Gabbard Offshore Wind Farms (OWFs) in the outer Thames estuary. Similar features have also been noted for other OWFs in the waters of Germany, The Netherlands and Belgium, suggesting that this is a general phenomenon associated with the placement of these structures in the sea (Forster, 2017).

3.11.8 The development and impacts of turbid wakes as a result of WTG structures during the O&M phase are fully assessed in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2). This chapter assesses turbid wakes in the context of increased suspended sediment concentrations on water quality receptors as a result of these processes.

3.11.9 There is now a wide range of evidence regarding turbid wakes at TOWF (and other wind farms). The evidence includes remote sensing data (e.g. Vanhellemont and Ruddick, 2014; NASA, 2016), aerial photography (e.g. VWPL, 2017) and local field studies (Forster, 2017). Analysis of satellite observed (sea surface) SPM concentrations suggests that these features have resulted in a net increase in average surface SPM within and nearby to the TOWF array area, with a notable increase in the frequency with which SPM in the range 10 to 20 mg/l is encountered. The field evidence collected by Forster (2017) from TOWF shows that plumes are caused by re-distribution of suspended sediment in the water column due to increased vertical mixing in the monopile wake. Not only are suspended sediment concentrations higher at the surface, but the evidence shows that the near-bed concentration of sediment is actually lower within the plume. This supports that there is a re-distribution of suspended material from the near-bed to the surface which is caused by the increased turbulence within the wake.

3.11.10 The extent of the turbid wakes will fluctuate over tidal cycles (ebb/ flood, spring/ neap) and also possibly in response to seasonal influences (e.g. input of finer grained sediment from fluvial discharge). The maximum length to which the turbid wake features could theoretically extend is limited by the spring tidal excursion distance, approximately 13 km from the array area.

3.11.11 According to the *in situ* measurements from Forster (2017) as well as the satellite data presented in Vanhellemont and Ruddick (2014) the SSC/ SPM in the surface waters of the turbid wakes at TOWF is typically between about 10 and 30 mg/l above background levels (typically greater than 10 mg/l with seasonal variability, see paragraph 3.7.20). The relative contrast in SSC between inside and outside of the turbulent wakes is likely to vary, in response to natural variability in the naturally present magnitude and vertical distribution of SSC both nearbed and elsewhere in the water column.

3.11.12 Because the naturally present distribution of SSC is expected to be broadly similar between the Thanet Extension and TOWF array areas, it is reasonable to assume that the magnitude of elevated SSC in turbid wakes at Thanet Extension will be broadly similar to those observed at TOWF at any given time.

3.11.13 Areas inside of the Thanet Extension array area that are downstream of foundations on both ebb and flood tides might theoretically be affected up to 100% of the time. Other parts of the array area and areas outside of the Thanet Extension array area that are downstream of foundations on either ebb or flood tides might theoretically be affected by turbid wake features for up to 50% of the time due to current direction reversal.

3.11.14 In practice, it is unlikely that the turbid wakes will be continually present. A period of 'no plume present' is apparent in satellite images acquired between one and two hours into the ebb tide (i.e. following tidal reversal and at relatively low current speeds) although further evidence is required to confirm this (Forster, 2017). Similarly, it is likely that during the stormier winter months, turbid wake features will be either less pronounced or absent due to naturally enhanced mixing of sediment through the water column in the ambient environment.

3.11.15 Monthly averaged satellite imagery of SPM suggests that within the Thanet Extension array area average (surface) SPM is generally greater than 10 mg/l, increasing markedly throughout winter months to values between 30 and 80 mg/l (Eggleton et al. 2011; Cefas, 2016), occasionally reaching up to 100 mg/l. Higher values are anticipated during spring tides and storm conditions, with the greatest concentrations encountered close to the bed.

3.11.16 Given that the increases in the surface SPM anticipated with turbid wakes are within natural variability and sediments are thought to be redistributed throughout the water column rather than a net increase, the magnitude is considered to be Negligible despite being a permanent feature during the O&M phase. The sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Therefore, the significance of the effect is deemed to be of **Minor** adverse significance for designated sites and of **Negligible** adverse significance for non-designated sites respectively, which are not significant in EIA terms.

Accidental releases or spills of construction materials or chemicals

3.11.17 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. Thanet Extension is committed to the use of best practice and pollution prevention guidelines at all times. A MPCP would be in place and agreed with the MMO in line with the Integrated Pollution Prevention and Control (IPPC) Directive such that any potential risk is minimised. Any permitted discharges would be small volumes, intermittent and dilute and disperse quickly.

3.11.18 The magnitude of this potential impact is considered to be Negligible as a result of the controls and best practice measures that will be captured within the PEMP, to be submitted for approval post-consent as required in the dML, furthermore it is not anticipated that any accidental release or spill would affect the waterbodies performance against their EQSs as the potential impacts will be temporary in nature. The sensitivity has been primarily determined based on the presence and absence of designations for the impacted waters given the predicted magnitude of the impacts. The sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Therefore, the significance of the effect is deemed to be **Minor** adverse significance for designated sites and **Negligible** adverse significance for non-designated sites, which are not considered to be significant in EIA terms.

3.12 Environmental assessment: decommissioning phase

Deterioration in water quality due to re-suspension of sediments

3.12.1 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. The sensitivity has been primarily determined based on the presence and absence of designations for the impacted waters given the predicted magnitude of the impacts. The sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Despite different sensitivities the significance of the effect is deemed to be of **Minor** adverse significance, which is not considered to be significant in EIA terms.

Release of contaminants from disturbed sediments

3.12.2 The impacts during decommissioning are considered to be similar or less than those during construction.

3.12.3 The impacts to water quality receptors as a result of the release of sediment-bound contaminants are therefore considered to be of Negligible magnitude. The sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Despite different sensitivities the significance of the effect is deemed to be **Minor** adverse significance, which is not considered to be significant in EIA terms.

Accidental releases or spills of construction materials or chemicals

3.12.4 The potential impacts during decommissioning are considered to be similar or less than during construction.

3.12.5 The magnitude of this potential impact is considered to be Negligible as a result of the controls and best practice measures that will be captured within the PEMP. The sensitivity has been primarily determined based on the presence and absence of designations for the impacted waters given the predicted magnitude of the impacts. Therefore, the sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Despite different sensitivities the significance of the effect is deemed to be of **Minor** adverse significance, which is not considered to be significant in EIA terms.

3.13 Environmental assessment: cumulative effects

3.13.1 Cumulative effects refer to effects upon receptors arising from the Thanet Extension when considered alongside other proposed developments and activities and any other *reasonably foreseeable project(s)* proposals. In this context the term *projects* are considered to refer to any project with comparable effects and is not limited to offshore wind projects.

3.13.2 The approach to cumulative assessment for Thanet Extension takes into account the Cumulative Impact Assessment Guidelines issued by RenewableUK in June 2013, together with comments made in response to other renewable energy developments within the Southern North Sea, and PINS ‘Advice Note 9: Rochdale Approach’. The renewable energy developments that have informed this approach have been agreed within the Scoping Opinion, the suggested tiers, and the Cumulative Impact Assessment conducted for Thanet Extension.

3.13.3 In assessing the potential cumulative impact(s) for Thanet Extension, it is important to bear in mind that for some projects, predominantly those 'proposed' or identified in development plans etc. may or may not actually be taken forward. There is thus a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals. For example, relevant projects/ plans that are already under construction are likely to contribute to cumulative impact with Thanet Extension (providing effect or spatial pathways exist), whereas projects/ plans not yet approved or not yet submitted are less certain to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors.

3.13.4 For this reason, all relevant projects/ plans considered cumulatively alongside Thanet Extension have been allocated into 'Tiers', reflecting their current stage within the planning and development process. This allows the cumulative impact assessment to present several future development scenarios, each with a differing potential for being ultimately built out. Appropriate weight may therefore be given to each scenario (Tier) in the decision-making process when considering the potential cumulative impact associated with Thanet Extension (e.g. it may be considered that greater weight can be placed on the Tier 1 assessment relative to Tier 2).

3.13.5 The projects and plans selected as relevant to the assessment of impacts to marine water and sediment quality are based upon an initial screening exercise undertaken on a long list. Each project, plan or activity has been considered and scoped in or out on the basis of effect–receptor pathway, data confidence and the temporal and spatial scales involved. For the purposes of assessing the impact of Thanet Extension on marine water and sediment quality in the region, the cumulative impact technical note submitted with the Scoping Report (PINS, 2017) screens in the following projects and activities.

3.13.6 The proposed tier structure that is intended to ensure that there is a clear understanding of the level of confidence in the cumulative assessments provided in the Thanet Extension ES is as follows:

Tier 1

3.13.7 Thanet Extension considered alongside other projects/ plans currently under construction and/ or those consented but not yet implemented, and/ or those submitted but not yet determined where data confidence for the projects falling within this category is high.

3.13.8 Built and operational projects will be included within the cumulative assessment where they have not been included within the environmental characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and/ or any residual impact may not have yet fed through to and been captured in estimates of 'baseline' conditions or there is an ongoing effect.

Tier 2

3.13.9 All projects included in Tier 1 plus other projects/ plans consented but not yet implemented and/ or submitted applications not yet determined where data confidence for the projects falling into this category is Medium.

Tier 3

3.13.10 The above plus projects on relevant plans and programmes (the PINS Programme of Projects and MMO 'Marine Case Management System' being the source most relevant for this assessment). Specifically, all projects where the developer has advised PINS in writing that they intend to submit an application in the future were considered. This includes, for example, projects for which scoping reports have been submitted and data availability is limited and/ or data confidence is low.

3.13.11 The specific projects scoped into this cumulative impact assessment, and the tiers into which they have been allocated are presented in Table 3.12 below. The operational projects included within the table are included due to their completion/ commission subsequent to the data collection process for Thanet Extension and as such not included within the baseline characterisation.

Table 3.12: Projects for cumulative assessment

Development type	Project	Status	Data confidence assessment/ phase	Tier
Cable installation	Nemo Interconnector Cable	Consented	High - Third party project details published in the public domain and confirmed as being 'accurate'.	Tier 1
Disposal Area	Nemo Disposal Site B	Open	High - Third party project details published in the public domain and confirmed as being 'accurate'.	Tier 1
Disposal Area	Nemo Disposal Site C	Open	High - Third party project details published in the public domain and confirmed as being 'accurate'.	Tier 1
Disposal Area	Pegwell Bay	Open	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'.	Tier 2
Disposal Area	Pegwell Bay B	Open	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'.	Tier 2
Disposal Site	Ramsgate Harbour Site A	Open	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'.	Tier 2
Disposal Site	Ramsgate Harbour Site B	Open	Medium - Third party project details published in the public domain but not confirmed as being 'accurate'.	Tier 2

3.13.12 The cumulative Rochdale Envelope is described in Table 3.13.

Table 3.13: Cumulative Rochdale envelope

Impact	Scenario	Justification
Cumulative temporary increases in SSC and associated sediment deposition	Tier 1: *Construction phase* All projects within Tier 1 Tier 2: *Construction phase* All projects within Tier 2	The Nemo Interconnector cable has permission to use three disposal sites, with the two sites screened into this cumulative effect assessment having a total permitted disposal volume of 94,308 m^3. The use of the Pegwell Bay and Ramsgate Harbour disposal sites is primarily for the dumping of sediment removed during maintenance dredging. The use of these sites is intermittent and the volumes used are unknown in advance and therefore it is not possible to determine if the use of the sites will overlap with impacts from the construction of Thanet Extension. However, the volumes of dredged sediment are likely to be greater but the impacts are likely to be similar to those for the deposition of the drilling arisings predicted for Thanet Extension.

3.13.13 Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2) details a full cumulative assessment for temporary increases in SSC and bed levels as a result of Thanet Extension export cable installation and dredge disposal activities. The conclusion of the assessment was that physical process receptors will be insensitive to elevated SSC as a result of cumulative effects.

3.13.14 This section details the assessment in terms of water quality receptors of increased SSC rather than the processes of SSC themselves.

3.13.15 The sediments identified along the Nemo Interconnector route are similar to those identified for Thanet Extension and therefore sediment disturbed by the installation of both developments will behave in the same manner, with the impacts being equivalent to those described for Thanet Extension.

3.13.16 Given the rapid rates of dispersion, of fine grained sediment, as described in Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes (Document Ref: 6.2.2) it is anticipated that any contaminants will be rapidly dispersed also. Therefore, rapid dispersion and high dilution of contaminants will occur and at the point of plume overlap the concentrations of released contaminants as a result of any projects will not be discernible from background levels. There is not expected to be any temporal overlap between the cable installation projects or the respective sediment plumes.

3.13.17 The magnitude of the cumulative impact from the increased SSC and associated contaminants, in the study area, is considered to be Negligible due to the limited interaction between the impacts of the different projects and anticipated high dilution.

3.13.18 The sensitivity for designated sites such as WFD waterbodies, BW and SFWs is deemed to be Medium. Whereas, the sensitivity for non-designated waters such as in the array are deemed to be Low. Therefore, the significance of the effect is deemed to be of **Minor** adverse significance for designated sites and of **Negligible** adverse significance for non-designated sites, which are not considered to be significant in EIA terms.

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, jack-up vessel use etc., may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short-term, temporary or transient effects, or incorporate longer term effects.

3.14.2 A description of the likely inter-related effects arising from Thanet Extension on benthic ecology 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 marine water and sediment quality 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; and
- Marine Geology, Oceanography and Physical Processes – the physical processes controlling SSC, SPM and scour are directly related to the resuspension of contaminated sediments.

3.15 Mitigation

3.15.1 No further mitigation is required beyond the embedded mitigation detailed in section 3.9 of this report.

3.16 Transboundary statement

3.16.1 No transboundary impacts are predicted to result from the construction, O&M and decommissioning phases of Thanet Extension in terms of marine water and sediment quality receptors.

3.17 Summary of effects

3.17.1 This chapter has investigated the potential effects on marine water and sediment quality receptors arising from Thanet Extension. The range of potential impacts and associated effects has been informed by Scoping responses and consultation responses (including those submitted during the formal consultation process required under Section 42) from stakeholders, alongside reference to existing legislation and guidance.

3.17.2 Two project specific surveys have been undertaken to ensure adequate data coverage of the intertidal, OECC and the array for sediment contaminants to inform this assessment.

3.17.3 Cumulative impacts were also considered and an assessment was carried out examining the potential for interaction of direct and indirect impacts (including the interaction of sediment plumes) as a result of the combined activities of Thanet Extension and other activities in the study area. This includes the installation of electricity cables and disposal sites.

3.17.4 These potential impacts have been investigated using a combination of methods including analytical techniques, the existing evidence base and numerical modelling. In accordance with the requirements of the Rochdale Envelope approach to EIA, the worst-case characteristics of the proposed development have been considered thereby providing a highly conservative assessment.

3.17.5 A summary of the effects of the proposed development during construction, O&M and decommissioning phases on marine water and sediment quality within the study area are presented in Table 3.14.

Table 3.14: Summary of predicted impacts of Thanet Extension

Description of impact	Impact	Possible mitigation measures	Residual impact
Construction			
Deterioration in water quality due to re-suspension of sediments-WFD waterbodies	Minor adverse	N/A	Minor adverse
Deterioration in water quality due to re-suspension of sediments-non-designated sites	Minor adverse	N/A	Minor adverse
Deterioration in water quality due to re-suspension of sediments-BW	Minor adverse≠	N/A	Minor adverse≠
Deterioration in water quality due to re-suspension of sediments-SFWs	Minor adverseα	N/A	Minor adverse α
Release of contaminants from disturbed sediments	Minor adverse	N/A	Minor adverse
Accidental releases or spills of construction materials or chemicals	Minor adverse	N/A	Minor adverse
Contamination from leachate from the historic landfill	Minor adverse and Negligible adverse	N/A	Minor adverse and Negligible adverse
Release of bentonite from HDD at the landfall	Minor adverse and Negligible adverse	N/A	Minor adverse and Negligible adverse
O&M			
Deterioration in water quality due to re-suspension of sediments-scour-designated sites	Minor adverse	N/A	Minor adverse
Deterioration in water quality due to re-suspension of sediments-scour-non-designated sites	Negligible adverse	N/A	Negligible adverse
Deterioration in water quality due to re-suspension of sediments – turbid wakes-designated sites	Minor adverse	N/A	Minor adverse
Deterioration in water quality due to re-suspension of sediments – turbid wakes-non-designated sites	Negligible adverse	N/A	Negligible adverse
Release of contaminants from disturbed sediments- designated sites	Minor adverse	N/A	Minor adverse
Release of contaminants from disturbed sediments- non-designated sites	Negligible adverse	N/A	Negligible adverse
Accidental releases or spills of construction materials or chemicals-designated sites	Minor adverse	A MPCP would be in place and agreed with the MMO in line with the IPPC Directive.	Minor adverse
Accidental releases or spills of construction materials or chemicals-non-designated sites	Negligible adverse	A MPCP would be in place and agreed with the MMO in line with the IPPC Directive.	Negligible adverse
Decommissioning			
Deterioration in water quality due to re-suspension of sediments	Minor adverse	N/A	Minor adverse
Release of contaminants from disturbed sediments	Minor adverse	N/A	Minor adverse
Accidental releases or spills of construction materials or chemicals	Minor adverse	N/A	Minor adverse
Cumulative effects			
Release of contaminants from disturbed sediments-designated sites	Minor adverse	N/A	Minor adverse
Release of contaminants from disturbed sediments-non-designated sites	Negligible adverse	N/A	Negligible adverse

≠ see Volume 4, Annex 3-2: Water Framework Directive Assessment (Document Ref: 6.4.32).

α see Volume 2, Chapter 6: Fish and Shellfish (Document Ref: 6.2.6).

3.18 References

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