FOREWIND

DOGGER BANK
TEESSIDE A & B

October
2013

Draft Environmental Statement
Chapter 10 Marine Water and Sediment Quality

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Drafted by		Royal HaskoningDHV (Christa Page)	
Checked by		Angela Lowe	
Date / initials check			31 July 2013
Approved by		Rufus Howard	
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Forewind Approval			
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Prepared by: Royal HaskoningDHV (Christa Page)	Checked by: Angela Lowe	
Approved by: Rufus Howard	Signature / Approval (Forewind) Gareth Lewis	Approval Date: 23 September 2013

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1. Introduction

1.1.1. This chapter of the draft Environmental Statement (ES) describes the existing environment with regard to marine water and sediment quality and assesses the potential impacts of Dogger Bank Teesside A & B during the construction, operation and decommissioning phases. Where the potential for significant impacts is identified, mitigation measures and residual impacts are presented

1.1.2. Certain elements of the assessment are informed by **Chapter 9 Marine Physical Processes**. Related onshore issues are considered in **Chapter 24 Geology, Water Resources and Land Quality**. A separate Water Framework Directive Compliance Assessment is provided at **Appendix 24E**.

2. Guidance and Consultation

2.1. General

2.1.1. The assessment of potential impacts on marine water and sediment quality has been made with specific reference to the relevant National Policy Statements (NPS). These are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIP). Those relevant to Dogger Bank Teesside A & B in relation to marine water and sediment quality are:

- Overarching NPS for Energy (EN-1) (Department of Energy and Climate Change (DECC) 2011a); and
- NPS for Renewable Energy Infrastructure (EN-3) (DECC 2011b).

2.1.2. The specific assessment requirements for marine water and sediment quality, as detailed in the NPS, are summarised in **Table 2.1**, together within an indication of the section number of this draft ES chapter where each is addressed. Where any part of the NPS has not been followed within the assessment an explanation as to why the requirement was not deemed relevant, or has been met in another manner, is provided.

Table 2.1 NPS assessment requirements

NPS requirement	NPS reference	ES reference
Infrastructure development can have adverse effects on the water environment, including groundwater, inland surface water, transitional waters and coastal waters. During the construction, operation and decommissioning phases, discharges to water could occur. There may also be an increased risk of spills and leaks of pollutants to the water environment. These effects could lead to adverse impacts on health or on protected species and habitats and could, in particular, result in surface waters, ground waters or protected areas failing to meet environmental objectives established under the Water Framework Directive.	EN-1 Section 5.15	Sections, 6, 7 and 8. Water Framework Directive Compliance Assessment provided at **Appendix 24E**.
Where the project is likely to have adverse 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 draft Environmental Statement or equivalent.	EN-1 Section 5.15	Sections, 6, 7 and 8

NPS requirement	NPS reference	ES reference
The construction, operation and decommissioning of offshore energy infrastructure can affect marine water quality through the disturbance of seabed sediments or the release of contaminants, with subsequent indirect effects on habitats, biodiversity and fish stocks.	EN-3 Paragraph 2.6.189	Sections, 6, 7 and 8
The Environment Agency regulates emissions to land, air and water out to 3nm. Where any element of the wind farm or any associated development included in the application to the Infrastructure Planning Commission (IPC) (now the Planning Inspectorate) is located within 3nm of the coast, the Environment Agency should be consulted at the pre-application stage on the assessment methodology for impacts on the physical environment and that beyond 3nm, the Marine Management Organisation (MMO) is the regulator. The applicant should consult the MMO and Centre for Environment, Fisheries & Aquaculture Science (Cefas) on the assessment methodology for impacts on the physical environment at the pre-application stage.	Paragraphs 2.6.191 and 2.6.192 of EN-3	Section 2

2.1.3. The principle European and International policy and legislation used to inform the assessment of potential impacts on marine water and sediment quality includes:

- Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the community action in the field of water policy (the Water Framework Directive);
- Directive 74/464/EEC Water pollution discharges of certain dangerous substances (Dangerous Substances Directive) and Priority Substances Directive;
- Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive);
- Directive 2006/7/EC concerning the management of bathing water quality and repealing Directive 76/160/EEC (the Bathing Waters Directive); and
- The International Convention for the Prevention of Marine Pollution by Ships (MARPOL Convention) 73/78.

2.1.4. These key European Directives are transposed into UK law though a number of regulations as set out below.

Water Framework Directive

2.1.5. The Water Framework Directive is a key piece of European legislation relating to the protection of water quality and the ecological status of freshwaters and coastal waters out to one nautical mile (nm).

2.1.6. The Water Framework Directive provides a mechanism by which regulatory controls on human activities, that have the potential to impact on water quality, can be managed effectively and consistently. In addition to a range of inland surface waters and groundwater, the Water Framework Directive covers transitional waters (estuaries and lagoons) and coastal waters out to 1nm. Existing regulations that will eventually be subsumed by the Water Framework Directive include the Freshwater Fish Directive (consolidated as 2006/44/EC), the Shellfish Waters Directive (76/464/EEC). The Water Framework Directive is implemented in England and Wales primarily through the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (known as the Water Framework Directive Regulations).

2.1.7. UK surface waters have been divided into a number of discrete units termed 'water bodies', with typologies that relate to both their physical and ecological characteristics. Based on ecology and water quality, these water bodies have then been classified into different status classes which have specific objectives in relation to achieving a good ecological status.

2.1.8. The Water Framework Directive requires that all inland and coastal waters must reach at least 'good' status by 2015 and that the status of all water bodies should not deteriorate. Individual water bodies that have been modified to the extent that it will not be possible for them to meet the Water Framework Directive targets are classified as Heavily Modified Water Bodies. A Water Framework Directive Compliance Assessment is provided at **Appendix 24E.**

Dangerous Substances Directive/Priority Substances Directive

2.1.9. The Dangerous Substances Directive (76/464/EEC) and its daughter Directives are concerned with controlling the level of discharges that may contain dangerous substances that may reach inland, coastal and territorial waters. The Directive identified substances for which limit values and Environmental Quality Standards (EQS) were established at European Level (List I).

2.1.10. Some of these EQS have now been superseded by standards established by the Priority Substances Directive 2008/105/EC for priority substances and priority hazardous substances identified in Annex X of the Water Framework Directive. Where this is not the case, limit values and environmental quality standards set by the 'daughter' Directives listed in Annex IX of the Water Framework Directive remain in force. The Priority Substances Directive is implemented in England and Wales by the River Basin Districts Typology, Standards and Groundwater Threshold Values (Water Framework Directive) (England and Wales) Directions 2010. Compliance with these standards forms the basis of good surface water chemical status under the Water Framework Directive.

Marine Strategy Framework Directive

2.1.11. The objective of the Marine Strategy Framework Directive (2008/56/EC) is to achieve "*good environmental status*" in Europe's seas by 2020, to enable the sustainable use of the marine environment and to safeguard its use for future generations.

2.1.12. The Marine Strategy Framework Directive establishes a comprehensive structure within which EU Member States are required to develop and implement the cost effective measures necessary to achieve or maintain "*good environmental status*" in the marine environment.

2.1.13. The Directive establishes European Marine Regions and requires Member States to apply an ecosystem based approach to the management of human activities. The timetable for implementation of the strategy is from July 2010 through to December 2016. In the UK, the Directive is implemented via the Marine Strategy Regulations, 2010.

2.1.14. In coastal waters out to 1nm, both the Water Framework Directive and the Marine Strategy Framework Directive apply. However, in these areas, the Marine Strategy Framework Directive only applies for aspects of good environmental status that are not already addressed by the Water Framework Directive. These include issues such as the impacts of marine noise and litter, and certain aspects of biodiversity but not water quality.

Bathing Waters Directive

2.1.15. The Bathing Waters Directive (76/160/EEC) is implemented through the Bathing Waters Regulations 2008. The Environment Agency monitors and assesses bathing water quality at each designated bathing water site in England and Wales annually between May and September. A resulting annual water quality classification is then allocated for every season. This classification is calculated from 20 samples on the basis of concentrations of bacteria in each of the following groups:

- Total coliforms;
- Faecal coliforms; and
- Faecal streptococci.

2.1.16. Designated bathing waters also comes under the umbrella of protected areas as identified by the Water Framework Directive and this Directive will be replaced by the revised Bathing Waters Directive (2006/7/EC) in 2015. This new directive aims to set more stringent water quality standards and also puts a stronger emphasis on beach management and public information. General parameters to be assessed are reduced and the bacterial parameters listed above are replaced by:

- *Escherichia coli*; and
- Intestinal enterococci.

2.1.17. It also puts in place three new compliance categories - excellent, good and sufficient, as well as the existing poor category. The Government will be required to ensure that all bathing waters are of sufficient standard by 2015 and that appropriate measures are taken to increase the numbers classified as excellent or good. Classification will be based on four years' worth of data

MARPOL Convention 73/78

2.1.18. The UK is also a signatory to the International Convention for the Prevention of Pollution from Ships (the MARPOL Convention 73/78) and all ships flagged under signatory countries are subject to its requirements, regardless of where they sail. The convention includes regulations aimed at preventing and minimising pollution from ships, both accidental and that arising from routine operations.

2.2. Consultation

2.2.1. To inform the draft ES, Forewind has undertaken a thorough pre-application consultation process, which has included the following key stages:

- Scoping Report submitted to the Planning Inspectorate (May 2012);
- Scoping Opinion received from the Planning Inspectorate (June 2012);
- First stage of statutory consultation (in accordance with sections 42 and 47 of the Planning Act 2008) on Preliminary Environmental Information (PEI) 1 (report published June 2012); and
- Second stage of statutory consultation (in accordance with sections 42, 47 and 48 of the Planning Act 2008) on the draft ES (this document) designed to allow for comments before final application to the Planning Inspectorate.

2.2.2. In between the statutory consultation periods, Forewind consulted specific groups of stakeholders on a non-statutory basis to ensure that they had an opportunity to inform and influence the development proposals. Consultation undertaken throughout the pre-application development phase has informed Forewind's design decision making and the information presented in this document. Further information detailing the consultation process is presented in **Chapter 7 Consultation**. A Consultation Report will be provided alongside this draft ES as part of the overall planning submission.

2.2.3. A summary of the consultation carried out at key stages throughout the project, of particular relevance to marine water and sediment quality is presented in **Table 2.2.** This table only includes the key items of consultation that have defined the assessment. A considerable number of comments, issues and concerns raised during consultation have been addressed in meetings with consultees and hence have not resulted in changes to the content of the draft ES. In these cases, the issue in question has not been captured in **Table 2.2**. A full explanation of how the consultation process has shaped the draft ES, as well as tables of all responses received during the statutory consultation periods, is provided in the Consultation Report.

Table 2.2 Summary of Consultation

Date	Consultee	Summary of issue	Section reference
July (2013) Consultation meeting	Environment Agency	Meeting to discuss coastal impacts – covered issues associated with potential impacts on designated bathing waters and Water Framework Compliance	Section 5
June 2012 (Scoping)	Environment Agency	In addition to the surveys listed in Table 7.1 (of the scoping report), the cable route within the intertidal zone should be tested for heavy metal contamination.	Section 3
June 2012 (Scoping)	PINS	The scope for the surveys listed in Table 7.1 (of the scoping report) should also be agreed in consultation with the relevant stakeholders to include the MMO, JNCC, Natural England and Cefas.	Section 3
June 2012 (Scoping)	Environment Agency	The EIA should assess the available options for spoil disposal and the impact on these options upon water quality and marine ecology.	Section 5
June 2012 (Scoping)	Environment Agency	The EIA should consider the potential impact of the development upon bathing water quality, particularly in relation to the works associated with the construction of the Export Cable Corridor and the landfall works within the designated bathing waters.	Section 5
June 2012 (Scoping)	JNCC/IPC	Advises that the interrelations with ecology and the sandbank habitat of the Dogger Bank cSAC are assessed within this section.	Section 9 of this chapter, Sections 6.7, 7.8, 8.4 and 9 of **Chapter 12 Marine and Intertidal Ecology** and Section 5.4 of **Chapter 31 Inter-relationships**
June 2012 (Scoping)	JNCC	The effect of spoils should be addressed in the EIA for the effect upon benthic habitats and communities; turbidity and general water quality; and the potential for increasing or inhibiting sediment transport. Particular thought should be given to the impact of arisings from drilling into chalk as these have been seen to persist in the marine environment at other sites.	Section 5

3. Methodology

3.1. Study area

3.1.1. The assessment of impacts on marine water and sediment quality is largely derived from the information provided in **Chapter 9**, which considers the effects over two spatial scales:

- Far-field: the southern North Sea area surrounding the development site, Dogger Bank Teesside A & B Export Cable Corridor and landfall (below Mean High Water Springs (MHWS)) over which remote effects may occur and interact with other activities; and
- Near-field: the footprint of the development that resides in the marine and coastal environments, including the wind turbine foundations, substation and/or converter stations foundations, inter-array cable routes, Dogger Bank Teesside A & B Export Cable Corridor and landfall (below MHWS).

3.1.2. Impacts in relation to marine water and sediment quality are, therefore, considered over the same spatial scales.

3.1.3. For the purpose of this assessment the following terminology applies

- Tranche A and Tranche B – the parts of the Dogger Bank Zone in which Dogger Bank Teesside A & B is located;
- Dogger Bank Teesside A & B Export Cable Corridor – the cable route from Dogger Bank Teesside A & B to the landfall area at Marske-by-the-Sea.

3.2. Characterisation of existing environment – methodology

General Context

3.2.1. Regional context is provided through data collection from previous studies and includes:

- Physical processes studies carried out by Royal HaskoningDHV to inform **Chapter 9**;
- Several papers written about marine water and sediment contamination within the Dogger Bank Zone (Gubbay *et al*., 2002; Eleveld *et al*., 2006 Langston *et al*., 1999; and Thompson *et al*., 2011); and
- It should be noted that the offshore location of Dogger Bank Teesside A & B and much of the Dogger Bank Teesside A & B Export Cable Corridor, means that water quality information is very limited in spatial extent, as monitoring programmes for water quality generally cover nearshore areas only. A review of available literature regarding water and sediment quality at Dogger Bank Teesside A & B was undertaken; a summary of the information is discussed below.

Site Specific Survey

3.2.2. In order to provide more specific information in relation to Dogger Bank Teesside A & B, data was collected across Tranche A and Tranche B and the Dogger Bank Teesside A & B Export Cable Corridor. Two benthic surveys were undertaken. Tranche A samples were collected in 2011 and 2012 (reported in Emu 2012) and Tranche B samples were collected in 2012 (reported in Gardline Environmental Ltd.). These benthic surveys aimed to characterise the physical, biological and chemical nature of the seabed throughout Tranche A and Tranche B and the Dogger Bank Teesside A & B Export Cable Corridor.

3.2.3. The survey plans included sub-sampling for subsequent analysis of contaminants, fauna and particle sizes, with additional camera investigations undertaken to examine habitats throughout the survey area. Within Tranche B, 55 stations were sampled, 11 of which were analysed for contaminants. Within Tranche A, three sites analysed for contaminants were located within the Dogger Bank Teesside B boundary. Along the Dogger Bank Teesside A & B Export Cable Corridor, nine samples were analysed for contaminants. A Day Grab was used to collect 0.1m^2 seabed samples which were analysed for the following metals and hydrocarbons by the National Laboratory Service of the Environment Agency:

- Metals;
- Selenium;
- Boron;
- Total organic carbon (TOC);
- Polyaromatic Hydrocarbons (PAH)
- Total petroleum hydrocarbons (TPH);
- Polychlorinated Biphenyls (PCB); and
- Organotins.

3.2.4. Further details in relation to the contaminant analysis techniques and limits of detection are presented in **Appendix 12G**.

3.3. Assessment of impacts – methodology

3.3.1. The assessment of impacts within this chapter follows the general methodology set out in **Chapter 4 EIA Process**.

3.3.2. The assessment of water quality impacts is based on the standards outlined in the Water Framework Directive, the Priority Substances Directive and the Bathing Waters Directives, or comparison of concentrations to the baseline environment where possible (for example in relation to suspended solid concentrations).

3.3.3. The context of the contaminants found within sediments of the proposed development area is established through the use of recognised guidelines and action levels. These levels are used in order to indicate general contaminant levels in the sediments. If overall levels do not generally exceed the higher threshold values of each of these sets of guideline standards, then contamination levels are not deemed to be of significant concern and are low risk in terms of impacts on water quality. These guidelines are:

- Cefas Action Levels for the disposal of dredged material (Cefas 2000); and
- Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment (CCME) 2002).

3.3.4. 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. These Action Levels are used in conjunction with a range of other assessment methods (e.g. bioassays) and data to assess risk to the environment. Selected current Action Levels are set out in **Table 3.1**.

Table 3.1 Selected Cefas Action Levels (taken from Cefas 2000)

Contaminant	Action Level 1 (mg/kg)	Action Level 2 (mg/kg)
Arsenic	20	100
Cadmium	0.4	5
Chromium	40	400
Copper	40	400
Nickel	20	200
Mercury	0.3	3
Lead	50	500
Zinc	130	800
Organotins(Tributyltin (TBT) and Dibutyltin (DBT))	0.1	1
PCBs (sum of ICES 7)	0.01	none
PCBs (sum of 25 congeners)	0.02	0.2
Total hydrocarbons	100	none

3.3.5. Cefas guidance indicates that, in general, contaminant levels below Action Level 1 are not considered to be of concern and are, therefore, likely to be approved for disposal at sea. Material with contaminant levels above Action Level 2 are generally considered to be unsuitable for disposal at sea. Dredged material with contaminant levels between Action Levels 1 and 2 requires further consideration and testing before a decision can be made.

3.3.6. The Canadian Sediment Quality Guidelines involved the derivation of Interim marine Sediment Quality Guidelines (ISQGs) or Threshold Effect Levels (TEL) and Probable Effect Levels (PEL) from an extensive database containing direct measurements of toxicity of contaminated sediments to a range of aquatic organisms exposed in laboratory tests and under field conditions (CCME, 2002).

3.3.7. These values are not statutory standards. They were designed specifically for Canada and are based on the protection of pristine environments. The findings should, therefore, be treated with caution. In the absence of suitable alternatives, however, it has become commonplace for these guidelines to be used by regulatory and statutory bodies in the UK, and elsewhere, as part of a 'weight of evidence' approach. The use of these standards within impact assessments for offshore wind farm projects is also widely accepted.

3.3.8. Selected Canadian guidelines are presented in **Table 3.2**, and comprise two assessment levels. The lower level is referred to as the TEL and represents a concentration below which adverse biological effects are expected to occur only rarely (in some sensitive species for example). The higher level, the PEL, defines a concentration above which adverse effects may be expected in a wider range of organisms.

Table 3.2 Selected Canadian Sediment Quality Guidelines values (taken from CCME 2002)

Contaminant	Units	TEL	PEL
Arsenic	mg/kg	7.24	41.6
Cadmium	mg/kg	0.7	4.2
Chromium	mg/kg	52.3	160
Copper	mg/kg	18.7	108
Mercury	mg/kg	0.13	0.7
Lead	mg/kg	30.2	112
Zinc	mg/kg	124	247
Acenaphthene	µg/kg	6.71	88.9
Acenaphthylene	µg/kg	5.87	128
Anthracene	µg/kg	46.9	245
Benz(a)anthracene	µg/kg	74.8	693
Benzo(a)pyrene	µg/kg	88.8	763
Chrysene	µg/kg	108	846
Dibenz(a,h)anthracene	µg/kg	6.22	135
Fluoranthene	µg/kg	113	1494
Fluorene	µg/kg	21.2	144
Napthalene	µg/kg	34.6	391
Phenanthrene	µg/kg	86.7	544
Pyrene	µg/kg	153	1398

3.3.9. The potential for release and dispersion of sediments due to the construction, operation and decommissioning of Dogger Bank Teesside A & B has been informed by a physical processes assessment (see **Chapter 9** for further details). This study describes the potential interaction of the proposed development on wave, tidal and sediment regimes and establishes volumes of sediments released during the construction, operation and decommissioning phases, followed by a prediction of their subsequent dispersion and settlement profiles.

Receptor sensitivity

3.3.10. As set out in **Chapter 4** the sensitivity of a receptor is a function of its capacity to accommodate change and reflects its ability to recover if it is affected. It is quantified via a consideration of adaptability, tolerance, recoverability and value.

3.3.11. **Table 3.3** sets out the generic 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.

Table 3.3 Criteria used to determine the sensitivity of marine water quality receptors.

Sensitivity	Definition
Negligible	Specific water quality conditions of the receptor are likely to be able to tolerate proposed change with very little or no impact upon the baseline conditions detectable.
Low	The water quality of the receptor has a high capacity to accommodate change to water quality status due, for example, to large relative size of the receiving water and capacity for dilution and flushing. Background concentrations of certain parameters already exist.
Medium	The water quality of the receptor supports high biodiversity and/or has low capacity to accommodate change to water quality status.
High	The water quality of the receptor supports or contributes towards the designation of an internationally or nationally important feature and/or has a very low capacity to accommodate any change to current water quality status, compared to baseline conditions.

3.3.12. The study area has a large physical scale (the Dogger Bank Zone itself extends over approximately 8,660km^2), and a high degree of temporal and spatial variance. Whilst conservation designations are present within the study area, the sensitivity of the surrounding marine environment with respect to water quality is considered to be low. However, the landfall and nearshore element of the cable route is located within very close proximity to a European designated bathing water and therefore the sensitivity of the water for this area is considered to be high.

Magnitude of effect

3.3.13. Prediction of the magnitude of potential effects has been based on the consequences that the proposed development might have upon the marine water quality status (see **Table 3.4**).

3.3.14. These descriptions of magnitude are specific to the assessment of marine water quality impacts and are considered in addition to the generic descriptors of impact magnitude presented in **Chapter 4**. Potential impacts have been considered in terms of permanent or temporary, and adverse or beneficial effects.

3.3.15. Where an effect could reasonably be assigned more than one level of magnitude, professional judgement has been used to determine which rating is acceptable.

Table 3.4 Criteria used to determine the magnitude of marine water quality effects

Magnitude	Definition
Negligible	Although there may be some impact upon water quality status, activities predicted to occur over a short period. Any change to water quality status will be quickly reversed once activity ceases.
Low	Noticeable but not considered to be significant changes to the water quality status of the receiving water feature. Activity not likely to alter local status to the extent that water quality characteristics change considerably or EQSs are compromised.
Medium	Significant changes to key characteristics of the water quality status taking account of the receptor volume, mixing capacity, flow rate, etc. Water quality status likely to take considerable time to recover to baseline conditions.
High	Very significant change to key characteristics of the water quality status of the receiving water feature. Water quality status degraded to the extent that a permanent or long term change occurs. An inability to meet (for example) EQS is likely.

Overall impact

3.3.16. Impacts are assessed by relating the magnitude of an effect to the sensitivity (or value) of the receptor (in this case, the actual status of water quality in the water column itself). This relationship is presented as an Impact Assessment Matrix in **Table 3.5.**

Table 3.5 Overall impact resulting from each combination of receptor sensitivity and the magnitude of the effect

Receptor sensitivity	Magnitude of effect			
	High	Medium	Low	Negligible
High	Major	Major	Moderate	Minor
Medium	Major	Moderate	Minor	Negligible
Low	Moderate	Minor	Minor	Negligible
Negligible	Minor	Negligible	Negligible	Negligible

3.3.17. Where the potential for an accidental spillage is concerned, the assessment is based on the risk of a spill or other accidental pollution event occurring. This is considered in relation to control measures that are available to minimise the risk.

3.3.18. 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.

4. Existing Environment

4.1. Background

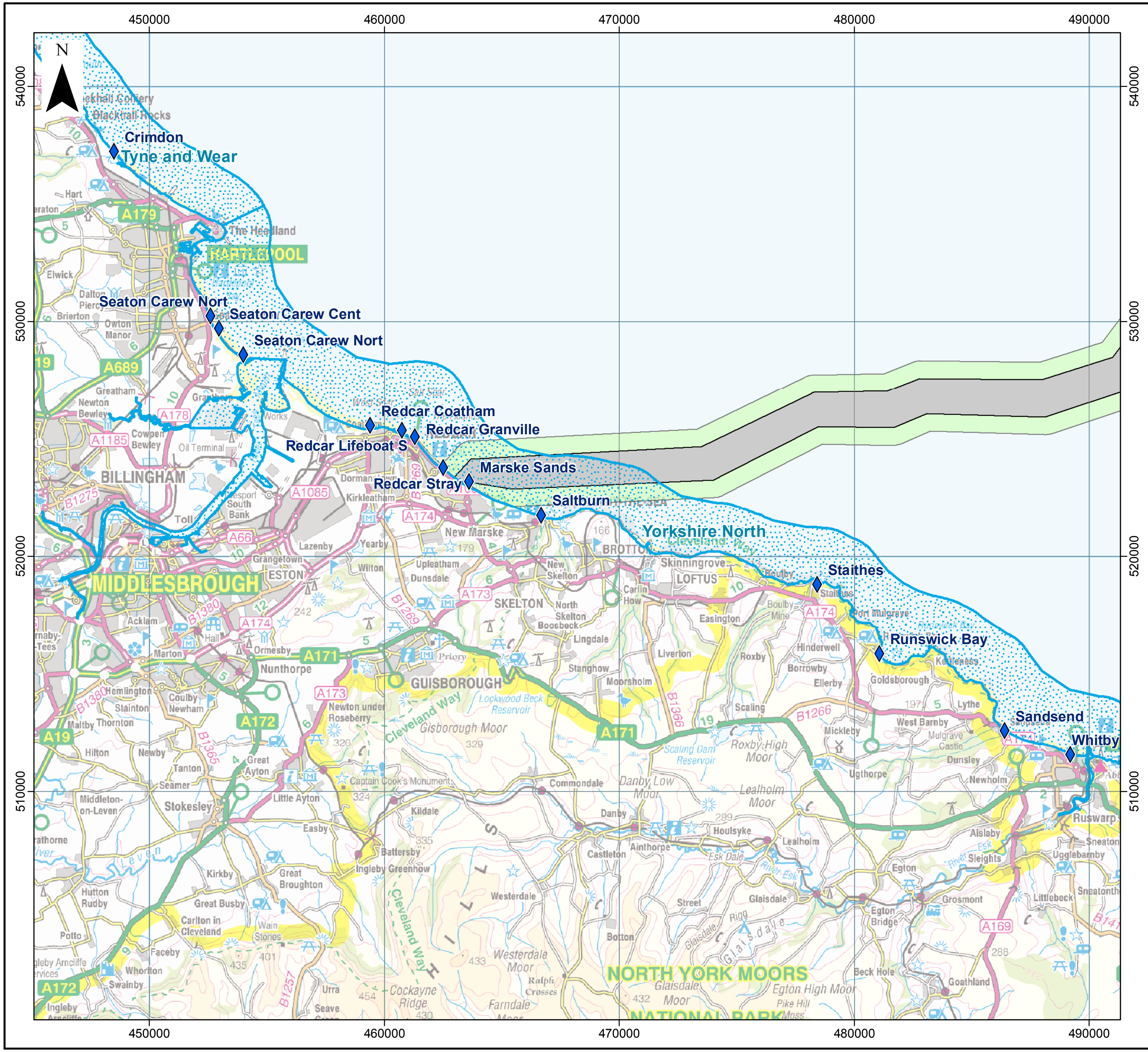
4.1.1. Several papers and information sources have been consulted in order to provide detail on general background levels of suspended solids and associated contaminants, both in the water column and in the seabed sediments. There is some debate regarding whether sediments of the Dogger Bank contain elevated levels of contamination (Gubbay *et al*. 2002) and, specifically, concerns have related to concentrations of metals.

4.1.2. Sources of metals could relate to oil and gas and/or shipping activities in and around the Dogger Bank as well as far-reaching effects associated with licensed waste disposal sites (dredge spoil, industrial waste and, historically, sewage sludge) in the North Sea. In addition to these direct marine impacts, airborne, riverine and other terrestrial run-off sources of potential pollutants are thought to be of significant concern (OSPAR 2000).

4.1.3. There are a number of inactive and active cables and pipelines that run through the Dogger Bank Zone, in close proximity to Dogger Bank Teesside A & B and the Dogger Bank Teesside A & B Export Cable Corridor.

4.1.4. In terms of the nearshore environment, the Dogger Bank Teesside A & B Export Cable Corridor runs through the Water Framework Directive coastal water body Yorkshire North (GB650301500003). This water body is classified as ‘heavily modified’ due to the coastal protection works that are present within it. In terms of current ecological quality, the water body is classified as having ‘good potential’. Currently, the water body is considered to be at ‘good’ chemical quality with respect to levels of chemical contaminants. The aim of this water body is to achieve ‘Good Ecological Potential’ and ‘Good Chemical Status’ by 2015.

4.1.5. There are designated waters within the water body which are protected under the ‘protected areas’ element of the Water Framework Directive. The closest designated bathing water to the Dogger Bank Teesside A & B Export Cable Corridor is Marske Sands which is located within the corridor and landfall site (**Figure 4.1**). An additional designated bathing water, Redcar Stray, is located approximately 1km from the Dogger Bank Teesside A & B Export Cable Corridor. Both bathing waters have achieved ‘Minimum Water Quality’ meaning that the bathing waters met the mandatory standards in 2012.



LEGEND

- Export cable corridor
- Temporary works area
- Water body location
- Designated bathing waters

0 5

Kilometres

Bathing Waters © Environment Agency, 2013
Water Bodies © Environment Agency 2012
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PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.1 Designated bathing waters and Water Framework Directive water bodies

VER	DATE	REMARKS	Drawn	Checked
1	06/09/2013	Draft	LW	CP
2	08/10/2013	PEI3	LW	CP

DRAWING NUMBER: **F-OFL-MA-451**

SCALE	1:250,000	PLOT SIZE	A4	DATUM	OSGB36	PROJECTION	BNG

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4.2. Water quality

4.2.1. With regard to water quality in the wider North Sea, the OSPAR Commission Quality Status Report (2010) has evaluated the quality status of the North East Atlantic during a ten year monitoring and assessment programme (OSPAR, 2010). The Dogger Bank Zone is located within Region II of the North East Atlantic, the Greater North Sea. The Greater North Sea region summary highlights the issue of eutrophication caused by nutrient inputs along the coast of the North Sea, from Belgium to Norway and in some small estuaries and bays of eastern England and north west France (although this problem is mostly confined to coastal areas in the eastern North Sea and not the coast of the UK). In addition, concentrations of metals (cadmium, mercury and lead) and persistent organic pollutants are above typical background concentrations in some offshore waters of the North Sea.

4.2.2. Marine disposal activities can also influence marine water quality. The Inner and Outer Tees (TY160 and TY150) are the closest active dredged material disposal sites to Dogger Bank Teesside and are located approximately 240km to the west of Dogger Bank Teesside B and approximately 10km north from the Dogger Bank Teesside A & B Export Cable Corridor.

4.2.3. Within the study area, the main responsibility for inshore water quality lies with the Environment Agency and Northumbrian Water. Following failure of the Bathing Waters Directive at Saltburn beach, substantial investment to provide better sewage treatment by Northumbrian Water together with work by Local Authorities and the Environment Agency in the early 1990's and again in 2000, has improved current water quality.

Suspended sediment concentrations

4.2.4. Suspended sediment is transported within the water column and comprises the relatively fine fraction of the mobile sediment. Increases in suspended sediment concentrations can affect water quality and in turn impact on fisheries and marine ecology.

4.2.5. For full details of concentrations of suspended solids naturally present within the Dogger Bank Zone and the Dogger Bank Teesside A & B Export Cable Corridor, see **Chapter 9**. For ease of reference, a short summary of the findings is provided below.

4.2.6. The Dogger Bank Zone typically sees relatively low suspended sediment concentrations of <10 mg/l (Doergger and Fisher, 1994; Eleveld *et al*., 2006) and high bed shear stresses in the area have been seen to coincide with low concentrations of suspended matter (Stanev *et al*., 2008). Generally, suspended concentrations throughout the Dogger Bank Zone and the Dogger Bank Teesside A & B Export Cable Corridor are not thought to significantly increase over and above 2mg/l.

4.2.7. The main driving force for suspended sediment dynamics in the North Sea is considered to be turbulence induced by tidal currents and waves. Generally, the fundamental mechanisms controlling sediment re-suspension from the seabed is considered to be bed shear stress (Stanev *et al*., 2008). However, Stanev *et al*. (2008) showed that during storm conditions there is no clear correlation between Dogger Bank bed shear stress and suspended sediment concentrations. They concluded, therefore, that the availability of sediment that could be re-suspended at the bed across the Dogger Bank is limited. This, in addition to the predominantly sandy bed material type, is particularly important in determining the potential for impacts associated with seabed disturbance during construction, operations and decommissioning of the proposed project.

4.3. Sediment quality

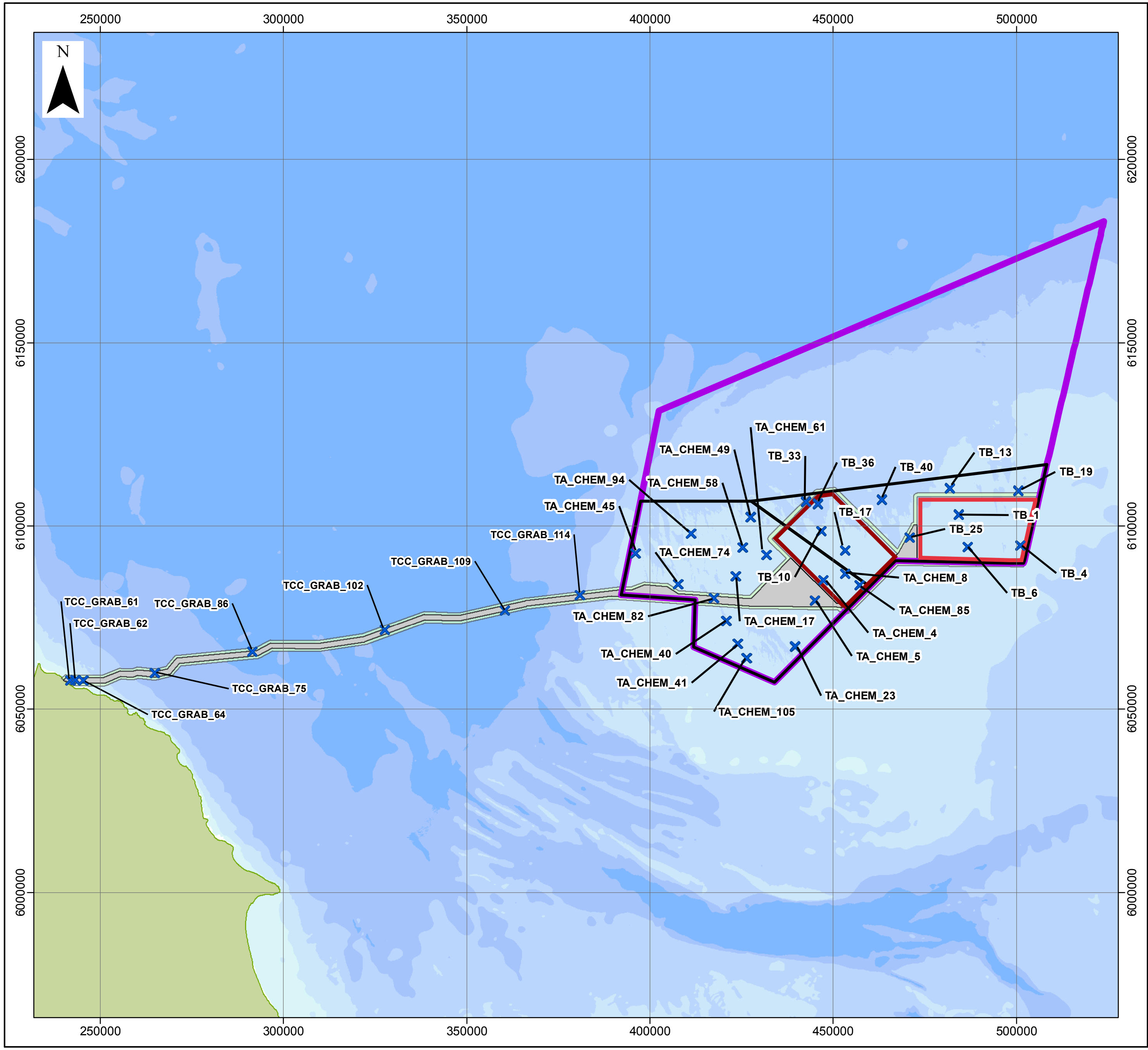
4.3.1. In terms of sediments, compared with the central North Sea region, elevated levels of particle associated heavy metals have been reported in the vicinity of Dogger Bank (Gubbay *et al.* 2002). As previously mentioned, additional studies have also reported that Dogger Bank sediments are not polluted, with reductions in dissolved cadmium and lead concentrations in water over Dogger Bank recorded between 1982 and 1990 (Scholten *et al*. 1998).

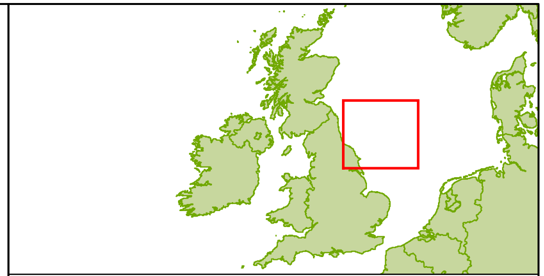
4.3.2. Furthermore, concentrations of several organochlorine pesticides and poly aromatic hydrocarbons (PAHs) in the Dogger Bank area have been reported to be similar to those of coastal areas (WWF, no date).

4.4. Site specific work

4.4.1. In order to inform the baseline for sediment quality, site specific surveys were carried out in 2011 and 2012 by Emu Ltd and Gardline Environmental Ltd respectively. The locations of the stations for which contaminant analysis was undertaken are shown in **Figure 4.2**.

4.4.2. Sediment contaminant data is summarised in **Table 4.1** and **Table 4.3** (Dogger Bank Teesside A & B Export Cable Corridor) and **Table 4.2** and **Table 4.4** (Offshore). Data highlighted in yellow indicates concentrations of contaminants over either Cefas Action Level 1 or Canadian Sediment Quality Guideline TEL. Red indicates concentrations greater than Cefas Action Level 2 or Canadian Sediment Quality Guideline PEL.





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Export cable corridor
- Temporary works area
- Contaminant sample site

0 20 40
Kilometres

Data Source:
Sample sites from Gardline Environmental Limited survey (2012),
Round 3 offshore wind farm boundary © Crown Copyright, 2013,
Background bathymetry image derived in part from TCarta data 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.2 Sediment contamination sample sites

VER	DATE	REMARKS	Drawn	Checked
1	06/09/2013	Draft	GC	GS
2	07/10/2013	PEI3	LW	GS

DRAWING NUMBER: **F-OFL-MA-452**

SCALE	1:1,600,000	PLOT SIZE	A4	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

Table 4.1 Results compared to the Cefas Action Levels (Dogger Bank Teesside A & B Export Cable Corridor). Yellow indicates exceedance of Action level 1 and red indicates exceedance of Action Level 2. All TBT and PCB results were below the limit of detection (<0.003mg/kg for TBT and <0.1µg/kg for PCBs).

Contaminant mg/kg	**Dogger Bank Teesside A & B Export Cable Corridor**								
	61	**62**	**64**	**75**	**86**	**95**	**102**	**109**	**114**
Arsenic	20	15.3	7.14	25.5	9.87	9.42	9.77	10.1	6.74
Cadmium	0.152	0.143	0.165	0.136	0.079	0.082	0.076	0.1	0.053
Chromium	126	312	387	221	193	233	164	103	66
Copper	55.9	121	196	62.7	116	88.8	138	70.3	63.5
Mercury	0.046	0.009	0.008	0.049	0.003	0.002	0.002	0.016	<0.002
Lead	58	53.5	54.2	104	29.4	25.5	26.5	35.9	14.9
Nickel	56.8	149	220	118	106	136	90.6	43.5	41.4
Zinc	113	115	112	118	50.3	41.2	51.9	69	31
Total hydrocarbons	27	35.2	60.2	41	5.43	3.16	4.59	10.3	<3

Table 4.2 Results compared to the Cefas Action Levels (offshore). Yellow indicates exceedance of Action Level 1, red indicates exceedance of Action Level 2. All TBT results were below the limit of detection (<0.003mg/kg).

Contaminant mg/kg	**Site reference (offshore)**													
	TB_1	**TB_4**	**TB_6**	**TB_10**	**TB_13**	**TB_17**	**TB_19**	**TB_25**	**TB_33**	**TB_36**	**TB_40**	**TA_85**	**TA_8**	**TA_4**
Arsenic	2.65	2.5	2.59	2.7	2.28	5.31	2.3	2.79	3.04	2.22	2.57	1.64	1.13	2.69
Cadmium	<0.03	<0.03	<0.03	<0.03	<0.03	0.071	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	<0.03	<0.03
Chromium	15.1	22.4	11.2	25	15.1	112	13.5	10	13.9	21.3	11	15.5	14.8	25.4
Copper	4.24	6.06	3.73	5.18	3.15	160	4.47	4.13	2.64	3.27	2.74	4.12	3.86	3.32
Mercury	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Lead	6.97	7.28	7.21	7.03	6.57	12.3	8.67	12.6	6.99	9.19	7.05	8.18	6.38	6.6
Nickel	2.79	7.44	3.21	7.84	2.85	52.4	2.37	4.57	5.82	3.72	3.63	3.7	3.07	2.96
Zinc	8.07	15.5	11.2	10.1	7.47	46.3	16	11.5	10.6	14.6	7.87	Not analysed		
Total hydrocarbons	0.12	0.25	0.38	0.13	0.22	0.48	0.93	0.5	0.53	0.79	0.1	0.35	0.05	0.12
PCBs (sum ICES 7)	Below limit of detection for all samples													

Table 4.3 Results compared to the Canadian Interim Sediment Quality Guidelines (Dogger Bank Teesside A & B Export Cable Corridor). Yellow indicates exceedance of TEL and red indicates an exceedance of PEL.

Contaminant (units vary)	Site reference (Offshore)													
	TB_1	TB_4	TB_6	TB_10	TB_13	TB_17	TB_19	TB_25	TB_33	TB_36	TB_40	TA_85	TA_8	TA_4
Arsenic (mg/kg)	2.65	2.5	2.59	2.7	2.28	5.31	2.3	2.79	3.04	2.22	2.57	1.64	1.13	2.69
Cadmium (mg/kg)	<0.03	<0.03	<0.03	<0.03	<0.03	0.071	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	<0.03	<0.03
Chromium (mg/kg)	15.1	22.4	11.2	25	15.1	112	13.5	10	13.9	21.3	11	15.5	14.8	25.4
Copper (mg/kg)	4.24	6.06	3.73	5.18	3.15	160	4.47	4.13	2.64	3.27	2.74	4.12	3.86	3.32
Mercury (mg/kg)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Lead (mg/kg)	6.97	7.28	7.21	7.03	6.57	12.3	8.67	12.6	6.99	9.19	7.05	8.18	6.38	6.6
Zinc (mg/kg)	8.07	15.5	11.2	10.1	7.47	46.3	16	11.5	10.6	14.6	7.87	Not analysed		
Acenaphthene (µg/kg)	<2	<2	<2	2.35	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Acenaphthylene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Anthracene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Benzo(a)anthracene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Benzo(a)pyrene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Chrysene (µg/kg)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<3	<3	<3
Dibenz(a,h)anthracene (µg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Fluoranthene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	3.25	<2
Fluorene (µg/kg)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Napthalene (µg/kg)	61.5	<30	<30	69.6	<30	41	<30	<30	<30	<30	<30	<30	<30	<30
Phenanthrene (µg/kg)	<10	<10	<10	<10	<10	10.5	<10	<10	<10	<10	<10	11.3	16.7	<10
Pyrene (µg/kg)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	5.28	3.97	<3

Table 4.4 Results compared to the Canadian Sediment Quality Guidelines (Offshore). Yellow indicates exceedance of TEL, red indicates exceedance of PEL

Contaminant (units vary)	Site reference (Offshore)													
	TB_1	TB_4	TB_6	TB_10	TB_13	TB_17	TB_19	TB_25	TB_33	TB_36	TB_40	TA_85	TA_8	TA_4
Arsenic (mg/kg)	2.65	2.5	2.59	2.7	2.28	5.31	2.3	2.79	3.04	2.22	2.57	1.64	1.13	2.69
Cadmium (mg/kg)	<0.03	<0.03	<0.03	<0.03	<0.03	0.071	<0.03	<0.03	<0.03	<0.03	<0.03	0.03	<0.03	<0.03
Chromium (mg/kg)	15.1	22.4	11.2	25	15.1	112	13.5	10	13.9	21.3	11	15.5	14.8	25.4
Copper (mg/kg)	4.24	6.06	3.73	5.18	3.15	160	4.47	4.13	2.64	3.27	2.74	4.12	3.86	3.32
Mercury (mg/kg)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Lead (mg/kg)	6.97	7.28	7.21	7.03	6.57	12.3	8.67	12.6	6.99	9.19	7.05	8.18	6.38	6.6
Zinc (mg/kg)	8.07	15.5	11.2	10.1	7.47	46.3	16	11.5	10.6	14.6	7.87	Not analysed		
Acenaphthene (µg/kg)	<2	<2	<2	2.35	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Acenaphthylene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Anthracene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Benzo(a)anthracene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Benzo(a)pyrene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Chrysene (µg/kg)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<3	<3	<3
Dibenz(a,h)anthracene (µg/kg)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Fluoranthene (µg/kg)	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	3.25	<2
Fluorene (µg/kg)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Napthalene (µg/kg)	61.5	<30	<30	69.6	<30	41	<30	<30	<30	<30	<30	<30	<30	<30
Phenanthrene (µg/kg)	<10	<10	<10	<10	<10	10.5	<10	<10	<10	<10	<10	11.3	16.7	<10

Contaminant (units vary)	Site reference (Offshore)													
	TB_1	TB_4	TB_6	TB_10	TB_13	TB_17	TB_19	TB_25	TB_33	TB_36	TB_40	TA_85	TA_8	TA_4
Pyrene (µg/kg)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	5.28	3.97	<3

4.4.3. The data displayed above suggests that whilst sediments generally exceed the Cefas Action Level 1 for copper, chromium and nickel within the Dogger Bank Teesside A & B Export Cable Corridor, the concentrations are only marginally above Action Level 1 concentrations at the majority of sites. The near-shore areas do appear to indicate higher concentrations along the Dogger Beck Teesside A & B Export Cable Corridor (sites 62 and 64). There is only one exceedance of Action Level 2 and this is for nickel at site 64.

4.4.4. Samples taken offshore, overall, do not indicate significant levels of contamination across the site. There are three contaminants exceeding Action Level 1 at site TB_17, however, these concentrations are limited to this one sample.

4.4.5. In order to provide a further indication regarding the potential toxicological effects of the contaminant levels within the sediments, the data has also been compared to the Canadian Sediment Quality Guidelines. Again the offshore sites do not indicate levels of contamination that would be of concern. Comparison at site TB_17 highlights levels of chromium and copper that could have toxicological impacts, but these levels are limited to this one site.

4.4.6. In terms of the Dogger Bank Teesside A & B Export Cable Corridor, the majority of sites indicate levels of contamination that could give rise to toxicological effects (i.e. exceed the PEL) in relation to copper and chromium levels. In the samples collected nearshore, additional parameters (arsenic, lead and PAH naphthalene) indicate potential exceedances of the TEL.

4.4.7. From the information and data presented above, it can be concluded that the baseline sediment quality for the marine environment particularly within the Dogger Bank Zone is generally good. The site specific survey has highlighted elevated levels within the Dogger Bank Teesside A & B Export Cable Corridor, particularly approaching the coast. Despite this, the predominantly sandy nature of the sea bed sediments, both within Tranche A, Tranche B and the Dogger Bank Teesside A & B Export Cable Corridor significantly reduces the potential for any contaminants to accumulate and for sediments to be re-suspended into the water column and transported over long distances, thus reducing the potential for far-field effects.

Additional Surveys

4.4.8. A Phase 1 biotope survey of the intertidal zone located between the towns of Redcar and Marske-by-the-Sea was conducted by the Institute of Estuarine and Coastal Studies (IECS). As part of the survey, sediments were taken and analysed for contaminant levels. Three samples were taken from three different transects, one each from the upper, middle and lower shore locations.

4.4.9. All sediment samples were identified as marine fine sand with small amount of gravel and shell fragments. The results of the survey were compared to the Canadian Sediment Quality Guidelines as these levels are more conservative than the Cefas Action Levels and overall, levels of contaminants are generally low (See **Table 4.5**).

4.4.10. All data for PCBs and organotins recorded levels of contamination below the detection levels (0.1µg/kg for PCBs and 3µg/kg for TBT). There were only two exceedances of the TEL for arsenic and these were marginal. As a result, the material is not considered to be high risk in terms of contaminant levels and potential toxicological effects.

Table 4.5 Results of the intertidal survey compared with Canadian Sediment Quality Guidelines (selected on the basis of existence of guideline and where contaminant recorded a positive value)

	Hydrocarbon mg/kg	Sample 1	Sample 2	Sample 3
Selected Metals	Arsenic (mg/kg)	7.72	6.58	8.06
	Cadmium (mg/kg)	<0.03	<0.03	<0.03
	Chromium (mg/kg)	6.94	4.99	5.97
	Copper (mg/kg)	9.54	3.12	2.84
	Lead (mg/kg)	16.4	12	13.4
	Zinc (mg/kg)	40.8	29.5	30.2
Selected PAHs	Anthracene (µg/kg)	3.35	6.38	7.08
	Benzo(a)anthracene (µg/kg)	5.18	16.4	8.83
	Benzo(a)pyrene (µg/kg)	3.47	12.4	6.04
	Chrysene (µg/kg)	6.11	13.4	11
	Fluoranthene (µg/kg)	11.4	39.1	28.2
	Napthalene (µg/kg)	<30	<30	<30
	Phenanthrene (µg/kg)	15.9	34.8	38.7
	Pyrene (µg/kg)	10.2	33.5	32.1

5. Assessment of Impacts – Worst Case Definition

5.1. General

5.1.1. This section establishes the realistic worst case scenario for each category of effect as a basis for the subsequent impact assessment. For the assessment, this involves both a consideration of the construction scenarios (i.e. the manner in which Dogger Bank Teesside A & B will be built out), as well as the particular design details of each project (such as the maximum construction footprint at the landfall) that define the Rochdale envelope[1].

5.1.2. Full details of the range of development options being considered by Forewind are provided within **Chapter 5 Project Description**. For the purpose of the marine water and sediment quality impact assessment, the realistic worst case scenarios, taking these options into consideration, are set out in **Table 5.1**.

5.1.3. Only those design parameters with the potential to influence the level of impact are identified. Therefore, if the design parameter is not described, it is not considered to have a material bearing on the outcome of the assessment.

5.1.4. The realistic worst case scenarios identified here are also applied to the Cumulative Impact Assessment (CIA). When the worst case scenarios for the project in isolation do not result in the worst case for cumulative impacts, this is addressed within the cumulative section of this chapter (see Section 10) and summarised in **Chapter 33 Cumulative Impact Assessment**.

5.2. Construction scenarios

5.2.1. There are a number of key principles relating to how the projects will be built, and that form the basis of the Rochdale Envelope (see **Chapter 5**). These are:

- The two projects may be constructed at the same time, or at different times;
- If built at different times, either project could be built first;
- If built at different times, the duration of the gap between the end of the first project to be built, and the start of the second project to be built may vary from overlapping, occurring in series or having a gap between projects;
- Offshore construction will commence no sooner than 18 months post consent, but must start within seven years of consent (as an anticipated condition of the development consent order); and
- Assuming a maximum construction period per project of six years, and taking the above into account, the maximum construction period over

[1] As described in **Chapter 5** the term 'Rochdale Envelope' refers to case law (R.V. Rochdale MBC Ex Part C Tew 1999 "the Rochdale case"). The 'Rochdale Envelope' for a project outlines the realistic worst case scenario or option for each individual impact, so that it can be safely assumed that all lesser options will have less impact.

which the construction of Dogger Bank Teesside A & B could take place is 11 years and six months.

5.2.2. The following assessment applies the results of the marine physical processes assessment, which has described the changes/effects in hydrodynamic and sedimentary processes against the existing environment. In order to do this, the marine physical processes assessment has used a variety of numerical modelling tools and conceptual techniques. The spatial and temporal scale at which these tools and techniques have been implemented has been used to ensure that the Rochdale Envelope incorporates all of the possible construction scenarios that are identified above and further detailed in **Chapter 5**. Where appropriate, this is carried forward into the marine water and sediment quality assessment (details provided in **Table 5.1** below).

5.3. Operation scenarios

5.3.1. **Chapter 5** provides details of the operational scenarios for Dogger Bank Teesside A & B. Flexibility is required to allow for the following three scenarios:

- Dogger Bank Teesside A to operate on its own;
- Dogger Bank Teesside B to operate on its own, and
- For the two projects to operate concurrently.

5.3.2. As above, the numerical modelling tools and conceptual techniques applied to this assessment have been implemented at a spatial and temporal scale to ensure that the worst case of all three operation scenarios has been assessed (details provided in **Table 5.1** below). For full details refer to **Chapter 9**.

5.4. Decommissioning scenarios

5.4.1. **Chapter 5** provides details of the decommissioning scenarios for Dogger Bank Teesside A & B. Exact decommissioning arrangements will be detailed in a Decommissioning Plan (which will be drawn up and agreed with DECC prior to construction); however, for the purpose of this assessment it is assumed that decommissioning of Dogger Bank Teesside A & B could be conducted separately, or at the same time.

5.5. Realistic worst case scenarios

5.5.1. The key design parameters that form the realistic worst case scenarios for each category of impact are set out in **Table 5.1**. The parameters identified have been derived from a desktop review and consultation with stakeholders.

Table 5.1 Key design parameters forming the realistic worst case scenario for the assessment of impacts on marine water and sediment quality

Impact	Realistic worst case scenario	Rationale
Construction		
Deterioration in water quality due to re-suspension of sediments associated with installation and foundation type	12m drilled monopile foundations (concrete)	The worst case scenario is represented by that which could result in the maximum volume of arisings (and therefore maximum volume of material that could be released into suspension). As detailed in **Chapter 9 Marine Physical Processes**, two scenarios have been considered. One reflects the potential for re-suspension when installing Gravity Base Structures (GBS) (large surface area may need to be dredged for seabed preparation) and one for installation of monopiles where drilling is required. Of the options considered, modelling predicts that the worst case, in terms of plume creation, occurs with the installation of 12m monopile foundations. Full details are provided in **Chapter 9 Marine Physical Processes**.
Deterioration in water quality due to re-suspension of sediments associated with cabling	During cable installation all sediment is mobilised and released into the marine environment.	The export cable volume released is based on a cable that will be placed in a trench 1.5m wide with a maximum depth of 3m (in an approximate ‘U’ shape) over a length that can be excavated of 216km (the assumed cable length from landfall to project). An excavation rate of 298.6m/hour was used (total time to complete excavation would be 30 days). Excavation rates could, however, vary.
Deterioration in water quality due to re-suspension of sediments associated with scouring	Not applicable	A specific scenario has not been identified here as scour was assessed as part of the re-suspension of sediments alongside installation requirements. The worst case is therefore included within the assessment as detailed for “deterioration in water quality due to re-suspension of sediments associated with installation and foundation type” above.
Deterioration in water quality due to re-suspension of contaminants within sediments	The worst case represents that by which the most sediment is re-suspended and therefore the comments related to foundation seabed preparation, cable installation and scouring are relevant here.	The worst case represents that by which the most sediment is re-suspended and therefore the comments related to foundation seabed preparation, cable installation and scouring as described above are also relevant here.

Impact	Realistic worst case scenario	Rationale
Deterioration in water quality due to re-accidental spillage of construction materials/use of offshore installation	Maximum construction period per project of six years, with construction taking place year round. Total number of offshore vessels on site at any one time of 66 (each project). Approximately 5150 annual construction vessel trips from port to site (each project).	Highest activity likely to occur in year 2 for which this vessel number is predicted. Higher likelihood of an incident occurring as a result of more activities taking place over a longer time period. It should be noted, however, that significant discharges are generally not anticipated during wind farm construction.
Deterioration in water quality due to landfall construction requirements	Four cofferdams	Based on consideration of likely landfall requirements and amount of material to be excavated (See **Chapter 5 Project Description**).
Operation		
Deterioration in sediment and water quality as a result of use of hazardous materials, specifically in relation to accidental discharges of grey water and spillages	Up to two accommodation platforms (in relation to discharge of grey/black water). Maintenance and inspection visits. Approximately 26 operation and maintenance vessels on site within each project area at any one time. Approximately 730 annual operation and maintenance vessel trips from port to site (each project).	This worst case scenario provides for the maximum level of operational activity and therefore the highest likelihood of an incident occurring due to increased vessels/activities. It should be noted, however, that significant discharges from wind farms are generally not anticipated.
Deterioration in water quality due to re-suspension of sediments associated with scouring during operation	An array of 400 6MW conical GBS foundations	Based on an empirical assessment of potential scour volumes associated with different foundation types undertaken by Forewind (2013).
Decommissioning		
Impacts on water quality associated with re-suspension of sediments and contaminants.	Removal of all structures associated with the wind farm	Until arrangements have been clarified, the worst case scenario is that all structures will be removed.

6. Assessment of Impacts during Construction

6.1. General

6.1.1. The construction scenarios on which this assessment has been prepared are presented in detail within **Chapter 5**.

6.2. Deterioration in water quality (turbidity) due to re-suspension of sediments

6.2.1. There is the potential that the proposed activities could re-suspend sediments thus impacting on the turbidity of the water in and around the development area. The specific activities that could contribute to this are as follows:

- Sediment release from seabed preparations or any drilling required for the turbine foundations;
- Sediment release from scouring of the foundations;
- Sediment release from trenching of the inter-array and inter-platform cables; and
- Sediment release from trenching of the Dogger Bank Teesside A & B Export Cable Corridor.

6.2.2. In order to assess the potential increase, dispersion and deposition of seabed sediments affected by the project, modelling has been undertaken using a 3D model MIKE3-FM Mud Transport (MT) over the areas of Tranche A and Tranche B. **Chapter 9** provides full details of the model and the method used to calculate the predicted sediment plumes.

6.2.3. It should be noted that an assessment was undertaken of various installation scenarios and it was determined that the 12m drilled monopile produced higher maximum suspended solids concentrations than other foundation types (see **Chapter 9** for full details). For the purposes of this chapter therefore, it is this scenario that has been taken forward for assessment. Additionally, the figures used in this assessment use maximum concentrations that when averaged out, provide a much lesser impact on suspended sediments concentrations. As a result, this is a highly conservative assessment.

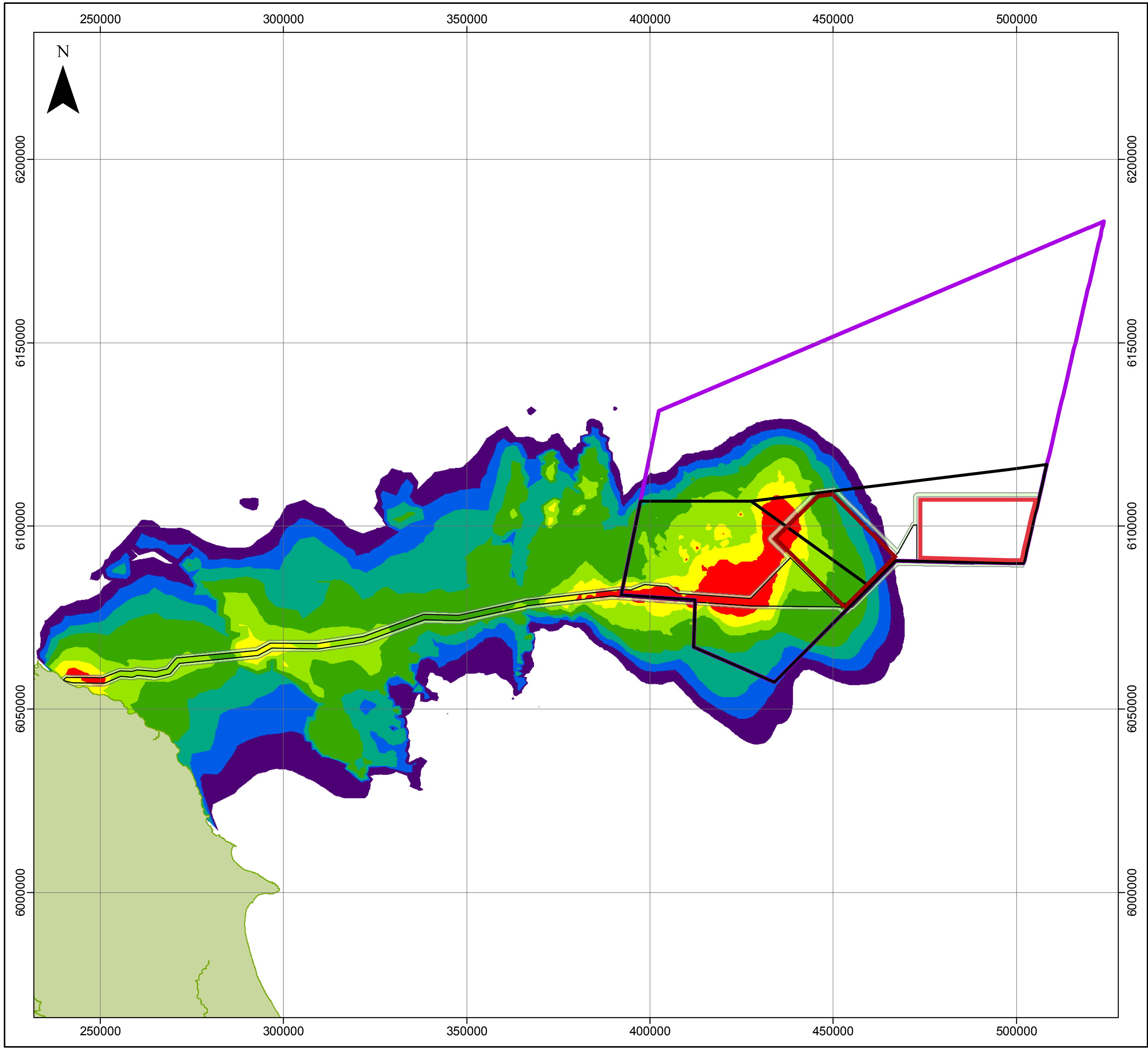
6.2.4. The modelling of sediment plumes for the wind farm was carried out over a 30-day simulation period using the baseline 30-day hydrodynamic simulation already established. The modelling of sediment plumes from the export cable installation was run over the same 30-day simulation period as the foundation simulation thus allowing simultaneous dispersion from both the foundations and the export cable. The predictions therefore account for cumulative impacts within the different components of the development. **Figure 6.1** presents the maximum concentration of suspended solids in the bottom layer over the natural background level, over the modelled period (i.e. 30 days).

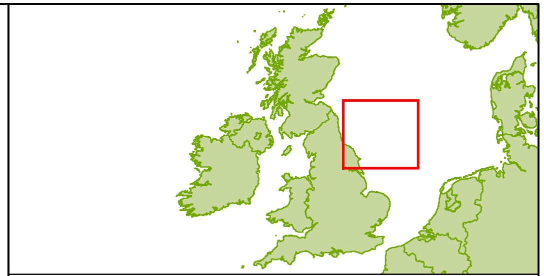
6.2.5. As would be expected, the maximum concentrations are noted within the immediate vicinity of the foundations and concentrations decrease as the plume moves away and material settles out or is dispersed. Concentrations vary from over 200mg/l above background levels close to the foundations, reverting to baseline levels (2mg/l) approximately 40km from the centre of the foundations (see **Figure 6.1**). For the in-zone cable route, concentrations exceed 200mg/l in the vicinity of the cable and then reduce to background levels within approximately 40km of the development.

6.2.6. Maximum concentrations of suspended solids within the vicinity of the Dogger Bank Teesside A & B Export Cable Corridor, outside of the Dogger Bank Zone, are generally predicted to be 20-50mg/l above baseline for approximately half of the cable route and then increase to 50-100mg/l towards the coast. There is also a small area on the coast that predicts concentrations to be above 100mg/l. Concentrations revert to baseline conditions approximately 50km to the north and 45km to the south. The small area predicted to exceed 100mg/l radiates from the coast for approximately 10km.

6.2.7. Conversely, the maximum predicted suspended solid concentrations in the sea surface layer predicted within the location of the foundations is of the same magnitude, but the spatial extent over which these concentrations occur is significantly smaller (i.e. less than 8km from the centre of the foundations) (see **Figure 6.2**). It should therefore be noted that the predicted maximum concentrations for the bottom layer will not be present throughout the water column.

6.2.8. As detailed above, the sensitivity of the water in terms of the potential for water quality impacts is considered to be low. The magnitude of effect is considered to be medium for the offshore location due to the long term nature of the impact and low for the Dogger Bank Teesside A & B Export Cable Corridor due to the much shorter duration of cable installation activities. Baseline conditions will, however, return to normal following cessation of activities and so any impact will only be present during the installation process. Overall therefore a **minor adverse** impact is expected. See Section 6.4 below for impacts on designated bathing waters.





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Export cable corridor
- Temporary works area

Suspended sediment concentration kg/m³

- Above 0.200
- 0.100 - 0.200
- 0.050 - 0.100
- 0.020 - 0.050
- 0.010 - 0.020
- 0.005 - 0.010
- 0.002 - 0.005
- Below 0.002

0 10 20
Kilometres

Data Source:
Modelling © Danish Hydraulic Institute, 2013

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

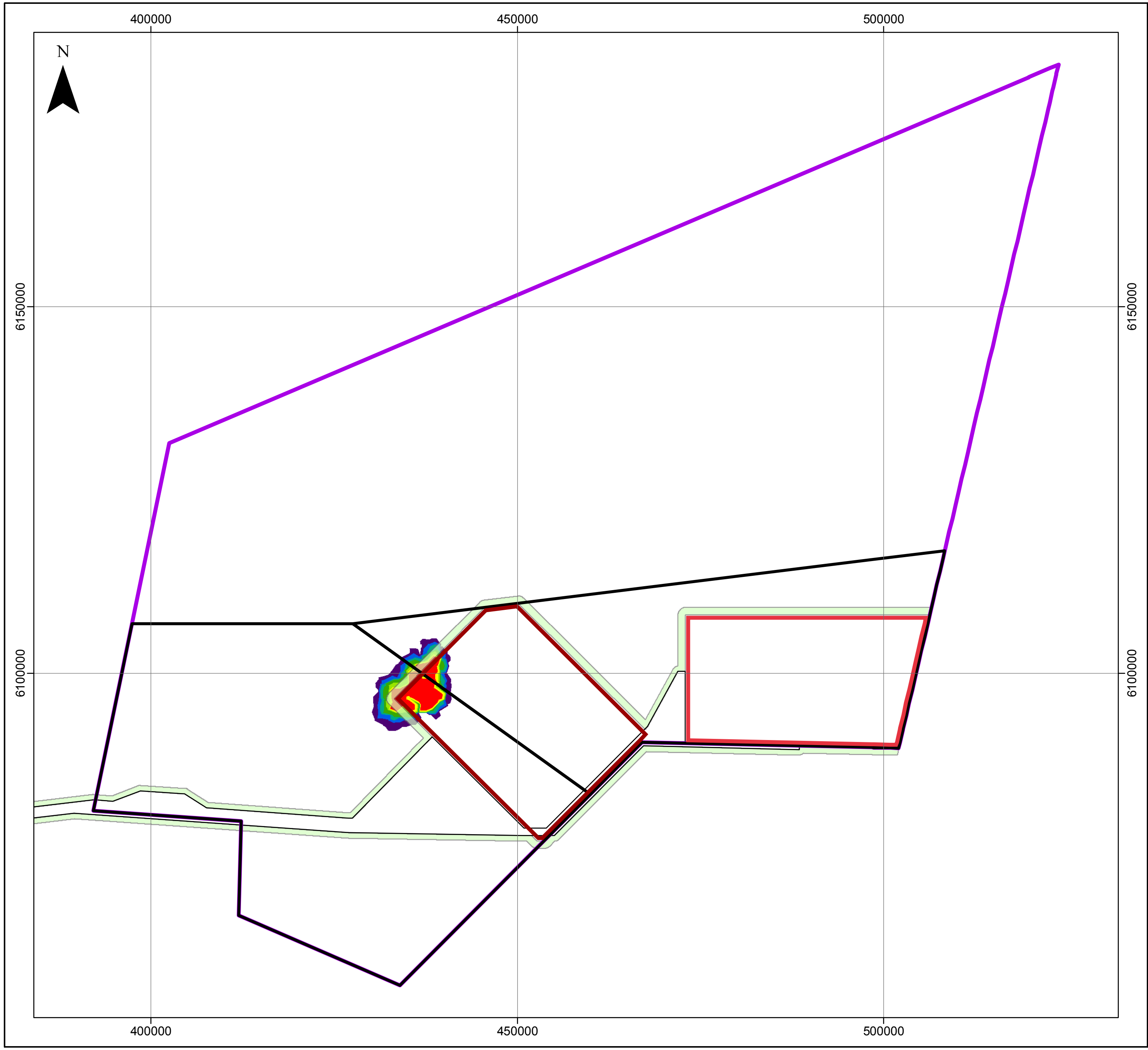
Figure 6.1 Maximum SSC in the bottom layer predicted over the simulation period for the construction phase for 12m monopoles using the re-suspension of fractions 1 and 2 method

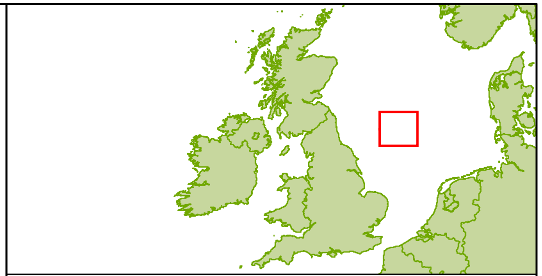
VER	DATE	REMARKS	Drawn	Checked
1	08/04/2013	Draft	FK	DB
2	08/10/2013	PEI3	LW	DB

DRAWING NUMBER: **F-OFL-MA-453**

SCALE	1:1,600,000	PLOT SIZE	A4	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Export cable corridor
- Temporary works area

Suspended sediment concentration kg/m³

- Above 0.200
- 0.100 - 0.200
- 0.050 - 0.100
- 0.020 - 0.050
- 0.010 - 0.020
- 0.005 - 0.010
- 0.002 - 0.005
- Below 0.002

0 10 Kilometres

Data Source:
Modelling © Danish Hydraulic Institute, 2013

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 6.2 Maximum SSC in the surface layer predicted over the simulation period for a 12m monopole using the re-suspension of fractions 1 and 2 method

VER	DATE	REMARKS	Drawn	Checked
1	08/04/2013	Draft	FK	DB
2	08/10/2013	PEI3	LW	DB

DRAWING NUMBER: **F-OFL-MA-454**

SCALE	1:800,000	PLOT SIZE	A4	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

6.3. Deterioration in water quality due to re-suspension of contaminated sediments

6.3.1. The re-suspension of sediments could also lead to the release of any contaminants that may be present within them, which may in turn affect compliance with water quality standards. The data in **Tables 4.1** to **Table 4.4** show that the levels of contaminants in the offshore area are low i.e. the majority of the contaminant levels are below the Cefas Action Level 1 and Canadian Sediment Quality Guidelines TEL values.

6.3.2. Additionally, drilling in order to install 12m monopiles (worst case scenario for increased turbidity) will introduce geological material to the water column and therefore an element of the plume shown in **Figure 6.1** will not contain material at risk of containing contaminants. It is estimated using Table 2.10 of **Appendix 9A Teesside A & B Physical Processes Assessment of Effects** that this quantity can be calculated to be approximately 40%. The remaining material contributing to the plume will be the coarser seabed sediments and since the levels of contamination are generally low across Tranche A and Tranche B, significant concentrations of contaminants are unlikely to be released when sediments are suspended. Impacts on water quality EQS' are therefore not predicted within the Dogger Bank Zone.

6.3.3. Data from the Dogger Bank Teesside A & B Export Cable Corridor, however, does indicate generally higher concentrations of contaminants, particularly in the locations nearer the coast where sample sites exceed at least Cefas Action Level 1. Additionally, concentrations of suspended solids are also predicted to significantly increase over background levels (see Section 6.2 above) within the bottom layer. However, this is very much the worst case scenario and average concentrations above baseline (within the bottom layer) are predicted to cover a significantly smaller area (see **Chapter 9**). It would also be expected that concentrations at the surface would be significantly less as settlement and dispersion will occur as the installation progresses.

6.3.4. It is important to note that the speed of export cable installation can typically be 50-300m/hour for a mechanical trencher, 150-400m/hour for a jetter and 250-500m/hour for a plough (See **Appendix 9A**). For Dogger Bank Teesside A & B, a figure of approximately 298m/hour has been applied to the sediment plume modelling as it is anticipated that trenching is likely to be the preferred installation method (see **Chapter 9**). Elevated levels of suspended solids will therefore temporarily increase and then decrease as the cable installation equipment moves along the cable route and material disperses and settles.

6.3.5. Since offshore levels of contamination within the sediments are low, the magnitude of effect is considered to be low. For cable installation, the magnitude of effect is also predicted to be low as cable installation will rapidly progress along the cable route (even at lower excavation rates) thus only giving rise to plumes from sediments at particular locations for very short periods of time. Overall therefore, the magnitude of effect on levels of contaminants within the water column is predicted to be low. Since the receptor is considered to be of low sensitivity, the re-suspension of contaminated sediments from construction activities is expected to have a **negligible** impact.

6.4. Deterioration in water quality of local bathing waters due to cabling

6.4.1. The re-suspension of sediments during the cabling works inshore could potentially impact on turbidity in the designated bathing waters located along the coast.

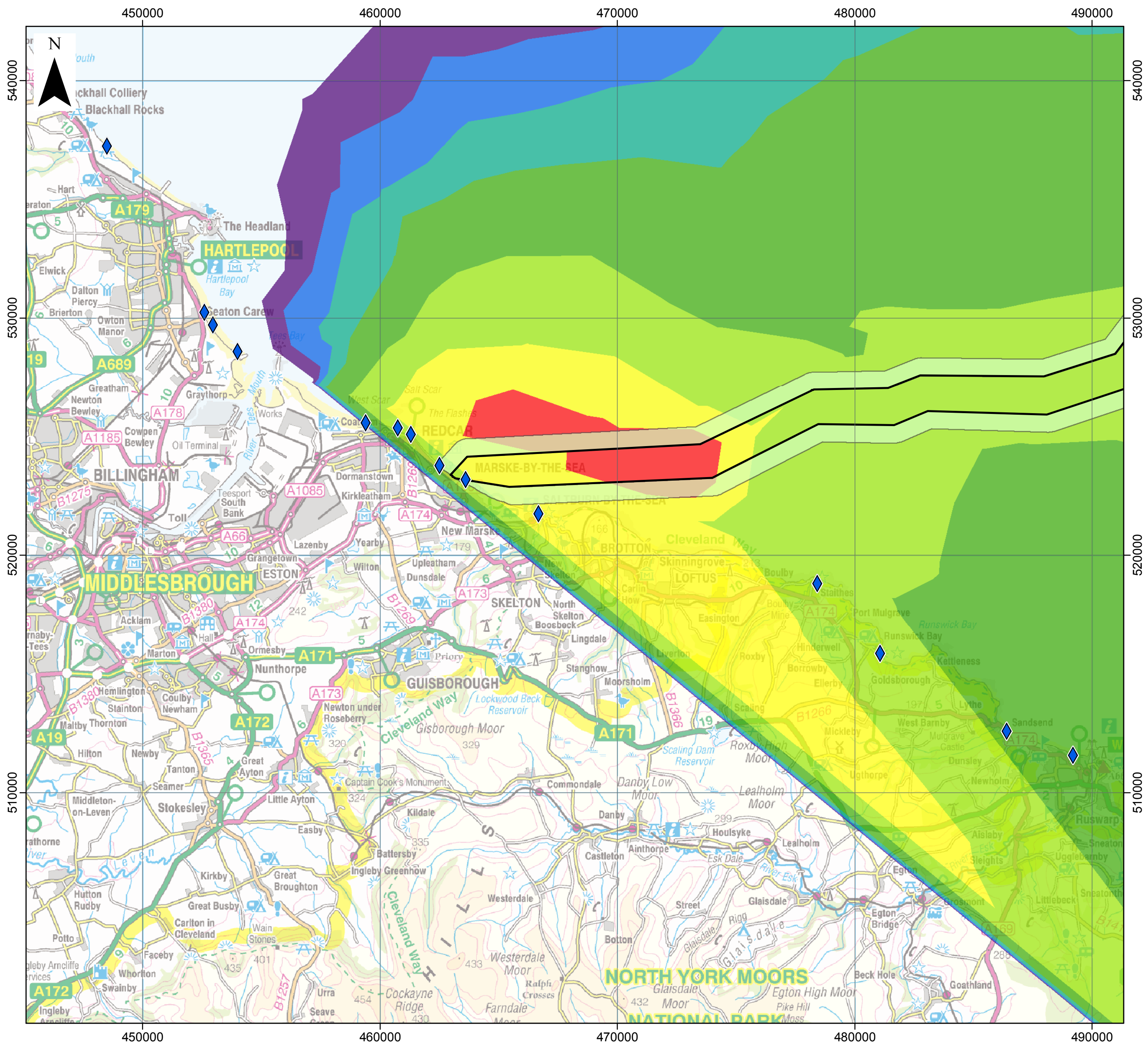
6.4.2. Baseline environment information indicates that concentrations of suspended solids can reach relatively high concentrations in the coastal area, and the high energy environment along this coastline (see **Chapter 9**) supports the likelihood that these concentrations are also experienced within the designated bathing waters. Significant natural variation is, therefore, likely to exist.

6.4.3. **Figure 6.3** shows the modelled maximum concentrations of suspended solids in the bottom layer against the locations of the Environment Agency bathing water monitoring points. This is very much the worst case scenario and average concentrations above baseline (within the bottom layer) are predicted to cover a significantly smaller area (see **Chapter 9**). It would also be expected that concentrations at the surface would be significantly less as settlement and dispersion will occur as the installation progresses.

6.4.4. It is also important to note that the speed of export cable installation can typically be 50-300m/hour for a mechanical trencher, 150-400m/hour for a jetter and 250-500m/hour for a plough (See **Appendix 9A**). For Dogger Bank Teesside A & B, a figure of approximately 298m/hour has been applied to the sediment plume modelling as trenching is the likely to be the preferred methodology of installation (see **Chapter 9**). The installation process close to the coast may therefore be completed in a matter of hours, even with lower excavation rates. Additionally, the unrestricted nature of the receiving environment will also mean that a plume would quickly disperse following cessation of activities. This is further supported by time series extracted from the modelling which demonstrates that the high levels of suspended solids in the bottom layer highlighted in **Figure 6.3** only exist for 12 hours or so before they begin to return to baseline conditions (see **Appendix 9A**).

6.4.5. Given the localised and very short term nature of the impact, the potential effects on the designated bathing waters (deemed to be high sensitivity) will be of negligible magnitude and as a result, **negligible** impact is predicted.

6.4.6. Since significant, long term plume impacts are not anticipated at any of the bathing waters, no impacts associated with contaminants and bacteriological parameters released into the environment via cable installation techniques are predicted.



LEGEND

- Export cable corridor
- Temporary works area
- Designated bathing waters

Suspended sediment concentration kg/m³

- Above 0.200
- 0.100 - 0.200
- 0.050 - 0.100
- 0.020 - 0.050
- 0.010 - 0.020
- 0.005 - 0.010
- 0.002 - 0.005
- Below 0.002

0 5
Kilometres

Data Source:
Bathing Waters © Environment Agency, 2013
Modelling © Danish Hydraulic Institute, 2013
Ordnance Survey data © Crown copyright and database right, 2012

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 6.3 Predicted maximum suspended solids concentrations in the bottom layer within designated bathing waters

VER	DATE	REMARKS	Drawn	Checked
1	06/09/2013	Draft	LW	CP
2	08/10/2013	PEI3	LW	CP

DRAWING NUMBER: **F-OFL-MA-455**

SCALE	1:250,000	PLOT SIZE	A4	DATUM	OSGB36	PROJECTION	BNG

FOREWIND

6.5. Deterioration in water quality due to impacts relating to landfall works

6.5.1. It is proposed that up to four temporary cofferdams will be installed to protect excavated trenches within which the export cables will be placed. These cofferdams will create a dry area thus isolating any works from the marine environment. In order to install the cofferdams, excavation of material and storage on a barge for subsequent replacement following completion of the works, will be required. The excavated sediment will then be backfilled into the cofferdam pit by mechanical means and the beach re-instated.

6.5.2. Since the excavated material will not be discharged or placed within an area exposed to tidal flows, no impact on suspended sediment and contaminant concentrations in the water column are predicted. There will be no planned point source discharges to marine waters from any welfare facilities associated with the landfall works.

6.6. Deterioration in water and/or sediment quality due to accidental spillage of construction materials

6.6.1. A wide range of vessels and construction methodologies will be employed during offshore construction ranging in size from small craft (<10m) to large crane vessels. Examples include jack-up crane barges, Dynamic Positioning (DP) cable-lay vessels, feeder barges, dredging vessels and survey vessels. In addition to the risks regarding the potential for pollution from leaks or spills of fuel carried on-board these vessels, there is also the potential for accidental pollution associated with the use of construction materials in the marine environment.

6.6.2. Whilst the majority of the structures will be transported to site having been pre-assembled or manufactured on land, it is likely that the use of grout will be required for all possible foundation types and cable protection may require pre or post-lay armouring using concrete, for example. There is therefore the potential for pollution from spills or leaks of fuel or oils, or the use of any hazardous materials required for construction of the wind farm.

6.6.3. However, in addition to ensuring that all working practices and vessels adhere to the requirements of the MARPOL Convention Regulations, control measures to be included within a Project Environmental Management and Monitoring Plan (EMMP) will be put in place in order to minimise the risk of a spill as far as possible. Some examples are listed below:

- All use of chemicals and the activity that requires them will consider ways in which a potential pathway from the activity could lead to discharge of the chemical to the sea. Where possible control measures will be implemented to remove this pathway;
- All vessels should carry spill kits for dealing with spills on vessel decks;
- All vessel personal should be trained in and be familiar with the Project EMMP;

- The discharge of sewage waste will be collected, treated and discharged to sea in accordance with the requirements of MARPOL; and
- Use of non-toxic and biodegradable chemicals and lubricants to be considered where possible.

6.6.4. Since the magnitude of the effect is difficult to assess, the assessment in this instance is considered in terms of the risk of a spill or other accidental pollution event occurring. Since control measures will be in place, the risk of a spill and an associated adverse impact is considered to be **low**.

7. Assessment of Impacts during Operation

7.1. Deterioration in suspended solid concentrations as a result of scour

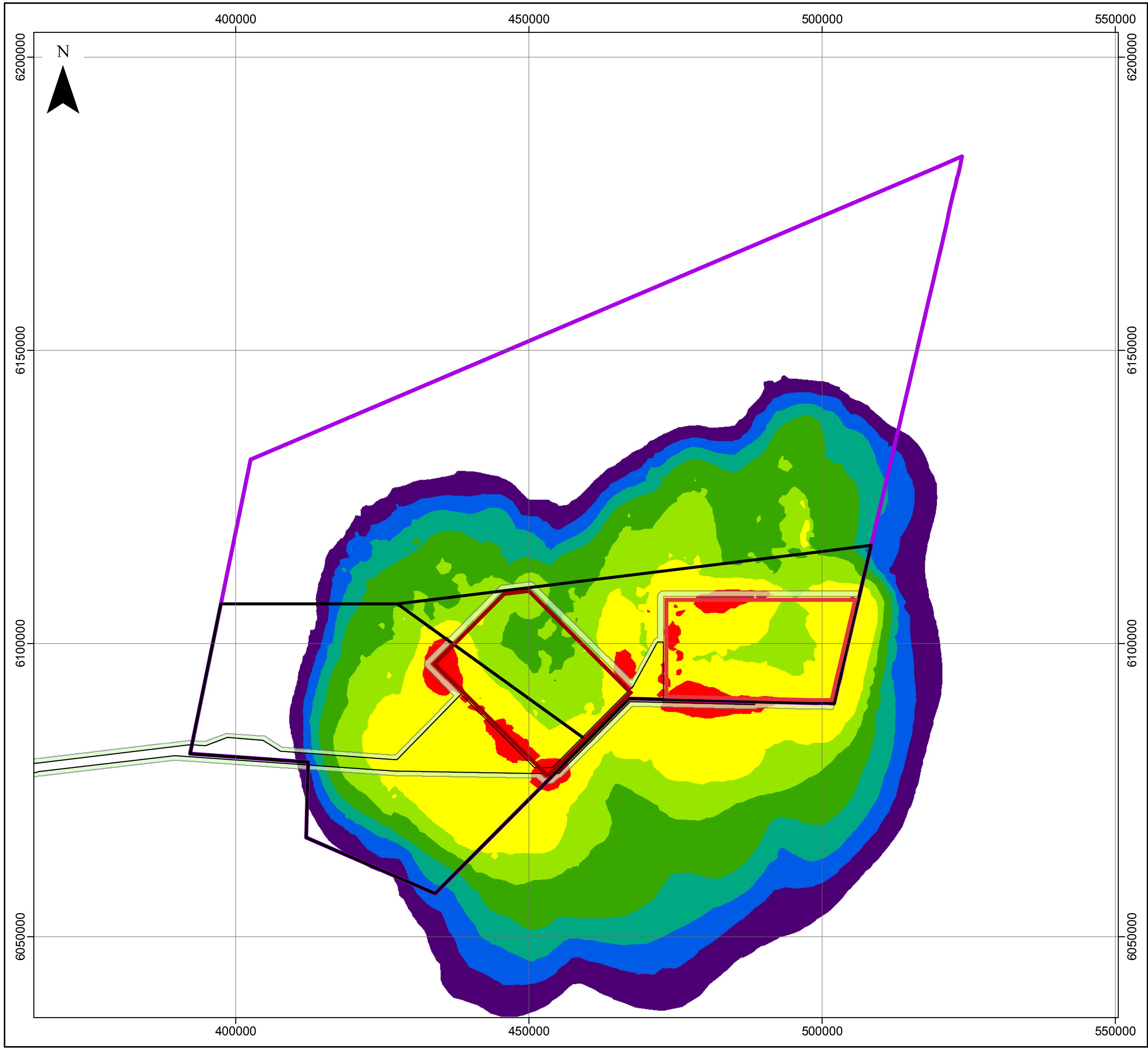
7.1.1. In order to undertake an assessment of the potential increase in suspended solids as a result of scour around the base of the foundations, physical modelling was again undertaken (see **Chapter 9** for full details). The results are presented in **Chapter 9** for a run of the model after one year (a one year storm is applied to half of the foundations) and a run of the model after two years (all foundations are struck by a 50 year storm).

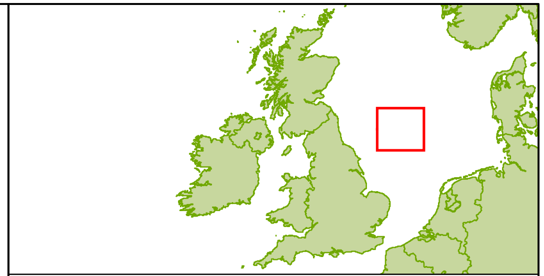
7.1.2. Results indicate that that the maximum suspended solid concentration predicted after two years of operation induced by a 50 year storm is higher than that predicted after one year of operation. However it should be noted, once the foundations have been scoured to their equilibrium depth, they are unlikely to refill. Hence once the process is complete, scouring will no longer continue as the scour holes will no longer to a source of sediment.

7.1.3. Results indicate that the maximum suspended solids concentrations exceed 200mg/l only within the local area of the foundations and reduce to background levels (2mg/l) within 40-54km to the south and 20-37km to the north of the project boundaries (see **Figure 7.1**).

7.1.4. It should be noted, however, that a comparison of the operational scour volumes produced against naturally occurring volumes of suspended sediments for the Dogger Bank Creyke Beck project, were at least five times greater than those that could arise due to scour (**Chapter 9**). This is directly relevant for Dogger Bank Teesside A & B due to the similar nature of the sediment. It can, therefore, be concluded that concentrations of suspended solids resulting from scouring processes are unlikely to exceed those naturally experienced in the Dogger Bank area during typically stormy conditions. Additionally whilst scouring will be an on-going process, it will eventually reach equilibrium and therefore cease.

7.1.5. The sensitivity of the water in terms of water quality is considered to be low. The magnitude of effect is assessed as low negligible due to the temporary nature of the increase, but also due to the likelihood that any change will be within natural variation. Overall, therefore, a **negligible** impact is expected.





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Export cable corridor
- Temporary works area

Suspended sediment concentration kg/m³

- Above 0.200
- 0.100 - 0.200
- 0.050 - 0.100
- 0.020 - 0.050
- 0.010 - 0.020
- 0.005 - 0.010
- 0.002 - 0.005
- Below 0.002

0 10 20
Kilometres

Data Source:
Modelling © Danish Hydraulic Institute, 2013

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 7.1 Maximum SSC in the bottom layer predicted over the simulation period after two years of operation using the re-suspension of fractions 1 and 2 method

VER	DATE	REMARKS	Drawn	Checked
1	08/04/2013	Draft	FK	DB
2	08/10/2013	PEI3	LW	DB

DRAWING NUMBER: **F-OFL-MA-456**

SCALE 1:1,000,000 | PLOT SIZE A4 | DATUM WGS84 | PROJECTION UTM31N

FOREWIND

7.2. Deterioration in sediment and water quality in relation to accidental spillages and discharges of grey water

7.2.1. In terms of accidental spillages during the operational phase, this could occur as a result of use of lubricants and maintenance chemicals required in order to ensure the operational parts of the wind farm perform efficiently. Vessels associated with the operational phase required to enable the application of these maintenance activities also require the use of fuels and materials in order to function. In addition to the control measures required under the MARPOL Convention Regulations, standard good practice will be applied as in the Project EMMP to be completed for the operational phase. As a result, the risk of a spill and an associated adverse impact is considered to be **low**.

8. Assessment of Impacts during Decommissioning

8.1. Impacts due to the re-suspension of sediments and contaminants

8.1.1. During decommissioning, the worst case scenario (see **Table 5.1**) is for all components to be removed. Therefore during removal, there is a potential risk that disturbance to the seabed will occur, however, this is anticipated to be on a much smaller scale than during the construction of the wind farm. The impact predicted for construction is **minor adverse** significance and therefore the significance of the impact will be the same or less.

8.1.2. Any fluids or contaminants contained within the structures on decommissioning have the potential to leak into the marine environment. In order to reduce the likelihood of these releases, it is proposed that a decommissioning plan is drafted and visual monitoring of the structures will be undertaken during their removal. Operating procedures contained within the decommissioning plan will be developed in order to address this potential risk. It should be noted that this plan will follow at a later date. As a result, the risk of a spill and an associated adverse impact is considered to be **low**.

9. Inter-relationships

9.1.1. In order to address the environmental impact of the proposed development as a whole, this section establishes the inter-relationships between marine water and sediment quality and other physical, environmental and human receptors. The objective is to identify where the accumulation of residual impacts on a single receptor, and the relationship between those impacts, gives rise to a need for additional mitigation.

9.1.2. There is potential for an inter-related impact between marine physical processes and marine water and sediment quality during all phases of development. For example, changes to hydrodynamics have the potential to cause deterioration in water quality due to increased turbidity or from the re-suspension of contaminants. However, these impacts have been assessed in this chapter (minor adverse and negligible respectively). The assessment has been based on the results of the hydrodynamic modelling as presented in **Chapter 9**.

9.1.3. Similarly, any impact on marine water and sediment quality from the proposed development has the potential to affect other receptors, such as marine and intertidal ecology, and fish and shellfish ecology. The information provided in this assessment has been considered in turn by each relevant linked chapter to establish the potential for and significance of inter-related impacts.

9.1.4. No inter-relationships have been identified where an accumulation of residual impacts on marine water and sediment quality and the relationship between those impacts gives rise to a need for additional mitigation.

9.1.5. **Table 9.1** summarises the inter-relationships that are considered of relevance to marine water and sediment quality and identifies where they have been considered within the draft ES.

Table 9.1 Interrelationships relevant to marine water and sediment quality

Inter-relationship	Section where addressed	Linked chapter
Construction		
Deterioration in water quality due to re-suspension of sediments associated with site preparation.	Section 6	Influencing parameter: **Chapter 9 Marine Physical Processes**. Affected receptors: **Chapter 12 Marine and Intertidal Ecology** and **Chapter 13 Fish and Shellfish Ecology**.
Deterioration in water quality due to re-suspension of sediments associated with cabling.		
Deterioration in water quality due to re-suspension of sediments associated with scouring.		

Inter-relationship	Section where addressed	Linked chapter
Deterioration in water quality due to re-suspension of contaminants.		
Operation		
Deterioration in water quality as a result of scouring during operation.	Section 7	Influencing parameter: **Chapter 9 Marine Physical Processes**. Affected receptors: **Chapter 12 Marine and Intertidal Ecology** and **Chapter 13 Fish and Shellfish Ecology**.
Decommissioning		
Impacts on water quality due to re-suspension of sediments and contaminants.	Section 8	Influencing parameter: **Chapter 9 Marine Physical Processes**. Affected receptors: **Chapter 12 Marine and Intertidal Ecology** and **Chapter 13 Fish and Shellfish Ecology**.

9.1.6. **Chapter 31 Inter-relationships** provides a summary of all of the inter-related impacts associated within the proposed development.

10. Cumulative Impacts

10.1. CIA strategy and screening

10.1.1. This section describes the CIA for marine water and sediment quality taking into consideration other plans, projects and activities. A summary of the CIA is presented in **Chapter 33**.

10.1.2. Forewind has developed a strategy (the 'CIA Strategy') for the assessment of cumulative impacts in consultation with statutory stakeholders including the Marine Management Organisation (MMO), the JNCC, Natural England and Cefas. Details of the approach to cumulative impact assessment adopted for this draft ES are provided in **Chapter 4**.

10.1.3. In its simplest form the CIA Strategy involves consideration of:

- Whether impacts on a receptor can occur on a cumulative basis between the wind farm project(s) subject to the application(s) and other wind farm projects, activities and plans in the Dogger Bank Zone (either consented or forthcoming); and
- Whether impacts on a receptor can occur on a cumulative basis with other activities, projects and plans outwith the Dogger Bank Zone (e.g. other offshore wind farm developments), for which sufficient information regarding location and scale exist.

10.1.4. In this manner, the assessment considers (where relevant) the potential for cumulative impacts in the following sequence:

- With the third phase of development in the Dogger Bank Zone, known as Dogger Bank Teesside C & D;
- With the above, plus any other activities, projects and plans in the Dogger Bank Zone; and
- With all the above, in addition to any other activities, projects and plans outwith the Dogger Bank Zone.

10.1.5. The strategy recognises that data and information sufficient to undertake an assessment will not be available for all potential projects, activities, plans and/or parameters, and seeks to establish the 'confidence' Forewind can have in the data and information available.

10.1.6. There are two key steps to the Forewind CIA strategy, which both involve 'screening' in order to arrive, ultimately, at an informed, defensible and reasonable list of other plans, projects and activities to take forward in the assessment.

10.1.7. The first step in the CIA for marine water and sediment quality involved an appraisal of the key impacts relevant to each of the receptors that have been identified in the assessment of Dogger Bank Teesside A & B (**Table 10.1**). For each impact, the potential for impacts to occur on a cumulative basis has been identified, both within and beyond the Dogger Bank Zone; the confidence in the data and information available to inform the CIA has been appraised (following the methodology set out in **Chapter 4**); and the other activities that could contribute to these impacts have been identified.

10.1.8. For the purposes of marine water and sediment quality, the only impact identified during the construction (Section 6), operation (Section 7) and decommissioning phases (Section 8) of Dogger Bank Teesside A & B that has the potential to result in a cumulative effect, is the deterioration in water quality due to increases in turbidity (**Table 10.1**). Due to the nature of the impact assessed for Dogger Bank Teesside A & B, there is the potential for cumulative impacts to manifest outwith the Dogger Bank Zone.

10.1.9. Contaminants are screened out on the basis that levels are generally low across the site where substantial sediment disturbance is likely to occur (i.e. the wind farm project areas within Tranche A and Tranche B) over long periods of time. The deterioration in water quality as a result of accidental pollution incidents is also screened out on the basis that it is assumed that all other plans and projects will be required to implement control measures in order to reduce the risk for accidental pollution and be compliant with MARPOL.

Table 10.1 Potential cumulative impacts

Impact	Dogger Bank Zone (within 1km)		Beyond 1km from the Dogger Bank Zone		Rationale for where no cumulative impact is expected
	Potential for cumulative impact	Data confidence	Potential for cumulative impact	Data confidence	
Deterioration in water quality due to increases in turbidity	Yes	High	Yes	Medium	N/A
Deterioration in water quality due to re-suspension of contaminants	No	High	No	Medium	Contaminant levels are generally low in areas where significant sediment disturbance is likely to occur over long periods.
Deterioration in water quality as a result of accidental pollution incidents	No	N/A	No	N/A	Project procedures to include pollution control measures and MARPOL compliance during all phases.

10.1.10. Where the first step has indicated the potential for cumulative impacts, the second step in the CIA for marine water and sediment quality involved the identification of the actual individual plans, projects and activities within those broad industry levels for inclusion in the CIA. In order to inform this, Forewind has produced an exhaustive list of plans, projects and activities occurring within a very large study area encompassing the greater North Sea and beyond (referred to as the 'CIA Project List', see **Chapter 4**). The list has been appraised, based on the confidence Forewind has in being able to undertake an assessment from the information and data available, enabling individual plans, projects and activities to be screened in or out.

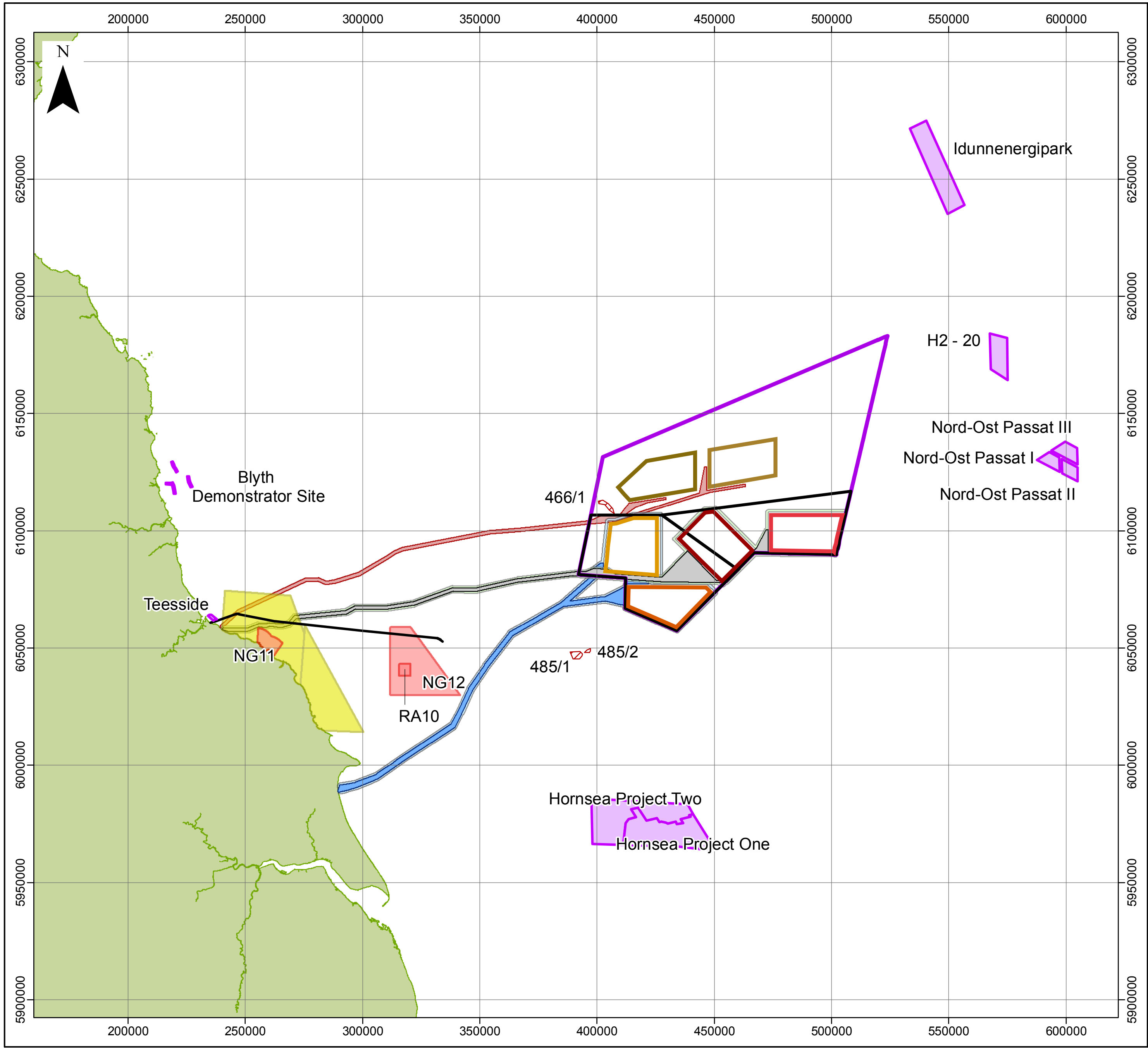
10.1.11. The plans, projects and activities relevant to marine water and sediment quality are presented in **Table 10.2** and **Figure 10.1**, along with the results of a further screening exercise that identifies whether there is sufficient confidence to take these forward in a detailed cumulative assessment, or whether they can be screened out on account of distance to the receptor in question. Following the first screening step, only projects likely to give rise to changes to suspended solids concentrations have been considered.

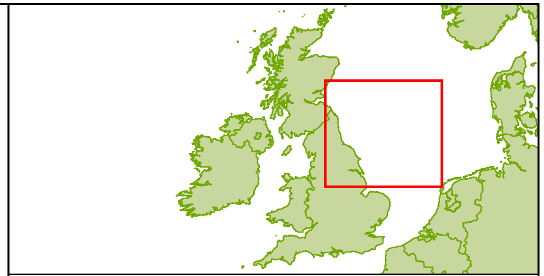
10.1.12. It should be noted that:

- Where Forewind is aware that a plan, project or activity could take place in the future, but has no information on how the plan, project or activity will be executed, it is screened out of the assessment; and
- Existing projects, activities and plans are considered to be a part of the established baseline and are therefore not included in the CIA.

Table 10.2 Cumulative impact assessment for marine water and sediment quality

Type of project	Project title	Project status	Predicted construction period	Distance from Dogger Bank Teesside A & B (km)	Confidence in project description	Confidence in project data	Carried forward to cumulative assessment?
Renewables – offshore wind farms	All wind farm projects that are already operational within the study area	Operational	N/A	N/A	As operational phases of wind farms generally do not predict large changes to turbidity during the operational phase (largely due to the presence of scour protection) these projects are screened out.		
Renewables – offshore wind farm	Dogger Bank Creyke Beck A & B	Pre-application	2016-2027	5km southwest of Dogger Bank Teesside B	High	High	Yes
Renewables – offshore wind farm	Dogger Bank Teesside C & D within Forewind's development plan	Pre-application	2018/19 - 2029	Within the Dogger Bank Zone. 5km north of Dogger Bank Teesside B	High	Medium	Yes
Renewables – offshore wind farm	All wind farms in pre-application, application or under construction	Pre-application, application or construction	2015 onwards	Nearest is the Hornsea Zone (approximately 100km south of Dogger Bank Teesside B). Teesside Offshore Windfarm is also located 4km north of Dogger Bank Teesside A & B Export Cable Corridor. German and Norwegian projects located to the north north east. Blyth Demonstration Project (60km north north west of Dogger Bank Teesside A & B Export Cable Corridor)	Medium/low	Medium/low	Yes
Aggregates	Application Area 466/1 within the Dogger Bank Zone for which an aggregate production licence is being sought by CEMEX UK Marine Ltd.	Application		Within the Dogger Bank Zone	High	High	Yes
Aggregates	Application Area 485/1 and 485/2	Application		60km southwest of Dogger Bank Teesside B	High	High	Yes





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Creyke Beck A
- Dogger Bank Creyke Beck B
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside C
- Dogger Bank Teesside D
- Dogger Bank Teesside A & B export cable corridor
- Dogger Bank Teesside A & B temporary works area
- Dogger Bank Creyke Beck export cable corridor
- Dogger Bank Creyke Beck temporary works area
- Dogger Bank Teesside C & D export cable corridor
- Aggregate application area
- Offshore wind farm
- Potash mine
- Breagh pipeline
- Recommended Marine Conservation Zone (NG) & Recommended Reference Area (NG RA)

0 20 40
Kilometres

Data Source:
Breagh pipeline data provided by RWE Dea UK
Designation © Natural England, 2012
UK offshore wind farm, Aggregate areas & Potash Mine © The Crown Estate, 2013
European wind farm boundary data supplied by MarineFind, 2013

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 10.1 Cumulative effects considered for marine physical processes

VER	DATE	REMARKS	Drawn	Checked
1	21/02/2013	Draft	FK	DB
2	07/10/2013	PEI3	LW	DB

DRAWING NUMBER: **F-OFL-MA-457**

SCALE	1:2,500,000	PLOT SIZE	A4	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

10.2. Interaction of proposed development within Dogger Bank (Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B)

10.2.1. Forewind is intending to develop four additional projects within the Dogger Bank Zone; Dogger Bank Creyke Beck A & B and Dogger Bank Teesside C & D. Forewind have developed a range of potential construction programmes that may apply to these six projects (see **Chapter 5**). The worst case scenario for impacts on suspended solids concentrations is that all of the projects could be constructed at the same time. Cumulative effects may therefore arise.

10.2.2. On consideration of the output of the plume modelling for Dogger Bank Teesside A & B alone, it is considered likely that should construction occur simultaneously, the plumes will combine to create a larger overall plume. The extent to which this might occur has, however, not been modelled.

10.2.3. On the basis that suspended solid concentrations are expected to return to background levels following cessation of the activities (i.e. any cumulative effect will only occur during installation), the magnitude of effect is anticipated to remain as medium. Therefore, since the sensitivity of the water is deemed to be low, the cumulative impact is anticipated to remain as minor adverse for the offshore area. Nearshore, cumulative impacts are not predicted on the basis that Dogger Bank Teesside A & B Export Cable Corridor and Dogger Bank Teesside C & D Export Cable Corridor plume footprints are unlikely to overlap, due to the distance of the cable corridors from one another and the short timeframe over which installation is likely to occur.

10.2.4. During the operation phase, it is also likely that cumulative effects will occur as the operational phases of the projects are highly likely to overlap in the offshore area. Any storm impacting on one project will therefore impact on the others which could result in a cumulative release of suspended sediment via scouring effects. In order to assess this, modelling was undertaken for all six projects operating simultaneously. Full results are presented in **Chapter 9**, however, for ease of reference, a summary of the findings is provided here.

10.2.5. The model was run with all foundations for the six projects in place and then struck by a 50-year storm. The maximum predicted suspended solid concentrations in the bottom layer are presented in **Figure 10.2** and show predicted concentrations to be greater than 200mg/l, 22km away from the developments. Concentrations then reduce to background levels approximately 39km south of the southern boundary and 24km north of the northern boundary.

10.2.6. The area over which concentrations exceed 100mg/l is significantly greater with all sites operating simultaneously than the area predicted to be impacted by Dogger Bank Teesside A & B alone, however, the effect will still be temporary and will only occur until scour equilibrium is reached. Additionally, all sites are unlikely to become operational at exactly the same time and therefore scouring will already have occurred at sites completed first. It is also anticipated that baseline conditions will return to normal. The plume predictions shown in **Figure 10.2** therefore represent a very precautionary approach to the assessment.

10.2.7. As a result, the magnitude of the impact is again predicted to be medium and therefore the cumulative impact is anticipated to be **minor adverse**.

10.3. Cumulative effects with Hornsea Projects One and Two

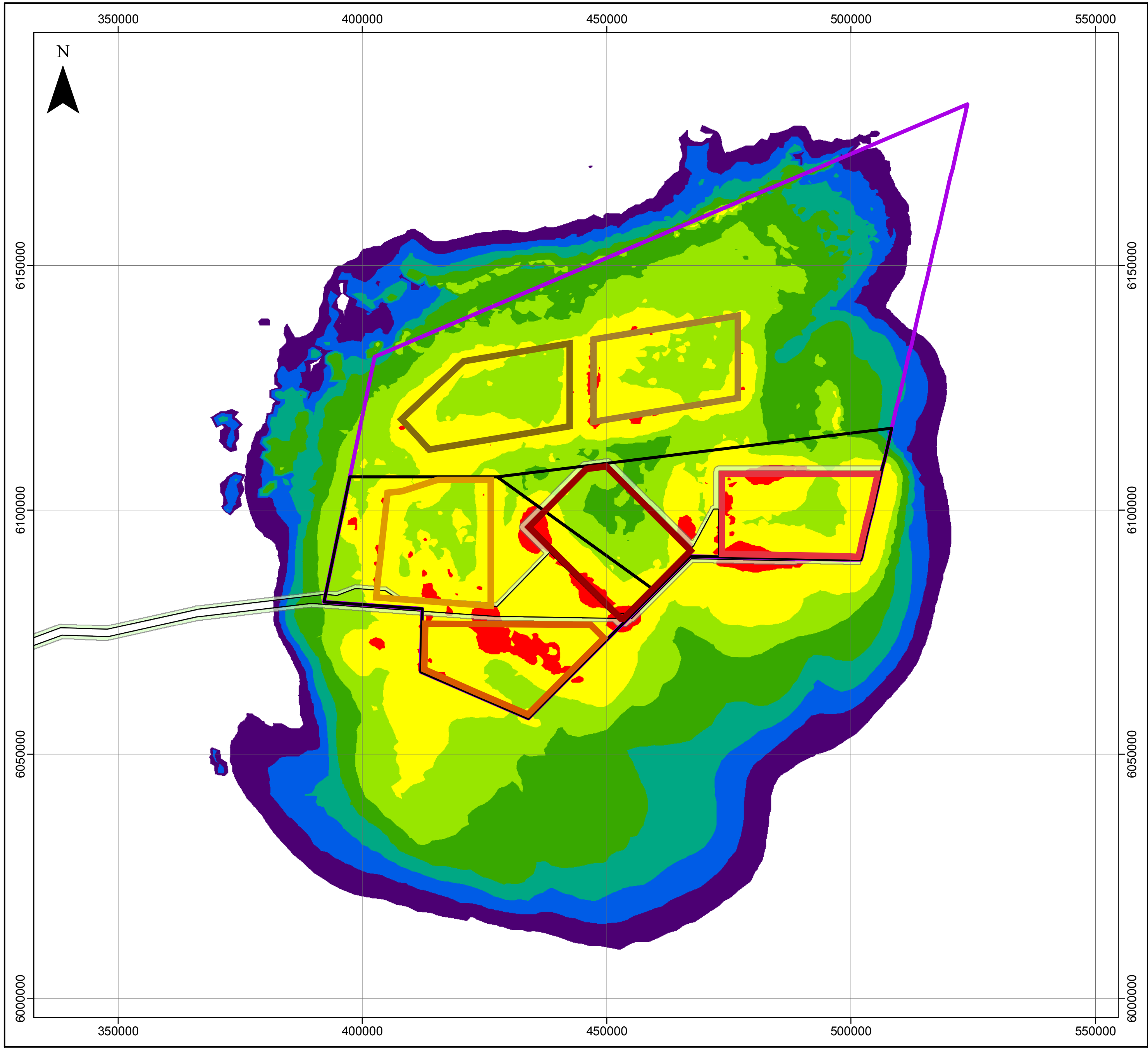
10.3.1. The potential for cumulative impacts has been assessed within the CIA of **Chapter 9** but for ease of reference a summary is provided here. For Project One, hydrodynamic modelling has been completed and the indicative worst case increases in suspended sediment concentrations, above background levels during construction, extend for approximately 10km north of the northern boundary of Project One. Additionally, levels were predicted to disperse rapidly and return to background levels immediately after the construction is complete (RPS Energy, 2013).

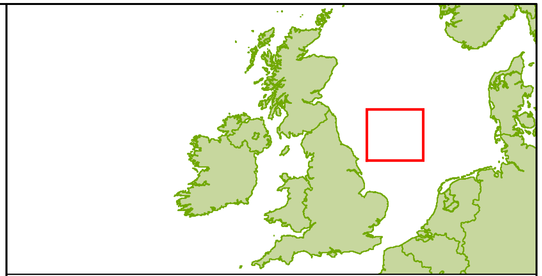
10.3.2. As a result, it is considered unlikely that the construction plume for Hornsea Project One will interact with the combined construction plume from Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B. It is also unlikely that the combined operational plume from Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B will interact with the construction plume from Hornsea Project One as the combined Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B operational plume is created during storm conditions under which construction of Hornsea will not be possible.

10.3.3. Conversely, Hornsea Project Two is only at the scoping phase and therefore detailed information is not yet available. However, it is considered likely, given the similar project size to Project One, that similar conclusions can be reached.

10.3.4. The cumulative impact therefore remains at that predicted for the combined plume from Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B (for both construction and operation), i.e. **minor adverse**.

10.3.5. During the operational phases of Hornsea Projects One and Two, scour protection is to be provided and therefore scour effects are not anticipated. As a result, the cumulative impact therefore remains at that predicted for the combined plume from Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B alone (for construction and operation), (i.e. **minor adverse**).





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Creyke Beck A
- Dogger Bank Creyke Beck B
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside C
- Dogger Bank Teesside D
- Dogger Bank Teesside A & B export cable corridor
- Dogger Bank Teesside A & B temporary works area

Suspended sediment concentration kg/m³

- Above 0.200
- 0.100 - 0.200
- 0.050 - 0.100
- 0.020 - 0.050
- 0.010 - 0.020
- 0.005 - 0.010
- 0.002 - 0.005
- Below 0.002

0 10 20
Kilometres

Data Source:
Modelling © Danish Hydraulic Institute, 2013

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 10.2 Maximum SSC in the bottom layer predicted over the simulation period after two years of operation using the re-suspension of fractions 1 and 2 method

VER	DATE	REMARKS	Drawn	Checked
1	08/04/2013	Draft	FK	DB
2	08/10/2013	PEI3	LW	DB

DRAWING NUMBER: **F-OFL-MA-458**

SCALE	1:1,200,000	PLOT SIZE	A4	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

10.4. Cumulative effects with Teesside Offshore Windfarm and the Blyth Demonstration Project

10.4.1. Teesside Offshore Windfarm is currently being constructed and will be operational before construction of Dogger Bank Teesside A & B commences. Therefore the only possible cumulative impact could be associated with the operational phase. Since scour protection is to be installed at Teesside Offshore Windfarm, operational plumes are not anticipated and therefore there are no situations whereby a cumulative impact could arise.

10.4.2. The Blyth Demonstration Project is located 55km north of the Dogger Bank Teesside A & B Export Cable Corridor and will consist of three arrays each containing five turbines. Due to the size of the demonstration project and the predictions that the construction plume for the Dogger Bank Teesside A & B Export Cable Corridor is only likely to extend 20km north (see **Chapter 9**), an overlap in sediment plumes is not considered likely.

10.4.3. The cumulative impact therefore remains at that predicted for the combined plume for Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B alone (i.e. **minor adverse**).

10.5. Cumulative effects with German and Norwegian offshore wind farms

10.5.1. A full description of these projects is provided in **Chapter 9**. In summary, the conclusion is reached that, due to the predictions of the combined construction and operational plumes for Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B being generally confined to UK waters, and the distance of the German and Norwegian wind farms from the Dogger Bank Zone, the likelihood of interaction is considered low. As a result, the cumulative impact remains at that predicted for the combined plume from Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B alone (i.e. **minor adverse**).

10.6. Cumulative effects with aggregate application area 466/1

10.6.1. Application Area 466/1 is located at the Northern boundary of Dogger Bank Creyke Beck B and may become active during the lifetime of any of the Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B projects. Additionally, it is located within the modelled maximum plume extent generated from construction simultaneously of Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B. Since aggregate extraction activities have the potential to release further sediment into the water column, there is the potential for a cumulative effect but only if aggregate dredging occurs at the same time.

10.6.2. A full assessment of the potential for the plumes to interact is provided in **Chapter 9**. In summary, it is concluded that if the aggregate dredging plume were to occur simultaneously with the combined construction plume from

Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B together, the effect is likely to be minor compared to the plume produced by all six projects combined. The overall impact, therefore, remains at that predicted for Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B together (i.e. **minor adverse**).

10.6.3. In terms of operational cumulative impacts, the relatively small plume associated with the aggregate dredging is unlikely to be significant in relation to that produced during the operation of Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B associated with scour effects. Inclusion of the plume within the operational combined plume associated with Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B is therefore unlikely to have any effect on its overall size and will remain unchanged in terms of suspended solid concentrations predicted for the plume from Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B combined. Additionally, it is unlikely that aggregate dredging will be undertaken during stormy conditions. The overall impact, therefore, remains at that predicted for Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B together (i.e. **minor adverse**).

10.7. Cumulative effects with aggregate application area 458

10.7.1. There is also an application for a licence for Area 485 located approximately 25km to the southwest of Dogger Bank Creyke Beck A and 20km south of the Dogger Bank Creyke Beck Export Cable Corridor 30km south of the Dogger Bank Teesside A & B Export Cable Corridor.

10.7.2. A full assessment of the potential for the plumes to interact is provided in **Chapter 9**. In summary, it is concluded that the likelihood of the plume created by the aggregate dredging will only increase concentrations in the local area in the order of 1 to 2 mg/l above background concentrations i.e. concentrations will be within natural variation. As a result, cumulative impacts with the combined plume from Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B are not predicted. The overall impact, therefore, remains at that predicted for Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B together (i.e. **minor adverse**).

10.7.3. In terms of operational cumulative impacts, the relatively small plume associated with the aggregate dredging is unlikely to be significant in relation to that produced during the operation of Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B associated with scour effects. Inclusion of the plume within the operational plumes associated with Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B is therefore unlikely to have any effect on its overall size and will remain unchanged in terms of suspended solid concentrations predicted for Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B together. Additionally, it is unlikely that aggregate dredging will be undertaken during stormy conditions. The overall impact, therefore, remains at that predicted for Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B together (i.e. **minor adverse**).

11. Transboundary Effects

11.1.1. This chapter has considered the potential for transboundary effects (effects across international boundaries) to occur on the marine water and sediment quality environment. The impact assessment has been based on both existing and site specific survey data which has established that, in summary, the only way in which transboundary effects are likely to occur is if the suspended sediment plume resulting from the combined construction phases (Dogger Bank Teesside A & B, Dogger Bank Creyke Beck A & B and Dogger Bank Teesside C & D) crosses the boundary at the eastern boundary of the Dogger Bank Zone with Dutch and German waters. The eastern boundary of Dogger Bank Teesside A is located on the international boundary with the Netherlands.

11.1.2. Cumulative sediment plume modelling undertaken in order to inform **Chapter 9** however, predicts that the operational plume for Dogger Bank Teesside A & B and Dogger Bank Creyke Beck A & B will only disperse up to about 15km into Dutch waters and does not cross into German, Danish or Norwegian waters. Additionally, it should be noted that the scouring effects would only occur until such time as equilibrium was reached. The effect will therefore be short term.

11.1.3. All other potential impacts on sediment and water quality are predicted to be localised or at low risk of giving rise to significant environmental impacts (such as the accidental spillage of materials during all three phases). As a result, no transboundary effects have been identified.

12. Summary

12.1.1. This chapter discusses the existing marine water and sediment quality within the vicinity of the proposed Dogger Bank Teesside A & B development. The impact assessment has taken into the account the general requirements of key European and international legislation and policy concerning environmental quality standards for chemical contaminants and guideline values to determine sediment quality.

12.1.2. Existing sediment and water quality is generally considered to be good with the offshore sites exhibiting lower levels of contamination than nearshore sites. This is expected as sources of contamination are less likely at the offshore sites.

12.1.3. **Table 12.1** summarises the predicted impacts, mitigation measures and residual impacts from the construction, operational and decommissioning phases of the proposed development. The impacts represent the maximum potential adverse impact as a result of having assessed the worst case development scenario for each receptor. Therefore the predictions made would not be worse should any other development scenario, to that assessed, be taken forward in the final scheme design.

Table 12.1 Summary of impacts on marine water and sediment quality

Description of impact	Mitigation measures	Residual impact
Construction		
Re-suspension of sediments	N/A	**Minor adverse**
Re-suspension of contaminants	N/A	**Negligible**
Re-suspension of sediments (bathing waters)	N/A	**Negligible**
Re-suspension of sediments (landfall)	N/A	**No impact**
Risk of accidental pollution	Control measures in place	**Low Risk**
Operation		
Re-suspension of sediments	N/A	**Negligible**
Risk of accidental pollution	Control measures in place	**Low Risk**
Decommissioning		
Risk of accidental pollution	Control measures in place	**Low Risk**
Cumulative impacts		
With the combined plume produced by Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B	N/A	**Minor adverse**
With wind farms not yet under construction with the combined plume produced by Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B	N/A	**Minor adverse**

Description of impact	Mitigation measures	Residual impact
With Aggregate Areas 466/1/485 with the combined plume produced by Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A & B	N/A	**Minor adverse**
Transboundary effects		
None	N/A	N/A

12.1.4. Overall therefore, residual impacts on marine water and sediment quality are generally predicted to be **minor adverse** or **negligible**, both alone or cumulatively, and no mitigation or monitoring additional to that already outlined in the assessment is deemed necessary.

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