Norfolk Vanguard Offshore Wind Farm

Chapter 19

Ground Conditions and Contamination

Environmental Statement

Volume 1

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Environmental Impact Assessment
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Glossary

BGS	British Geological Survey
BGL	Below ground level
CMS	Construction Method Statement
CoCP	Code of Construction Practice
CPRE	Campaign to Protect Rural England
CRS	Cable Relay Station
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
DrWPAs	Drinking Water Protected Areas
EEA	European Economic Area
EIA	Environmental Impact Assessment
EREC	Energy Network Engineering Recommendations
ES	Environmental Statement
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
m	Metre
MHWS	Mean High Water Spring
MMP	Materials Management Plan
MPA	Mineral Planning Authority
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OCoCP	Outline Code of Construction Practice
O&M	Operations and Maintenance
PAH	Polyaromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCOC	Potential Contaminant of Concern
PEIR	Preliminary Environmental Information Report
PPE	Personal Protective Equipment
PPG	Pollution Prevention Guidance
PRA	Preliminary Risk Assessment
RPE	Respiratory Protective Equipment
RSA	Restoring Sustainable Abstraction
SoS	Secretary of State
SAC	Special Area of Conservation
SgZs	Groundwater Safeguard Zones
SMP	Shoreline Management Plan
SPA	Special Protection Area
SPZ	Source Protection Zone
SSSI	Sites of Special Scientific Interest
SVOC	Semivolatile Organic Compound
SWMP	Site and Excavated Waste Management Plan
VOC	Volatile Organic Compound
WCS	Worst Case Scenario
WFD	Water Framework Directive

Terminology

Cable Relay Station	Primarily comprised of an outdoor compound containing reactors (also called inductors, or coils) and switchgear to increase the power transfer capability of the cables under the HVAC technology scenario as considered in the PEIR. This is no longer required for the project as the HVDC technology has been selected.
Landfall	Where the offshore cables come ashore at Happisburgh South
Link boxes	Underground chambers or above ground cabinets next to the cable trench housing low voltage electrical earthing links.
Mobilisation area	Areas approx. 100 x 100m used as access points to the running track for duct installation. Required to store equipment and provide welfare facilities. Located adjacent to the onshore cable route, accessible from local highways network suitable for the delivery of heavy and oversized materials and equipment.
National Grid overhead line modifications	The works to be undertaken to complete the necessary modification to the existing 400kV overhead lines
National Grid substation extension	The permanent footprint of the National Grid substation extension
Necton National Grid substation	The existing 400kV substation at Necton, which will be the grid connection location for Norfolk Vanguard
Onshore cable corridor	200m wide onshore corridor within which the onshore cable route would be located as submitted for PEIR.
Onshore cable route	The 45m easement which will contain the buried export cables as well as the temporary running track, topsoil storage and excavated material during construction.
Onshore cables	The cables which take the electricity from landfall to the onshore project substation
Onshore project area	All onshore electrical infrastructure (landfall; onshore cable route, accesses, trenchless crossing technique (e.g. Horizontal Directional Drilling (HDD)) zones and mobilisation areas; onshore project substation and extension to the Necton National Grid substation and overhead line modification)
Onshore project substation	A compound containing electrical equipment to enable connection to the National Grid. The substation will convert the exported power from HVDC to HVAC, to 400kV (grid voltage). This also contains equipment to help maintain stable grid voltage.
Running track	The track along the onshore cable route which the construction traffic would use to access workfronts
The Applicant	Norfolk Vanguard Limited.
The project	Norfolk Vanguard Offshore Wind Farm, including the onshore and offshore infrastructure
Transition pit	Underground structures that house the joints between the offshore export cables and the onshore cables within the landfall zone
Trenchless crossing zone (e.g. HDD)	Temporary areas required for trenchless crossing works.

19 GROUND CONDITIONS AND CONTAMINATION

19.1 Introduction

1. This chapter of the Environmental Statement (ES) considers the potential environmental impacts of the proposed Norfolk Vanguard project (herein referred to as 'the project') relating to ground conditions and contamination. The assessment focusses on the potential presence of contamination and pollutant linkages to sensitive receptors such as site workers, future site users, geology and groundwater. The assessment also considers the potential for impacts on mineral resources. This chapter does not assess potential impacts on soil quality in the context of an agricultural resource or an ecosystem service; this is discussed separately in Chapter 21 Land Use and Agriculture.

2. The focus of the assessment is on the potential pollutant linkages between contaminated land and / or groundwater and the soil and groundwater environment and other sensitive receptors, such as designated ecological sites. Potential impacts to the groundwater and surface waters are discussed in Chapter 20 Water Resources and Flood Risk.

3. The chapter provides an assessment of the potential impacts and associated mitigation for the construction, operation and decommissioning of the project. The assessment also considers cumulative impacts of other proposed projects. The proposed methodology adhered to for the Environmental Impact Assessment (EIA) and Cumulative Impact Assessment (CIA) is discussed in section 19.4.

4. Figures which accompany the text in this chapter are provided in Volume 2 Figures.

5. Because of the close association between ground conditions, groundwater, surface water and ecology topics, this chapter should also be read in conjunction with the other related ES chapters (and their appendices and supporting documents). The relevant chapters are:

   - Chapter 8 Marine Geology, Oceanography and Physical Processes;
   - Chapter 9 Marine Water and Sediment Quality;
   - Chapter 20 Water Resources and Flood Risk; and
   - Chapter 27 Human Health.

19.2 Legislation, Guidance and Policy

6. There are a number of pieces of legislation, policy and guidance applicable to ground conditions and contamination. The following sections provide detail on key pieces of international and UK legislation, policy and guidance which are relevant to this chapter.

19.2.1 Legislation and Policy

7. The assessment of potential impacts upon ground conditions and contamination 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 (NSIPs). Those relevant to the project are:

- Overarching NPS for Energy (EN-1) (Department of Energy and Climate Change (DECC) 2011a);
- NPS for Renewable Energy Infrastructure (EN-3) (DECC 2011b); and
- NPS for Electricity Networks Infrastructure (EN-5) (DECC 2011c).

8. Further detail on legislation and policy in relation to the wider project is provided in Chapter 3 Policy and Legislative Context.

9. The specific assessment requirements for ground conditions and contamination, as detailed in the NPSs, are summarised in Table 19.1, together with an indication of the paragraph numbers of the ES chapter where each is addressed.

Table 19.1 NPS assessment requirements relevant to ground conditions and contamination

NPS Requirement	NPS Reference	ES Reference
EN-1 Overarching NPS for Energy		
'Where the development is subject to EIA [Environmental Impact Assessment] the applicant should ensure that the ES [Environmental Statement] clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the Infrastructure Planning Commission (IPC) consider thoroughly the potential effects of a proposed project.'	Section 5.3	Existing environment is discussed in section 19.6. Impacts are set out in sections 19.7 and 19.8.
EN-5 Electricity Networks Infrastructure		
'Where possible, applicants should follow the principles below in designing the route of their overhead line proposals and it will be for applicants to offer constructive proposals for additional mitigation of the proposed overhead line. While proposed, underground lines do not require development consent under the Planning Act 2008, wherever the nature or proposed route of an overhead line proposal makes it likely that its visual impact will be particularly significant, the applicant should have given appropriate consideration to the potential costs and benefits of other feasible means of connection or reinforcement, including underground and sub-sea cables where appropriate. The ES should set out details of how consideration has been given to undergrounding or sub-sea cables as a way of mitigating such impacts, including,	Section 2.8	Underground cables are discussed in section 19.7.

NPS Requirement	NPS Reference	ES Reference
where these have not been adopted on grounds of additional cost, how the costs of mitigation have been calculated.'		
'The impacts and costs of both overhead and underground options vary considerably between individual projects (both in absolute and relative terms). Therefore, each project should be assessed individually on the basis of its specific circumstances and taking account of the fact that Government has not laid down any general rule about when an overhead line should be considered unacceptable. The IPC should, however only refuse consent for overhead line proposals in favour of an underground or sub-sea line if it is satisfied that the benefits from the non-overhead line alternative will clearly outweigh any extra economic, social and environmental impacts and the technical difficulties are surmountable. In this context it should consider: the environmental and archaeological consequences (undergrounding a 400kV line may mean disturbing a swathe of ground up to 40 metres across, which can disturb sensitive habitats, have an impact on soils and geology, and damage heritage assets, in many cases more than an overhead line would).'	Section 2.8.9	Impacts on geology are set out in sections 19.7 and 19.8. Soil resource is considered in Chapter 21 Land Use and Agriculture.

10. Part IIA of the Environmental Protection Act (1990), as amended, provides a legislative context for the assessment of contaminated land. Contaminated land for the purpose of Part IIA is defined as 'any land which appears to the Local Authority in whose area it is situated to be in such condition, by reasons of substances in, on or under the land that:

- 'Significant harm is being caused or there is a significant possibility of such harm being caused'; or
- 'Significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused'.

11. The project has potential to impact on mineral resource availability. The national minerals policy in Minerals Policy Statement 1: Planning and Minerals (MPS1) aims to secure adequate and steady supplies of the minerals needed by society and the economy.

19.2.2 Local Planning Policy

12. EN-1 states that the Planning Inspectorate will also consider Development Plan Documents or other documents in the Local Development Framework to be relevant to its decision making.

13. The onshore project area falls under the jurisdiction of Norfolk County Council and the following local planning authorities:

- Broadland District Council;
- North Norfolk District Council; and
- Breckland Council.

14. Appendix B (North Norfolk Ecological Network) of North Norfolk District Council's Policy EN 9 on Biodiversity emphasises the importance of the chalk rivers in the district.

15. Norfolk County Council has produced Mineral Safeguarding Guidance which outlines the measures needed to ensure that non-mineral development on Mineral Safeguarding Areas within Norfolk complies with adopted policy on the safeguarding of mineral resources.

16. Further advice in relation specifically to the project has been sought through consultation as detailed in section 19.3.

19.3 Consultation

17. Consultation is a key driver of the EIA and ES, and is an ongoing process throughout the lifecycle of the project, from the initial stages through to consent and post-consent. To date, consultation regarding ground conditions and contamination has been conducted through Expert Topic Group (ETG) meetings held in July 2017 and January 2018, the Scoping Report (Royal HaskoningDHV, 2016) and the Preliminary Environmental Information Report (PEIR) (Norfolk Vanguard Limited, 2017). Full details of the project consultation process are presented within Chapter 7 Technical Consultation. Ongoing landowner discussions are also being undertaken to help inform the project, and have fed into key project design decisions such as the cable route alignment. Whilst individual responses are not captured here, these are collated in a Consultation Report (Document reference 5.1), which will be submitted with the DCO application.

18. A summary of the consultation that has been undertaken to date with respect to ground conditions and contamination is provided in Table 19.2.

Table 19.2 Consultation responses

Consultee	Document / date received	Comment	Response / where addressed in the ES
Secretary of State (SoS)	11th November 2016 Scoping Opinion	The ES [Environmental Statement] should identify and assess potential impacts on the Mineral Safeguarding Areas underlying the onshore scoping area (see the comments of Norfolk County in Appendix 3 of this Opinion).	Mineral safeguarding data has been shared by Norfolk County Council and is considered within the assessment in sections 19.6 and 19.7.5.7.
SoS	11th November 2016	Paragraph 304 of the Scoping Report notes there is rapid cliff erosion on the coast of	Rapid cliff erosion on the coast of north east

Consultee	Document / date received	Comment	Response / where addressed in the ES
	Scoping Opinion	north east Norfolk. The potential impacts of landfall works on coastal processes, including erosion and deposition, should be addressed with appropriate cross reference to other technical reports including landscape and visual impacts. Reference should be made to the Kelling to Lowestoft Ness Shoreline Management Plan, where appropriate.	Norfolk is considered within the assessment in sections 19.4 and 19.7.5.1. Appendix 4.1 Coastal Erosion Study of Chapter 4 Site Selection and Assessment of Alternatives also provides information in relation to coastal erosion.
SoS	11th November 2016 Scoping Opinion	The Secretary of State welcomes the proposal to employ a Code of Construction Practice (CoCP) during site works to ensure that all appropriate Pollution Prevention Guidelines and good practice guidelines are followed. The proposal to provide a draft CoCP with the DCO application is welcomed and the Secretary of State recommends that this document contains sufficient information as to the minimum measures required to achieve the requisite level of mitigation.	An Outline Code of Construction Practice (OCoCP) (document reference 8.1) has been produced and is submitted with the DCO application.
SoS	11th November 2016 Scoping Opinion	The Scoping Report has scoped out all operational impacts on ground conditions and contamination, with the exception of cumulative impacts. The only justification for this is that operation and maintenance activities would follow standard procedures. Despite the limited justification provided, the Secretary of State does not consider there would be any significant effects from operation and therefore agrees this can be scoped out.	As per the Scoping Opinion, all operational impacts on ground conditions and contamination are scoped out from further assessment (section 19.7.6).
SoS	11th November 2016 Scoping Opinion	The Secretary of State welcomes the consideration of construction impacts on Water Framework Directive (WFD) groundwater bodies (see Section 4 of this Opinion for further details) and designated geological sites. Further comments on WFD assessment are provided in the Water Resources and Flood Risk section of this Opinion below.	Impacts on Water Framework Directive (WFD) groundwater bodies and designated geological sites are considered within the assessment. Details of WFD assessment can be found in Chapter 20 Water Resources and Flood Risk and Appendix 20.1 WFD Compliance Assessment
SoS	11th November 2016	The ES should justify the extent of the study areas used in the assessment.	Justification of the extent of the study area can be

Consultee	Document / date received	Comment	Response / where addressed in the ES
	Scoping Opinion		found in section 19.5.1.
Norfolk County Council	Scoping Opinion November 2016	3.2.1.2 Geology This section should refer to the Mineral Safeguarding Areas (sand and gravel) that underlie the onshore scoping area. The Mineral Safeguarding Area is shown in the adopted Revised Policies Map (Oct 2013) which is available to view on the County Council's website at: www.norfolk.gov.uk/nmwdf on the 'Adopted policy documents' page. The onshore scoping area also includes safeguarded operational, permitted and allocated sand and gravel extraction sites which should be referred to in this section. Policy CS16 of the adopted Minerals and Waste Core Strategy is relevant. Norfolk County Council has produced Mineral Safeguarding Guidance which outlines the measures needed to ensure that non-mineral development on Mineral Safeguarding Areas within Norfolk complies with adopted policy on the safeguarding of mineral resources.	Mineral safeguarding data has been shared by Norfolk County Council and is considered within the assessment in section 19.7.5.7.
Environment Agency	Scoping Opinion November 2016	Horizontal directional drilling (HDD) is mentioned at paragraph 834 as an embedded mitigation process and potential risks are discussed at paragraph 873. Although HDD is a recognised method to address sensitive locations there are residual risks to the environment which should be addressed in detail in the EIA. The potential risks to both groundwater resources and surface water bodies from leakage of drilling fluid should be addressed with sufficient information provided in the EIA to provide assurance that the risks to the water environment are fully understood and can be addressed through appropriate measures. Assessments of the use of HDD at each sensitive location should include site and ground investigations, risk assessment, appropriate mitigation and remediation.	Initial assessments of the use of trenchless crossing technique at each sensitive location can be found in section 19.7.5.3. Ground investigations required to develop a risk assessment, appropriate mitigation and remediation have been undertaken. The results of the ground investigation are provided by Terra Consult (2017) and GHD (2018).
Environment Agency	Scoping Opinion November 2016	We agree with the approach to identifying land contamination as set out in Section 3.2. The EIA should identify any areas of land contamination found within the cable corridor and provide a Preliminary Risk	A PRA was undertaken as part of the assessment and no major sources of contamination were found within the study

Consultee	Document / date received	Comment	Response / where addressed in the ES
		Assessment for each area. The Preliminary Risk Assessment [PRA] should provide sufficient information for the risks to the water environment to be fully understood and include site investigation and remediation measures. In respect of water resources, we agree the approach outlined in the Scoping Report. We recommend that the cable corridor does not cross or touch any areas designated as source Protection Zone 1.	area. The impacts on the water resources are considered in section 19.7.5.3 and section 19.7.5.4 of this chapter as well as Chapter 20 Water Resources and Flood Risk.
National Farmers Union	PEIR December 2017	Details of how soils will be treated and where stored during construction must be provided. Along with how sub and top soils will be kept separate and kept clean during the construction period. Due to the damage to soils during construction works must only take place when conditions are acceptable. During very wet conditions and if soils are waterlogged construction should be stopped. Further it is important for Vattenfall to set out how after soil has been reinstated what measures will be put in place to bring the soil back to its condition and quality before the works took place. An after care plan should be included in a Code of Construction. To enable the aftercare plan to be put in place Vattenfall must make sure that a record of condition is taken pre –construction including soil samples to determine the soil structure and the nutrients. This can then be used to set a soil target specification for each field on a holding. The soil target must also include yield records which can be provided by the landowner/occupier. The NFU is pleased to see that a Code of Construction has been mentioned along with a Soil Management Plan but the NFU would have expected to see draft details of these two documents within this PIER. The NFU would like to see draft documents as soon as further details are available and before the submission of the DCO.	Potential impacts on soils are discussed in Chapter 21 Land use and Agriculture, section 21.6.4 and 21.7.4.3. Handling and protection of soils, including measures such as the separate storage of topsoil and subsoil, and ceasing work during wet weather, will be managed through the Soil Management Plan, which has been produced and submitted alongside the DCO application. The OCoCP (document reference 8.1) also includes best practice measures for soil handling, which has been produced and submitted alongside the DCO application.
Environment Agency	PEIR December 2017	In common with comments made regarding WFD issues for surface waterbodies, neither designation nor WFD status is a satisfactory indication of sensitivity to impacts. We disagree with Secondary Aquifers being identified as a low sensitivity receptor. These aquifers are often very important in supplying base flow to surface waters and are	Designations and WFD status are not used as an indication of sensitivity to impacts on surface water bodies. The Secondary Aquifers A sensitivity was changed to moderate and

Consultee	Document / date received	Comment	Response / where addressed in the ES
		frequently in hydraulic continuity with the underlying principal aquifer particularly in the east of the application area. Similarly, we would not consider unlicensed water supplies low risk.	Secondary B / undifferentiated remained designated as low. See section 19.4 and Table 19.4.
Environment Agency	PEIR December 2017	We agree with the recommendation in paragraph 57 to undertake ground investigation and further assessment of the made ground in the on-site source areas at the dismantled railway lines and Bacton oil terminal. As well as establishing the risk to construction and potential for the re-use of soils, the investigation should also consider potential risks to controlled waters. We agree with paragraph 59 that protocols for dealing with unexpected contamination should be set in place prior to construction with the procedures agreed with the Regulators. This should include proposals to deal any waste soils extracted from the cable run.	Embedded mitigation measures related to contaminated land management are described in Table 19.14
Campaign to Protect Rural England (CPRE)	PEIR November 2017	7. Table 19. National Planning Statement describes the National Planning Statements for Nationally Significant Projects and quotes two which are relevant to the project. These are the overarching NPS for Energy EN-1 DECC 2011a and Electricity Networks Infrastructure EN-5 DECC, 2011b. EN-1 at section 5.3 states that the applicant clearly sets out any effects on designated sites of ecological or geological importance, protected species and on habitats and other species important to the conservation of biodiversity. The ENS section states that underground lines do not require development consent under the Planning Act 2008. Comment: There are in practice constraints on undergrounding, see comments by the Environment Agency at page 6 and tables 19.3 and 19.4 Both EN-1 and EN-5 are superseded on one important issue by the National Planning Policy Framework of March 2012, and this is particularly important for EN-1. EN-1 does not make any reference to ecological networks, and there is inadequate or no comment by Vattenfall (or Ørsted). Both companies should note and act on what the NPPF says at Chapter 11 Conserving and enhancing the natural environment on this	Reference to North Norfolk District Council Policy EN 9 Biodiversity Appendix B on the ecological network and the importance to the Chalk Rivers in the district is made in section 19.2.2

Consultee	Document / date received	Comment	Response / where addressed in the ES
		point. Paragraph 109 Minimising impacts on biodiversity and providing net gains in biodiversity where possible, contributing to the Government's commitment to halt the overall decline in biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures. The North Norfolk District Council Policy EN 9 Biodiversity has a six-page Appendix B on the ecological network and the importance to the Chalk Rivers in the district.	
CPRE	PEIR November 2017	41. Ground investigations are ongoing at key trenchless (e.g. HDD) crossing locations listed: Crossing 1 – A47; Crossing 2 –Norfolk Railway east and west sides; Crossing 3 – River Wensum east and west; Crossing 4 - River Bure west and east/Crossing 5 – A140; Crossing 6 – A149/Crossing – Norfolk Railway; Happisburgh South Landfall. We note that in addition there are trenchless crossings to the north west of North Walsham (from the route corridor maps looks to be the North Walsham and Dilham Canal), and just north of Bacton Wood/Witton Heath, presumably to underground the road running north-south to Horning and the Broads, a major tourism area. Comment: We would be supportive of these two additions, but suggest that there are a number of other locations which would benefit from a trenchless approach, and these should be identified in the next stage of work.	Trenchless crossing techniques have been identified for a range of locations, and these are summarised in detail in Chapter 5 Project Description and Chapter 20 Water Resources and Flood Risk.
CPRE	PEIR November 2017	58. The onshore cable corridor crosses four main catchment river catchments. Some tributaries and wetland areas for each river are listed. For the River Bure the most notable tributary is King's Beck. The downstream reaches of the river have a range of wetland features, including Hoveton Great Broad and Marshes, Woodbastwick Fens and Marshes, Bure Marshes. The River Wensum and several of its tributaries would be crossed, most notably Wendling Beck and the Blackwater Drain. The River Wissey headwaters fall within the area for the Necton National Grid substation extension. The North Walsham and Dilham Canal is crossed at North Walsham (see 41 above; note also a leisure interest).	Trenchless crossing techniques have been identified for a range of locations, and these are summarised in detail in Chapter 5 Project Description and Chapter 20 Water Resources and Flood Risk

Consultee	Document / date received	Comment	Response / where addressed in the ES
		Comment: The tributaries and wetlands listed above and others should be considered for a trenchless crossing to minimise the risk of silt entering the river systems, and not adding to the loading caused by arable run-off, a major problem for all rivers entering the Broads (Bure, Wensum and Ant). Those running into the Wensum have the additional issue is that the whole upper reach of the river is designated SAC.	
CPRE	PEIR November 2017	59. The baseline hydrology is described in more detail in Chapter 20 Water Resources and Flood Risk, but we note Tables 19.10 and 19.13 which show the status of the Broadland Rivers Chalk and Crag groundwater body and that of the North Norfolk Chalk groundwater body. 114. It is anticipated that surface watercourses are in hydraulic connectivity with groundwater contained within superficial deposits throughout the study area. The River Wensum is a chalk river that is designated as a Special Areas of Conservation (SAC) and Sites of Special Scientific Interest (SSSI) and is therefore considered to have high sensitivity. Tributaries of the Wensum such as Wendling Beck and the Blackwater drain are also considered to have high sensitivity, on the basis of their direct connectivity with the main River Wensum, on their basis of their direct connectivity with the main River Wensum. Comment: A team at UEA shows that much of the silt getting into a river system does so in a heavy rain event; and that in a drainage ditch will move on in the next heavy rain event until it reaches the main river. As such ditches only periodically in hydraulic contact with the groundwater also pose a risk.	Reference to the connectivity between groundwater and surface drainage systems has been included in section 19.7.5.5.
CPRE	PEIR November 2017	116. The overall impact on indirect or contamination of surface watercourse based on the situation which includes the integration of measures adopted in section 19.7.1 is considered to be minor adverse which is not significant in EIA terms. Comment: We consider there is a divergence between the theory and what happens on the ground. As a marker consider the persistent and severe problems with agriculture and	The risk associated with adverse impact on rivers resulting in flooding of property is discussed in Chapter 20 Water Resources and Flood Risk section 20.7.4.

Consultee	Document / date received	Comment	Response / where addressed in the ES
		arable run-off, in spite of good practices ELS, etc. As well as the adverse impact on rivers, it can also result in flooding of property.	
Anglian Water	PEIR December 2017	We have had discussions with Vattenfall relating to ground investigations associated with the onshore cable route in the vicinity of an existing borehole in Anglian Water's ownership. The proposed onshore corridor includes a number of locations in groundwater source protection zone 1. Further consideration should be given to any potential implications for existing boreholes in Anglian Water's ownership from the construction of proposed onshore elements of the proposal.	Embedded mitigation measures related to works undertaken within Source Protection Zone 1 (SPZ1) areas are described in Table 19.14.
Anglian Water	PEIR December 2017	Reference is made to a number of groundwater source protection zones in the area of the above project. We would wish to ensure that the proposals and any related development do not have an adverse impact on existing boreholes which are used for the supply of potable water by Anglian Water.	Embedded mitigation measures related to works undertaken within SPZ areas are described in Table 19.14.

19.4 Assessment Methodology

19.4.1 Impact Assessment Methodology

19. Chapter 6 EIA Methodology details the general impact assessment method, and the following sections describe more specifically the methodology used to assess the potential impacts of the project on ground conditions and contamination, as consulted on and agreed via ETG meetings held in January 2016, July 2017, January 2018, the Scoping Report (Royal HaskoningDHV, 2016) and the Preliminary Environmental Information Report (PEIR) (Norfolk Vanguard Limited, 2017).

19.4.1.1 Sensitivity

20. The sensitivity of receptors is assessed according to the criteria set out in Table 19.3 and is based on the capacity of receptors to tolerate change and whether or not increased risks would be acceptable within the scope of the prevailing legislation and guidelines. The degree of change that is considered to be acceptable is dependent on the value of a receptor, which is discussed in section 19.4.1.2.

Table 19.3 Definitions of sensitivity levels for ground conditions and contamination

Sensitivity	Definition
High	Has very limited or no capacity to accommodate physical or chemical changes. Increased risk of exposure / pollution would be unacceptable.
Medium	Has limited capacity to accommodate physical or chemical changes or influences. Increased risk of exposure/ pollution may be acceptable.
Low	Has moderate capacity to accommodate physical or chemical changes. Increased risk of exposure / pollution likely to be acceptable.
Negligible	Is generally tolerant of physical or chemical changes. Insensitive to increased risk of exposure / pollution.

21. Receptor sensitivity examples based on the above criteria are given in Table 19.4. It should be noted that some receptors may be assessed differently due to site-specific conditions.

22. The sensitivity criteria and examples for controlled waters receptors are aligned with those used in the assessment of water resources impacts in Chapter 20 Water Resources and Flood Risk.

Table 19.4 Receptor sensitivity assessment examples

Sensitivity / value	Examples
High	Human Health • Construction Workers; • Site Operatives; and • General Public (Off-site).
	Controlled Waters • Groundwater SPZ1 (Source Protection Zone) / 2 areas (including unpublished); and • Surface water or groundwater supporting internationally designated or nationally important conservation site (e.g. SAC, Special Protection Area (SPA), Ramsar site / SSSI) or fishery).
Medium	Controlled Waters • Principal Aquifer / Secondary A (resource potential); • Groundwater SPZ areas Total Catchment; • Licenced groundwater / surface water abstractions; and • Surface water or groundwater supporting regionally important wildlife sites (LNR, SNCI) or commercial aquaculture.
	Mineral Resources • Mineral Safeguard Area (regionally important resource).
Low	Controlled Waters • Secondary Undifferentiated / Secondary B Aquifer (resource potential); • Unlicensed water supplies; and • Surface water or groundwater supporting locally important wildlife or amenity site.
Very Low	Controlled Waters • Unproductive Strata (resource potential).

19.4.1.2 Value

23. The sensitivity assessment for ground conditions and associated water and mineral resources takes into account how 'acceptable' changes to the availability or quality of a particular resource would be. This is dependent on the value of that resource, which is assessed based on its strategic or geographic importance (Table 19.5).

Table 19.5 Definitions of value levels for ground conditions and contamination

Value	Definition
High	Is an international or nationally important resource.
Medium	Is a regionally important resource.
Low	Is a locally important resource.
Negligible	Is of no significant resource value.

24. It should be noted that high value and high sensitivity are not necessarily linked within a particular impact. A receptor could be of high value (e.g. Groundwater SPZ1 areas) but have a low or negligible physical/ecological sensitivity to an effect – it is important not to inflate impact significance just because a feature is 'valued'. This is where the narrative behind the assessment is important; the value can be used where relevant as a modifier for the sensitivity assigned to the receptor.

19.4.1.3 Magnitude of Effect

25. Potential effects may be adverse, beneficial or neutral. The magnitude of an effect is assessed qualitatively, according to the criteria set out in Table 19.6.

26. The following definitions apply to time periods used in the magnitude assessment:

- Long term: Greater than 5 years;
- Medium term: 2 to 5 years; and
- Short term: Less than 2 years.

27. For human health, magnitude reflects the likely increase or decrease in exposure risk for a particular receptor. For controlled waters, magnitude represents the likely effect that an activity would have on resource usability or value, at the receptor. Magnitude is therefore affected by the distance and connectivity between an impact source and the receptor.

Table 19.6 Definitions of magnitude levels for ground conditions and contamination

Magnitude	Definition
High	Permanent or large scale change affecting usability, risk, value over a wide area, or certain to affect regulatory compliance.
Medium	Moderate permanent or long-term reversible change affecting usability, value, risk, over the medium-term or local area; possibly affecting regulatory compliance.

Magnitude	Definition
Low	Temporary change affecting usability, risk or value over the short-term or within the site boundary; measurable permanent change with minimal effect usability, risk or value; no effect on regulatory compliance.
Negligible	Minor permanent or temporary change, undiscernible over the medium- to long-term short-term, with no effect on usability, risk or value.

19.4.1.4 Impact significance

28. Following the identification of receptor value and sensitivity and magnitude of the effect, it is possible to determine the significance of the impact. A matrix as presented in Table 19.7 will be used wherever relevant.

29. Where possible, impact significance is based upon quantitative and accepted criteria, together with the use of value judgement and expert interpretation to establish to what extent an impact is significant.

Table 19.7 Impact significance matrix

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

30. As with the definitions of magnitude and sensitivity, the matrix used for a topic is clearly defined by the assessor within the context of that assessment. The impact significance categories are divided as shown in Table 19.8.

Table 19.8 Impact significance definitions

Impact Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or, could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.

Impact Significance	Definition
Negligible	No discernible change in receptor condition.
No impact	No change, therefore no impact on receptor condition.

31. Note that for the purposes of this ES, major and moderate impacts are deemed to be 'significant'. In addition, whilst minor impacts are not significant in their own right, it is important to distinguish these from other non-significant impacts as they may contribute to significant impacts cumulatively or through interactions.

32. Embedded mitigation is included in the initial assessment of impact. If the impact does not require mitigation (or none is possible) the residual impact would remain the same. If, however, mitigation is required there should be an assessment of the post-mitigation residual impact.

19.4.2 Cumulative Impact Assessment

33. Chapter 6 EIA Methodology provides a general methodology with regards to the Cumulative Impact Assessment (CIA).

34. The potential for cumulative effects has been considered for the construction, operation and decommissioning of the onshore project area cumulatively with the offshore project area as well as with other onshore projects.

35. Cumulative impacts are discussed where the onshore project area has the potential to overlap with similar impacts arising from:

- Recent development, either built or under construction (which is not considered as part of the baseline);
- Approved development, awaiting implementation; and
- Proposals awaiting determination within the planning process with design information in the public domain.

36. The CIA involves consideration of whether impacts on a receptor can occur on a cumulative basis between the project and other activities, projects and plans for which sufficient information regarding location and scale exist.

37. For further details of the methods used for the CIA for ground conditions, see section 19.8.

19.4.3 Transboundary Impact Assessment

38. There are no transboundary impacts with regards to ground conditions and contaminated land as the onshore project area is entirely within the UK and would

not be sited in proximity to any international boundaries. Transboundary impacts are therefore scoped out of this assessment and will not be considered further.

19.5 Scope

19.5.1 Study Area

39. The onshore project area considered includes the following elements:

- Landfall;
- Onshore cable route, accesses, trenchless crossing (e.g. HDD) zones and mobilisation areas;
- Onshore project substation; and
- Extension to the Necton National Grid substation and overhead line modifications.

40. A full description of the above onshore infrastructure is provided in Chapter 5 Project Description.

41. The study area was consulted and agreed on at ETG meetings in July 2017 and January 2018, and during PEIR consultation (December 2017), and has been chosen to allow for the variance in final location and alignments and to identify any existing assets or infrastructure including landfills or contaminated land that might affect or be affected by the project.

42. The study area is defined by the distance over which impacts on ground conditions and contamination from the project may be and by the location of any receptors that might be affected by those potential impacts. This has been established by professional judgement supported by a Preliminary Risk Assessment (PRA) (Appendix 19.1).

43. For the landfall, National Grid Substation and onshore project substation, a 1km buffer was selected and a 250m buffer either side of the onshore cable route was also selected. The wider buffer size for landfall and onshore project substation was primarily to allow for variance in final location of this infrastructure. The onshore assessment commences at Mean High Water Spring (MHWS) and does not consider the intertidal zone. The intertidal zone is discussed in Chapter 8 Marine Geology, Oceanography and Physical Processes.

44. The study area is shown in Figure 19.1. It should be noted that the onshore project area has been further refined since the PRA was undertaken. However, the data collected and presented as part of the PRA is still considered to be valid because it covers a wider area than that has since been refined (i.e. reduced in scale within the PRA study area).

19.5.2 Data Sources

45. This assessment has been informed by the findings from a desk-based exercise using information colleced from July 2016 onwards. These data sets have been collected for different study areas depending upon the project information available at the time of collection. The data sources used to inform the ground conditions and contamination baseline are summarised in Table 19.9.

46. Therefore, the summary of baseline conditions only provides a broad guide to the conditions that are expected. Ground investigations were undertaken in 2017 by GHD and TerraConsult with local Norfolk subcontractor SI Drilling and in 2018 by GHD at key crossing locations (Figure 19.2) listed below as agreed with the Environment Agency and Anglian Water:

- **Crossing 1 – A47** The fieldwork was carried out between 28th July 2017 and 3rd August 2017 (TerraConsult, 2017a);
- **Crossing 2 – Mid-Norfolk Railway** The fieldwork was carried out between 18th July 2017 and 26th July 2017 (TerraConsult, 2017b);
- **Crossing 3 – River Wensum** The fieldwork was undertaken between 4th August 2017 and 14th August 2017 (TerraConsult, 2017c);
- **Crossing 4 – River Bure** The fieldwork was carried out between 4th August 2017 and 11th August 2017 (TerraConsult, 2017d);
- **Crossing 5 – A140** The fieldwork was carried out between 31st July 2017 and 3rd August 2017 (TerraConsult, 2017d);
- **Crossing 6 – A149**. The fieldwork was carried out between 13th July 2017 and 17th July 2017 (TerraConsult, 2017e);
- **Crossing 7– Norfolk Railway**. The fieldwork was carried out between 20th July 2017 and 28th July 2017 (TerraConsult, 2017e);
- **Happisburgh South landfall**. The fieldwork was undertaken between 3rd July 2017 and 19th July 2017 (TerraConsult, 2017f);
- **Wooded Copse**. The fieldwork was undertaken between 6th of November 2017 and 30th of January 2018 (GHD, 2018);
- **North Walsham and Dilham Canal**. The fieldwork was undertaken between 6th of November 2017 and 30th of January 2018 (GHD, 2018);
- **King's Beck**. The fieldwork was undertaken between 6th of November 2017 and 30th of January 2018 (GHD, 2018); and
- **Wendling Beck**. The fieldwork was undertaken between 6th of November 2017 and 30th of January 2018 (GHD, 2018).

Table 19.9 Data sources

Data	Year	Notes
Geology	2017	British Geological Survey (BGS) online viewer: www.mapapps.bgs.ac.uk
	2017	Terra Consult (2017) Ground investigation reports
	2018	GHD (2018) Norfolk Vanguard and Norfolk Boreas Offshore Wind Farm Site Investigations Phase II
Hydrogeology: groundwater vulnerability, groundwater Source Protection Zones (SPZ areas), abstractions	2017	Environmental Agency "What's in your back yard?" website: http://apps.environment-agency.gov.uk/wiyby/default.aspx
Landfills and mining		
Water Framework Directive (WFD) Classification	2017	Environmental Agency (2016) Catchment Data Explorer: www.environment.data.gov.uk /catchment-planning/
Private water supply	2017	Information obtained from District Councils

19.5.3 Assumptions and Limitations

47. This assessment is based on a range of publicly available information and data from bodies such as the Environment Agency and Local Authorities. The direct assessments and judgements given in this report are limited by the finite data on which they are based. However, there is a level of uncertainty associated with extrapolation of site specific data or non-site data to other locations within the study area, particularly where the study area is large as in the case of the project.

48. The acquisition of data is also constrained by both physical and economic factors and by definition is subject to the limitations imposed by the methods of investigations employed. In this instance the data has been obtained from borehole logs from mechanically drilled boreholes, which by their nature only provide spatially limited information.

49. Conditions at the site will change over time due to natural variations and may be affected by human activities. In particular, groundwater, surface water and soil gas conditions should be anticipated to change with diurnal, seasonal and meteorological variations.

19.6 Existing Environment

50. This section describes the existing environment in relation to ground conditions and contamination. It is based on a desk-top study of sources identified in Table 19.9 as a basis for the impact assessment.

19.6.1 Landfall

19.6.1.1 Geology

51. The cliffs at Happisburgh range in height from 6 – 10 metres (m) and are composed of a layer-cake sequence of several glacial tills, separated by beds of stratified silt, clay and sand. The basal unit within the stratigraphic succession at Happisburgh is the How Hill Member of the Wroxham Crag Formation. They consist of stratified brown sands and clays with sporadic quartzose-rich gravel seams.

52. The marine deposits are overlaid by a series of glacial lithologies deposited during several advances of glacier ice into the region during the Middle Pleistocene.

53. The Happisburgh Till crops-out at the base of the cliffs and its base is frequently obscured by modern beach material. The Happisburgh Till Member is a dark grey, highly consolidated till with a matrix composed of a largely massive clayey sand with occasional pebbles of local and far-travelled material.

54. Ground investigations were carried out in the landfall area between 3rd and 19th July 2017 and comprised nine boreholes. Sandy clay (Till Member) was found in most of the boreholes underneath to depths between 2.7 and 10m below ground level (bgl). The sandy clay was underlain by sand up to depths of 18m bgl.

19.6.1.2 Coastal processes

55. The landfall is located within the East of Cromer to Happisburgh area of the Kelling to Lowestoft Ness Shoreline Management Plan (SMP). This is the most active length of coast within the SMP area and is the main provider of sediment for beaches throughout much of the SMP frontage.

56. There are numerous erosion prevention / flood defence assets in the areas of Bacton gas terminal, and the smaller settlements of Bacton, Walcott and Happisburgh. The SMP seeks to maintain present defences for a period with a long-term plan to gradually retreat and relocate, thus enabling a naturally functioning sustainable system to re-establish. The SMP will allow unabated erosion throughout much of this area in the longer term. To manage relocation, occasional measures to temporarily delay (but not halt) this erosion from time to time may be acceptable in some locations where there are larger concentrations of assets.

57. From Walcott to Happisburgh (encompassing the landfall area at Happisburgh South) sediment transport rates have been estimated at just over 500,000m^3/year between 1979 and 1994 (AECOM, 2012). The rate of transport at Happisburgh is thought to be the highest along the coastline and more sediment is leaving from the south than is entering from the north-west, due in part to the updrift coastal defences and the change in orientation of the coastline. The cliffs between Walcott and Happisburgh consist of fine sediment, containing a mixture of silt/clay and fine sand, and

therefore contribute only small volumes of sediment to the beach system. The foreshore along this stretch of coast primarily relies on supply of sediment from the north-west.

58. The cliffs at Happisburgh South are eroding (see Appendix 4.1 Coastal Erosion Study in Chapter 4 Site Selection and Assessment of Alternatives). The shoreline has shown a history of net retreat and pre-defence maps (1900 – 1937) show the average erosion rate was between 0.4 and 2.1m/year. An analysis of post-defence erosion rates (1937 – 1999) concluded that erosion rates varied between 0.4 (north of the landfall site) and 0.8m/year. Since 1999, the shoreline has eroded at a higher rate of up to 10m/year along the landfall site in response to the failure of existing defences. Cliff-top analysis in 2017 showed a negligible change in cliff top retreat. However, this may not mean that retreat rates have slowed, but more that retreat is variable.

59. Detailed information on coastal process in the landfall area can be found in Chapter 8 Marine Geology, Oceanography and Physical Processes.

19.6.1.3 Designated geological sites

60. There is only one designated geological site within the study area. Happisburgh Cliffs SSSI is designated specifically for its geological interest (Figure 19.3). The cliffs are an important site for dating the Pleistocene succession in East Anglia, and display a range of marine, freshwater and glacial sediments which span five stages from the pre-Pastonian to the Anglian (Natural England, 1985). The SSSI is particularly important for several main features:

- Cliff exposures which uniquely show three glacial deposits;
- The Anglian-aged Cromer Tills, with intercalated water-deposited sediments; and
- The underlying Cromer Forest-bed Formation, which is exposed at the foreshore; and supports excellent development of pre-Pastonian and Pastonian deposits.

61. The SSSI is located approximately 300m from the landfall.

19.6.1.4 Land Quality

62. Based on the desk based information and the findings of the site walkover, potential sources of contamination at the landfall have been identified. These are electrical substation facilities (shown on the historic map from 1970), and oil and petroleum tanks in Happisburgh village (shown on the historic map from 1892). These may be associated with a very wide range of contaminants including hydrocarbons and other organic compounds like polychlorinated biphenyls (PCBs). It is understood that these tanks are connected with the lighthouse.

19.6.2 Onshore cable route and onshore project substation

19.6.2.1 Geology

63. The British Geological Survey (BGS) online viewer[1] shows that the solid geology beneath the study area (as shown in Figure 19.1 and Figure 19.2, and explained in more detail in Appendix 19.1) compromises White Chalk and Crag Group deposits which dip gently to the south east.

64. The Chalk is a white or grey limestone and is over 460m thick in Norfolk. It principally outcrops as a low, rolling plateau in west Norfolk, along the north Norfolk coast and near Norwich where the Rivers Yare and Wensum have cut down through overlying beds to expose it.

65. The Crag Group deposits are a sequence of sandy, marine deposits which outcrop in the eastern parts of the study area.

66. The solid deposits are overlain predominantly by glacial till dating from the Anglian glaciation, interspersed with sheets of glacial sands and gravels. Small isolated pockets or channels of superficial deposits exist over the Glacial Till Alluvium where watercourses are crossed.

67. Targeted ground investigations were undertaken along the onshore cable route in 2017 and 2018. The following ground conditions were encountered:

- Crossing 1: A47– the shallow geology is comprised of silty to gravely clay (Lowestoft Formation) with chalk and flint to a depth of 15.45 m bgl.
- Crossing 2: Mid-Norfolk Railway - the shallow geology is comprised of silty to gravely clay (Till Formation) with chalk and flint interspersed with fine to medium sands to a depth of 20 m bgl.
- Crossing 3: River Wensum - the shallow geology is comprised of fine to coarse gravels (Alluvium) interspersed with fine to coarse sands to a depth of 17 m bgl. Small pockets of peat (of thickness up to 1.55 m) were encountered in this area.
- Crossing 4: River Bure - the shallow geology is comprised of sandy – gravelly clay (Alluvium) interspersed with clayey sands to a depth of between 4.2 to 7 m bgl. The shallow geology was underlain by Chalk.
- Crossing 5: A140 - the shallow geology is comprised of fine to medium sand and clays (Brickearth) to a depth of approximately 4 m bgl, underlain by fine to coarse flint gravels and sand (Wroxham Crag Formation) to a depth of approximately 12 m bgl. The shallow geology was underlain by Chalk.
- Crossing 6: A149 - the shallow geology is comprised of fine to medium sands interspersed with sandy clay (Glaciofluvial deposits) to a depth of approximately 16 m bgl.

[1] www.bgs.ac.uk

- Crossing 7: Norfolk Railway - the shallow geology is comprised of fine to medium sands interspersed with sandy clay (Glaciofluvial deposits) to a depth of approximately 14 m bgl, underlain by fine and medium sands interspersed with clay (Wroxham Crag formation) to depths 20 m bgl.
- Wooded Copse – the shallow geology is comprised of medium dense sands interspersed with clay, encountered to a depth 10 m bgl.
- North Walsham and Dilham Canal – the shallow geology is comprised of silty clay and clayey silt to a depth of 9.2 m bgl, underlain by medium sands to a depth 10 m bgl.
- Kings Beck – the shallow geology is comprised of loose sands and gravel to depth 10 m bgl.
- Wendling Beck – the shallow geology is comprised of gravels to a depth of 1.6 m bgl, underlain by soft to firm clay to 3.5 m bgl. The shallow deposits were underlain by Chalk deposits.

19.6.2.2 Hydrology and surface drainage

68. The project is located within three main surface water catchments (Figure 20.2 in Chapter 20 Water Resources and Flood Risk):

- The River Bure and several of its tributaries (most notably King's Beck and the North Walsham and Dilham Canal) would be crossed by the onshore cable route. The river rises near Briston, from where it flows in an easterly direction until it reaches Aylsham. From here, it continues to flow to the south east until it enters the sea at Great Yarmouth. The downstream reaches of the river include a wide range of wetland features, including Hoveton Great Broad and Marshes, Woodbastwick Fens and Marshes, Bure Marshes and the Norfolk Broads.
- The River Wensum and several of its tributaries (most notably Wendling Beck and the Blackwater Drain) would be crossed by the onshore cable route. The river rises near Whissonsett, from where it flows north towards Fakenham before continuing in a broadly south easterly direction towards Norwich.
- The River Wissey, the headwaters of which fall within the area for the National Grid substation extension. The Wissey rises to the south of Dereham, from where it drains in a westerly direction towards Necton before eventually joining the River Great Ouse at Denver Sluice, near Downham Market.

69. The baseline hydrology is described in more detail in Chapter 20 Water Resources and Flood Risk.

19.6.2.3 Hydrogeology

70. The Crag and the Chalk aquifers are classified as Principal Aquifers by the Environment Agency. The superficial deposits are classified as Secondary A, B and undifferentiated aquifers (as shown on Figure 19.4).

71. The Water Framework Directive (2000/60/EC) (WFD) defines groundwater bodies as distinct volumes of groundwater within an aquifer or aquifers. It requires that groundwater bodies are designated as drinking water protected areas (DrWPAs) based on their use for human consumption.

72. All groundwater bodies in England are designated DrWPAs. The WFD aims to protect DrWPAs from over-abstraction and to prevent deterioration in quality that could increase the treatment of drinking water.

73. The Environment Agency groundwater vulnerability maps indicate the study area is located within an area of high groundwater vulnerability (overlying a permeable aquifer). This indicates soils which may be able to transmit a wide range of pollutants into any groundwater stored in the underlying strata.

74. The landfall and onshore cable corridor are mostly located on the Broadland Rivers Chalk and Crag groundwater body (GB40501G400300), as defined in the Anglian River Basin Management Plan (Environment Agency, 2015). The WFD status of the groundwater body has been classified by the Environment Agency as being of Poor Quantitative Status and Poor Chemical Status. The Poor Quantitative and Chemical Status is attributed to impacts from agriculture.

75. The onshore project substation is located within the Cam and Ely Ouse Chalk (GB40501G400500) and North West Norfolk Chalk (GB40501G400200) groundwater bodies the landfall is in the North Norfolk Chalk (GB40501G400100) groundwater body.

76. The detailed status of the water bodies is shown in Table 19.10 to Table 19.13. This information can be found on the Environment Agency's Catchment Data Explorer 2017 (the latest update was 10/05/17).

Table 19.10 Broadland Rivers Chalk and Crag groundwater body (GB40501G400300) status

Water body details	
Water body ID	GB40501G400300
Overall water body status	**Poor**
Quantitative	**Poor**
Quantitative Status element	Good
Quantitative GWDTEs test	*Poor*
Quantitative Saline Intrusion	*Good*
Quantitative Water Balance	*Good*
Chemical	**Poor**
Chemical Status element	Poor
Chemical Dependent Surface Water Body Status	*Good*

Water body details	
Chemical Drinking Water Protected Area	*Poor*
Chemical GWDTEs test	*Good*
Chemical Saline Intrusion	*Good*
General Chemical Test	*Good*
Supporting elements (Groundwater)	-
Prevent and Limit Objective	-
Trend Assessment	*Upward trend*

Table 19.11 Cam and Ely Ouse Chalk groundwater body (GB40501G400500) status

Water body details	
Water body ID	GB40501G400500
Overall water body status	**Poor**
Quantitative	**Poor**
Quantitative Status element	Poor
Quantitative GWDTEs test	*Poor*
Quantitative Saline Intrusion	*Good*
Quantitative Water Balance	*Poor*
Chemical	**Poor**
Chemical Status element	Poor
Chemical Dependent Surface Water Body Status	*Good*
Chemical Drinking Water Protected Area	*Poor*
Chemical GWDTEs test	*Good*
Chemical Saline Intrusion	*Good*
General Chemical Test	*Poor*
Supporting elements (Groundwater)	-
Prevent and Limit Objective	-
Trend Assessment	*Upward trend*

Table 19.12 North West Norfolk Chalk groundwater body (GB40501G400200) status

Water body details	
Water body ID	GB40501G400200
Overall water body status	**Poor**
Quantitative	**Poor**
Quantitative Status element	Poor

Water body details	
Quantitative GWDTEs test	*Good*
Quantitative Saline Intrusion	*Good*
Quantitative Water Balance	*Poor*
Chemical	**Poor**
Chemical Status element	Poor
Chemical Dependent Surface Water Body Status	*Good*
Chemical Drinking Water Protected Area	*Good*
Chemical GWDTEs test	*Good*
Chemical Saline Intrusion	*Good*
General Chemical Test	*Poor*
Supporting elements (Groundwater)	-
Prevent and Limit Objective	-
Trend Assessment	*No trend*

Table 19.13 North Norfolk Chalk groundwater body (GB40501G400100) status

Water body details	
Water body ID	GB40501G400100
Overall water body status	**Poor**
Quantitative	**Good**
Quantitative Status element	Good
Quantitative GWDTEs test	*Good*
Quantitative Saline Intrusion	*Good*
Quantitative Water Balance	*Good*
Chemical	**Poor**
Chemical Status element	Poor
Chemical Dependent Surface Water Body Status	*Good*
Chemical Drinking Water Protected Area	*Good*
Chemical GWDTEs test	*Good*
Chemical Saline Intrusion	*Good*
General Chemical Test	*Poor*
Supporting elements (Groundwater)	-
Prevent and Limit Objective	-
Trend Assessment	*Upward trend*

19.6.2.4 Groundwater abstractions

77. There are a number of licensed groundwater abstractions within the study area which are mostly associated with agricultural purposes. Broadland District Council, North Norfolk District Council and Breckland Council were contacted in May 2017 to obtain information regarding private water supplies located within the study area. There are 101 private water supplies within the study area in the areas administered by North Norfolk District Council, Breckland Council and South Holland Council. Broadland District Council does not hold records regarding private water supply and no information is available for this area.

78. There are a number of groundwater SPZ areas within the onshore project area (Figure 19.5). Currently, trenchless crossing techniques (e.g. HDD) are proposed in the following areas:

- SPZ3 in the area of Scarning;
- SPZ2 and SPZ3 north of Dereham;
- SPZ1 and SPZ2 in the area of North Walsham;
- SPZ3 under the River Wensum;
- SPZ2 and SPZ3 north of Aylsham;
- SPZ3 under the Cromer Road (A149); and
- SPZ3 south of Edingthorpe.

79. The study area does not cross any groundwater Safeguard Zones (SgZs). SgZs are non-statutory WFD designations by the Environment Agency for potable abstractions where the water quality is poor and where additional measures are needed to bring about improvement. SgZs are typically based on existing SPZ1 and SPZ2 areas. Designation means that there will be strict enforcement of existing measures for particular pollutants and activities, and possibly new voluntary measures.

19.6.2.5 Land Quality

80. The majority of the onshore cable route is located in agricultural land, where significant contamination is not expected as the agricultural activities are usually not associated with major contamination. There is a small risk of encountering buried asbestos or agrochemical waste. One historical common clay and shale pit is present which has been infilled, and may contain unknown and potentially contaminated fill material (see Figure 19.1 and Figure 19.2 Appendix 19.1).

81. The dismantled railway lines south east of Themelthorpe and south east of Oulton are largely Made Ground (man-made deposits such as embankments and spoil heaps on the natural ground surface) and have the potential to contain elevated concentrations of contaminants such as petroleum and diesel hydrocarbons, heavy metals and polyaromatic hydrocarbons (PAHs) see Figure 19.1 and Figure 19.2 and Appendix 19.1.

82. Historic clay bricks & tiles manufactures north and north east of North Walsham, which could be associated with heavy metals (e.g. hexavalent chromium) and inorganic compounds (arsenic compounds).

83. There is a graveyard north of North Walsham, which may be a source of contaminants such as metals, nutrients and pathogen (see Figure 19.1 and Figure 19.2 Appendix 19.1).

84. There are several registered waste treatment sites and licensed waste facilities south of the onshore cable route in the area of North Walsham. These may be associated with a very wide range of contaminants, including Volatile Organic Compound (VOCs), Semivolatile Organic Compound (SVOCs), heavy metals, cyanides, ammonium, chlorides, sulphates and PAHs.

85. There is one Hazardous Substance Consent located approximately 200m north of the cable route in the area of Witton. The consent is for the processes associated with usage of ammonium nitrate and ammonium nitrate compounds.

86. Historical landfill adjacent to the onshore cable route south west of Witton may be associated with a very wide range of contaminants, including VOCs, SVOCs, heavy metals, cyanides, ammonium, chlorides, sulphates and PAHs.

87. One minor pollution incident involving animal by-products occurred in the area of the River Bure in 1997.

88. There are two former mineral workings present (one clay and shale, and the other sand and gravel) adjacent to the onshore project substation which have been infilled and may contain potentially contaminated fill material. These do not overlap with the footprint of the onshore project substation (see Figure 19.1 and Figure 19.2 Appendix 19.1).

89. However, the clay and shale pit lies within the 400kV route that connects the onshore project substation to the Necton National Grid substation. This is shown in Appendix 19.1 Preliminary Risk Assessment Figure 19.2.

19.6.2.6 Minerals Safeguarding Area

90. The study area contains significant (177 ha) sand and gravel resources, associated with the glaciofluvial deposits (as shown in Figure 19.6). The onshore cable route crosses a number of Mineral Safeguard Areas. These are mostly associated with glacial sand and gravel deposits. A Minerals Safeguarding Area is an area designated by a Mineral Planning Authority which covers known deposits of minerals which are desired to be kept safeguarded from unnecessary sterilisation by non-mineral development.

19.6.3 Anticipated Trends in Existing Environment

91. This section discusses the likely future evolution of the existing baseline environment according to known trends in the base condition without implementation of the project.

19.6.3.1 Geology and coastal processes

92. No major changes to the geology of the study area are anticipated. However, as discussed in section 19.6.1.2, the cliffs at Happisburgh South are eroding and the rate of erosion could potentially change in the future in response to changes in sea level and wave energy. This is discussed in more detailed in Chapter 4 Site Selection and Assessment of Alternatives, Appendix 4.1 Coastal Erosion Study.

19.6.3.2 Land Quality

93. The review of the historical information (see sections 19.6.1.4 and 19.6.2.5) suggests that the potential for significant contamination to be present within the study area is low. Land affected by contamination is managed and driven by UK and local legislation and policies. The current risk based approach to the investigation of contaminated land was introduced by Part 2A of the Environmental Protection Act, 1990 (EPA, 1990). Under the legislation, local authorities were given the duty of identifying contaminated land and addressing the risks which arise from it in accordance with statutory provisions. The regime does not consider future uses; however, these would require a specific grant of planning permission. In addition to planning controls there is a clear trend for emissions from commercial and industrial sources to be driven down in compliance with stricter emissions legislations. This means that it is unlikely that any areas of controlled contamination will be introduced. Consequently, in relation to the project and its immediate receiving environment it is reasonable to predict that no new sources of contaminated land would be introduced.

19.6.3.3 Hydrology

94. Information regarding anticipated trends associated with surface water is provided in Chapter 20 Water Resources and Flood Risk section 20.6.5.

19.6.3.4 Hydrogeology and Groundwater Abstractions

95. The WFD aims to protect and enhance water bodies in Europe by controlling inputs of chemical pollutants and reverse existing chemical contamination to achieve good status. The current status of the groundwater bodies is provided in section 19.6.2.3. It is evident from monitoring that the pressures of land use and permeability of soils in the study area have resulted in substantial leaching of nitrate to the groundwater. The majority of this comes from land use in the form of agriculture. All water bodies within the study area are characterised by upward or no trend. This, coupled with increased regulation of agricultural chemicals, suggests that baseline groundwater

quality could improve in the future. However, any improvements are likely to become apparent only gradually, over long timescales.

96. The Water Abstraction Plan (2017) sets out how the government will reform water abstraction management over the coming years and how this will protect the environment and improve access to water. As part of the plan, the Environment Agency will review and amend existing abstraction licenses. As a result of the programme, it is anticipated that abstraction will decrease and approximately 90% of surface water bodies and 77% of groundwater bodies will meet the required standards by 2021 (Water Abstraction Plan, 2017).

19.7 Potential Impacts

97. This section details the impact assessment and proposed mitigation for the construction, operation and decommissioning phases of the project, based upon the worst case scenario with regards to receptor sensitivity and value (with embedded mitigation), and the magnitude of the potential impact (as detailed in section 19.4).

19.7.1 Embedded Mitigation

98. Norfolk Vanguard Ltd has committed to a number of techniques and engineering designs/modifications inherent as part of the project, during the pre-application phase, in order to avoid a number of impacts or reduce impacts as far as possible. Embedding mitigation into the project design is a type of primary mitigation and is an inherent aspect of the EIA process.

99. A range of different information sources has been considered as part of embedding mitigation into the design of the project (for further details see Chapter 5 Project Description, Chapter 4 Site Selection and Assessment of Alternatives and the Consultation Report (document reference 5.1)) including engineering requirement, feedback from community and landowners, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

100. The following sections outline the key embedded mitigation measures relevant for this assessment. These are presented in Table 19.14. Where other mitigation is required to reduce or eliminate a significant effect, this is referred to as mitigation and is presented in sections 19.7.5 to 19.7.7.

Table 19.14 Embedded mitigation

Parameter	Mitigation measures embedded into the project design	Notes
Strategic approach to delivering Norfolk Vanguard and Norfolk Boreas	Subject to both Norfolk Vanguard and Norfolk Boreas receiving development consent and progressing to construction, onshore ducts will be installed for both projects at the same time, as part of the Norfolk Vanguard construction works. This would allow the main civil works for the cable route to be completed in one construction period and in advance of cable delivery, preventing the requirement to reopen the land in order to minimise disruption. Onshore cables would then be pulled through the pre-installed ducts in a phased approach at later stages. In accordance with the Horlock Rules, the co-location of Norfolk Vanguard and Norfolk Boreas onshore project substations will keep these developments contained within a localised area and, in so doing, will contain the extent of potential impacts.	The strategic approach to delivering Norfolk Vanguard and Norfolk Boreas has been a consideration from the outset.
Commitment to HVDC technology	Commitment to HVDC technology minimises environmental impacts through the following design considerations; • HVDC requires fewer cables than the HVAC solution. During the duct installation phase this reduces the cable route working width (for Norfolk Vanguard and Norfolk Boreas combined) to 45m from the previously identified worst case of 100m. As a result, the overall footprint of the onshore cable route required for the duct installation phase is reduced from approx. 600ha to 270ha; • The width of permanent cable easement is also reduced from 54m to 20m; • Removes the requirement for a CRS; • Reduces the maximum duration of the cable pull phase from three years down to two years; • Reduces the total number of jointing bays for Norfolk Vanguard from 450 to 150; and • Reduces the number of drills needed at trenchless crossings (including landfall).	Norfolk Vanguard Limited has reviewed consultation received and in light of the feedback, has made a number of decisions in relation to the project design. One of these decisions is to deploy HVDC technology as the export system.
Site Selection	The project has undergone an extensive site selection process which has involved incorporating environmental considerations in collaboration with the engineering design requirements. Considerations include (but are not limited to) adhering to the Horlock Rules for onshore project substations and National Grid infrastructure, a preference for the shortest route length (where practical) and developing construction methodologies to minimise potential impacts. Key design principles from the outset were followed	Constraints mapping and sensitive site selection to avoid a number of impacts, or to reduce impacts as far as possible, is a type of primary mitigation and is an inherent aspect of the EIA process. Norfolk Vanguard Limited has reviewed consultation received to inform the site selection

Parameter	Mitigation measures embedded into the project design	Notes
	(wherever practical) and further refined during the EIA process, including; • Avoiding proximity to residential dwellings; • Avoiding proximity to historic buildings; • Avoiding designated sites; • Minimising impacts to local residents in relation to access to services and road usage, including footpath closures; • Utilising open agricultural land, therefore reducing road carriageway works; • Minimising requirement for complex crossing arrangements, e.g. road, river and rail crossings; • Avoiding areas of important habitat, trees, ponds and agricultural ditches; • Installing cables in flat terrain maintaining a straight route where possible for ease of pulling cables through ducts; • Avoiding other services (e.g. gas pipelines) but aiming to cross at close to right angles where crossings are required; • Minimising the number of hedgerow crossings, utilising existing gaps in field boundaries; • Avoiding rendering parcels of agricultural land inaccessible; and • Utilising and upgrading existing accesses where possible to avoid impacting undisturbed ground.	process (including local communities, landowners and regulators) and in response to feedback, has made a number of decisions in relation to the siting of project infrastructure. The site selection process is set out in Chapter 4 Site Selection and Assessment of Alternatives.
Duct Installation Strategy	The onshore cable duct installation strategy is proposed to be conducted in a sectionalised approach in order to minimise impacts. Construction teams would work on a short length (approximately 150m section) and once the cable ducts have been installed, the section would be back filled and the top soil replaced before moving onto the next section. This would minimise the amount of land being worked on at any one time and would also minimise the duration of works on any given section of the route.	This has been a project commitment from the outset in response to lessons learnt on other similar NSIPs. Chapter 5 Project Description provides a detailed description of the process.
Long HDD at landfall	Use of long HDD at landfall to avoid restrictions or closures to Happisburgh beach and retain open access to the beach during construction. Norfolk Vanguard Limited have also agreed to not use the beach car park at Happisburgh South.	Norfolk Vanguard Limited has reviewed consultation received and in response to feedback, has made a number of decisions in relation to the project design. One of those decisions is to use long HDD at landfall.
Trenchless Crossings	Commitment to trenchless crossing techniques to	A commitment to a number of trenchless

Parameter	Mitigation measures embedded into the project design	Notes
	minimise impacts to the following specific features; • Wendling Carr County Wildlife Site; • Little Wood County Wildlife Site; • Land South of Dillington Carr County Wildlife Site; • Kerdiston proposed County Wildlife Site; • Marriott's Way County Wildlife Site / Public Right of Way (PRoW); • Paston Way and Knapton Cutting County Wildlife Site; • Norfolk Coast Path; • Witton Hall Plantation along Old Hall Road; • King's Beck; • River Wensum; • River Bure; • Wendling Beck; • Wendling Carr; • North Walsham and Dilham Canal; • Network Rail line at North Walsham that runs from Norwich to Cromer; • Mid-Norfolk Railway line at Dereham that runs from Wymondham to North Elmham; and • Trunk Roads including A47, A140, A149.	crossings at certain sensitive locations was identified at the outset. However, Norfolk Vanguard Limited has committed to certain additional trenchless crossings as a direct response to stakeholder requests.

19.7.2 Worst Case

101. Chapter 5 Project Description details the parameters of the project using the Rochdale Envelope approach for the ES. This section identifies those parameters during construction, operation and decommissioning relevant to potential impacts on ground conditions and contamination.

102. For this assessment, this involves a consideration of the construction scenarios (i.e. the manner in which the project will be constructed), as well as the particular design parameters (such as the maximum construction footprint at the landfall) that define the Rochdale Envelope. If a design parameter is not described below, it is not considered to have a material bearing on the outcome of this assessment.

103. The realistic worst case scenarios identified in this section are also applied to the CIA. When the worst case scenarios for the project in isolation do not result in the worst case for cumulative impacts, this is addressed section 19.8.

104. Table 19.15 summarises the worst case assumptions for ground conditions and contamination.

Table 19.15 Worst case assumptions

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
Landfall			
Construction	Method	Trenchless technique (e.g. HDD)	Any potential impacts on the SSSI are discussed in section 19.7.5.1 and in Chapter 8 Marine Geology, Oceanography and Physical Processes.
	Maximum drill length	1,000m	
	Temporary works footprint	6,000m^2	
	Maximum temporary works duration	20 weeks	
HDD compounds	Maximum number and maximum land take for temporary HDD compounds	Assumes 2 at 3,000m^2 to support parallel drilling rigs	
Onshore cable route			
Construction	Method	Open cut trenching and trenchless crossing methods.	All crossing options will disturb ground materials and may disturb secondary aquifer materials, whereby surface water could hydraulically connect with groundwater in secondary aquifer. Cable installation footprints include the running track and joint bay (Norfolk Vanguard only).
	Maximum working width and length	45m and 60km	Norfolk Vanguard & Norfolk Boreas
	Duct parameters	Two 260mm diameter (typical) ducts and one small duct for fibre cables installed per trench.	
	Impermeable subsurface barrier	Minimum 1.05m to top of ducts	
	Cable installation maximum footprint	447,688m^2	Norfolk Vanguard only.
	Onshore cable corridor maximum footprint	2,700,000m^2	Norfolk Vanguard HVDC over two phases
Permanent joint pits	Maximum number and	Assume 150 at 90m^2 and	Norfolk Vanguard only,

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
	required dimensions	2m deep each	spaced approximately one per circuit per 800m cable.
Mobilisation areas	Maximum number and required dimensions	Assumes 14 at 10,000m^2	None
Trenchless launch and reception sites	Maximum number and maximum land take for trenchless launch and reception sites	Assumes 17 pairs at 7,500m^2 and 5,000m^2 respectively	None
Construction programme	Total Pre-construction works Duct installation HVDC cable installation	2020-2025 2020-2021 2022-2023 2024-2025	Pre-construction works would consist of road modifications, hedge and tree removal, ecological preparations, archaeological survey and pre-construction drainage.
Decommissioning		Jointing pits and ducts left in situ	Where cables are in pre-installed ducts, cables may be extracted once de-energised.
Onshore project substation			
Construction	Maximum land take for temporary works area Maximum duration	20,000m^2 (200m x 100m) 30 months Assumes piling is required during construction of foundations	Norfolk Vanguard only. Indicative construction window 24 months.
Operation	Maximum land take for permanent footprint	75,000m^2	Norfolk Vanguard only.
Decommissioning	No decision has been made regarding the final decommissioning policy for the onshore project substation, as it is recognised that industry best practice, rules and legislation change over time. However, the onshore project equipment will likely be removed and reused or recycled. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator. A decommissioning plan will be provided. As such, for the purposes of a worst case scenario, impacts as for the construction phase are assumed.		
National Grid extension and overhead line modification			
Construction	Maximum land take for temporary works area – substation extension Maximum land take for temporary works area – overhead line Maximum duration	67,500m^2 174,264m^2 30 months	Indicative construction window 24 months.
Operation	Maximum land take for substation extension permanent footprint	49,300m^2	Includes existing Necton National Grid substation area

Worst case assumptions Parameter	Worst case criteria	Worst case definition	Notes
	Maximum land take for overhead line permanent footprint	9,250m^2	

19.7.3 Monitoring

105. The development of the detailed design and Code of Construction Practice (CoCP) (DCO requirement 20) will refine the worst-case impacts assessed in this EIA. It is recognised that monitoring is an important element in the management and verification of the actual project impacts. The requirement for and appropriate design and scope of monitoring will be agreed with the appropriate stakeholders and included within the CoCP and the Construction Method Statement (CMS) (DCO requirement 20) commitments prior to construction works commencing.

19.7.4 Assessment Scenarios

106. Chapter 5 Project Description outlines the scenarios to be assessed in relation to the phasing of the works. The two phase option is assumed to be the worst case, due to the increased length of time that receptors such as drainage will be potentially impacted by the project. The phasing of the construction works is as follows:

- The offshore project may be constructed as one or two phases and elements of the onshore construction would also be phased to reflect this;
- Cable ducts would be installed in one operation over two years, regardless of the offshore strategy;
- Cable pull through would be done in either one or two phases;
- The onshore project substation ground preparation and main works would be done in one phase, anticipated to take two years for pre-construction works and 30 months for primary works;
- The required electrical infrastructure and plant within the onshore project substation compounds would then be installed as required for each phase if the one or two phase options were adopted for offshore construction; and
- Total construction window for the one phase scenario is anticipated to be five years, and six years for the two phase scenario.

19.7.5 Potential Impacts during Construction

19.7.5.1 Impact 1: Impacts to coast line, including designated geological sites

19.7.5.1.1 Landfall

107. Within the Happisburgh Cliffs SSSI, the cliff and beach have been subject to visible erosion and in places they are very unstable. As this site is located approximately

570m away from the project landfall, no direct impacts (physical disturbance) are anticipated to arise from the project construction works.

108. Impacts relating to offshore cable installation are assessed in Chapter 8 Marine Geology, Oceanography and Physical Processes.

109. The Happisburgh Cliffs SSSI, which is located approximately 570m north of the Happisburgh landfall site at its nearest point, is considered to be of high sensitivity.

110. It has been assessed that due to the distance of the landfall from the Happisburgh Cliffs SSSI there is no mechanism for direct impact and therefore **no impact** was identified during the assessment.

111. The HDD will be secured beneath the surface of the shore platform and the base of the cliff, drilled from a location greater than 150m landward of the cliff edge. The material through which the HDD will pass, and through which the cables will ultimately be located, is consolidated and will have sufficient strength to maintain its integrity during the construction process and during operation. Also, the cable will be located at sufficient depth to account for shore platform steepening (downcutting) as cliff erosion progresses, and so will not become exposed during the design life of the project. Hence, the continued integrity of the geological materials and the continued depth of burial of the cables mean that they will have no impact on coastal erosion during both construction and operation. The indirect impacts were assessed as **no impact**. Details of the assessment can be found it in Chapter 8 Marine Geology, Oceanography and Physical Processes, section 8.7.8.6.

19.7.5.2 Impact 2: Contamination of secondary aquifers as a result of construction stage activities

19.7.5.2.1 Onshore cable route, onshore project substation, landfall and National Grid substation extension

112. Direct impacts to the superficial deposits crossed by the project may occur due to the intrusive nature of trenching, and piling at the onshore project substation, dependent on the depth of the aquifer unit in relation to the proposed depth of excavation. At the secondary aquifer crossing locations the receptor could be directly affected through disturbance.

113. During construction, surface layers will be excavated, allowing increased infiltration of rainwater and surface run-off to the subsurface. This could potentially mobilise any residual contamination already present in overlying strata which could potentially migrate into the underlying superficial aquifer.

114. It is also anticipated that potentially polluting substances and activities could be introduced during the construction works, for example as a result of concrete

pouring, storage of fuels and chemicals, and leaks and spills of fuel and oil from construction plant. Any potential impacts will be minimised by the embedded mitigation measures (section 19.7.1).

115. However, any changes are predicted to be of local spatial extent within each aquifer unit, of short term duration (related to the working areas only), of intermittent occurrence and high reversibility. The magnitude of effect is therefore considered to be moderate.

116. The secondary aquifers which form part of the superficial deposits are considered to be of low to medium sensitivity.

117. The overall significance of disturbance or contamination of secondary groundwater aquifers is deemed to be **minor** to **moderate adverse**, based on the embedded mitigation measures set out in section 19.7.1**.**

118. Mitigation will include the CoCP, which will be adhered to during the construction (DCO requirement 20). This will include the Environment Agency's Pollution Prevention Guidance (PPG1, PPG5, PPG6, PPG21 and PPG22 (although this has been withdrawn as regulatory guidance in England, it remains a good source of best practice).

119. An Outline CoCP (OCoCP) has been produced (document reference 8.1) and submitted with the DCO application, and will set out proposed management measures for any onshore construction works associated with the project, to minimise the exposure of workers and the general public to potentially harmful substances.

120. This includes details of:

- Site security and preventing public access;
- Personal hygiene, and washing and changing procedures;
- Use of personal protective equipment (PPE) and where necessary, respiratory protective equipment (RPE);
- Adoption of dust suppression methods, wheel washing facilities for vehicles leaving the site, covering of stockpiled materials and materials being transported to and from site; and
- Measures to avoid surface water ponding.

121. The residual impact is considered to remain **minor adverse**, which is not significant in EIA terms.

19.7.5.3 Impact 3: Impacts on groundwater quality in the Principal Aquifer (including SPZ areas and abstractions) as a result of construction stage activities

19.7.5.3.1 Onshore cable route, onshore project substation, landfall and National Grid substation extension

122. The Secondary Aquifers are considered to be linked to the underlying Principal Aquifer. Leaching and groundwater transport may occur as a result of new vertical hydraulic connections between shallow perched groundwater and Principal Aquifer groundwater during open cut trench construction. Any impacts are predicted to be of local spatial extent (in the area of the construction works only) and intermittent occurrence.

123. If works are necessary within or close to a SPZ1 areas (e.g. along the cable corridor at Crostwight, the North Walsham and Dilham Canal crossing point, Cawston and Dereham, and the substation north of Braddenham), then ground investigation, an appropriate risk assessment (see section 19.7.1) and consultation with the Environment Agency and Anglian Water will be undertaken to ensure that any adverse effects are minimised. The magnitude of effect is therefore considered to be low.

124. The Principal Aquifer which underlies the superficial deposits beneath the whole study area is deemed to be of high vulnerability. The sensitivity of the receptor is therefore considered to be high. In SPZ1 and SPZ2 areas, the aquifer sensitivity can be considered to be high.

125. The overall significance of the impact on disturbance or contamination of the principal groundwater aquifer is considered to be of **moderate adverse**.

126. It is anticipated that after adopting mitigation measures to mitigate impacts on SPZ1 and 2 areas, including ensuring cable excavations would be designed to minimise groundwater disturbance and the use of best available techniques (BAT) in accordance with the Energy Network Engineering Recommendations (EREC), the magnitude of effect will be reduced to negligible therefore the residual impact is expected to be **minor adverse**, which is not significant in EIA terms.

19.7.5.4 Impact 4: Impacts on groundwater quality in the Principal Aquifer (including SPZ areas) resulting from trenchless crossing conduit construction and piling

19.7.5.4.1 Onshore cable route, onshore project substation, landfall and National Grid substation extension

127. Direct impacts to the principal aquifer may occur from deep ground workings related to horizontal drilling operations for cable installation beneath surface infrastructure and watercourses. There is potential for drilling mud to leak along the drill path, or from the immediate area of the mud pits or tanks which could cause contamination

of groundwater. The volume of drilling fluid that could be released is dependent on a number of factors, including the size of the fracture, the permeability of the geological material, the viscosity of the drilling fluid, and the pressure of the hydraulic drilling system. In addition, there may be a need for piling to provide foundations for the onshore project substation. Piling has the potential to create preferential pathways through a low permeability layer allowing potential contamination of an underlying aquifer.

128. The impacts are predicted to be of local spatial extent (occurring only at trenchless crossing locations and at the substation if piling is required) and of intermittent occurrence. Any impacts would be managed by embedded mitigation measures. The magnitude of effect is therefore considered to be low.

129. The magnitude of effect on public water supply from trenchless crossing techniques (e.g. HDD) works within SPZ2 areas is considered to be low. If works within or close to SPZ1 are necessary, then ground investigation, an appropriate risk assessment (see section 19.7.1) and consultation with the Environment Agency and Anglian Water will be undertaken to ensure that any adverse effects are minimised.

130. The Principal Aquifer which underlies the superficial deposits beneath the whole of the site is deemed to be of high vulnerability. The sensitivity of the receptor is considered to be high.

131. For works in SPZ1 and SPZ2 areas, the aquifer sensitivity is considered to be high.

132. It is anticipated that after adopting mitigation measures presented in section 19.7.1 the magnitude of effect will be reduced to medium and therefore the impact would be **major adverse**.

133. In order to minimise impacts mitigation measures are therefore proposed. Ground investigations and a hydrogeological risk assessment would be undertaken at each trenchless crossing (e.g. HDD) site.

134. Where works are proposed within any SPZ1 or SPZ2 areas, a more detailed hydrogeological risk assessment meeting the requirements of Groundwater Protection Principles and Practice (GP3) (Environment Agency, 2017), and in agreement with the Environment Agency and Anglian Water, would be undertaken for each trenchless crossing location.

135. It is anticipated that, after adopting these mitigation measures, the magnitude of effect will be reduced to minor therefore the residual impact is expected to be **minor adverse**, which is not significant in EIA terms.

19.7.5.5 Impact 5: Impacts on the quality of surface waters fed by groundwater during construction

19.7.5.5.1 Onshore cable route, onshore project substation, landfall and National Grid substation extension

136. The presence of the Till in many locations throughout the study area will significantly delay the potential migration of any contaminants encountered or disturbed during excavations associated with the project. However, leaching or groundwater transport of contaminants may occur as a result of hydraulic connections between surface waters and superficial aquifers affected by trenching or piling construction. The effect is predicted to be of local spatial extent, of intermittent occurrence and high reversibility. The magnitude of effect is therefore, considered to be low.

137. The ground investigations undertaken within the onshore cable route confirmed the presence of shallow groundwater in many areas along the onshore cable route and it is anticipated that surface watercourses are in hydraulic connectivity with groundwater contained within superficial deposits throughout the study area. The sensitivity of surface watercourses varies from low to high (the detailed information regarding the watercourse sensitivity is presented in section 20.6).

138. The overall level of impact on indirect disturbance or contamination of surface watercourses based on the situation which includes the integration of measures adopted in section 19.7.1 is considered to be **minor adverse** which is not significant in EIA terms. No further mitigation is therefore proposed.

19.7.5.6 Impact 6: Impacts to human health, including construction workers and general public during any excavations associated with construction

19.7.5.6.1 Onshore cable route, onshore project substation, landfall and National Grid substation extension

139. A desk-based assessment of contamination risks has been undertaken for the project (Appendix 19.1). The majority of the study area crosses agricultural land where no significant contamination is expected. However, a number of localised potential sources of contamination have been identified within the study area, for example: a dismantled railway, historical common clay and shale, sand and gravel pits, historic clay bricks and tiles manufactures, graveyards and historic tanks (Figure 19.1 and 19.2 Appendix 19.1).

140. Potential contaminants of concern (PCOC) could be present in the study area and could represent an unacceptable risk to construction workers, and potentially the public, if exposed during construction activities. Construction activities, particularly earthworks associated with the project could potentially disturb and expose construction workers to localised made ground soils and potential soil and/or

groundwater contamination associated historical land uses within study area. Construction activities could create pollutant linkages through ingestion, inhalation and direct dermal contact pathways.

141. In the event of exposing soils and stockpiling construction waste (including excavated materials), dust could be generated during dry and windy conditions. Under these conditions, construction workers and the general public, such as users of neighbouring sites and surrounding residents, could temporarily be exposed to contamination via the inhalation of potentially contaminated dust.

142. The short term risks to construction workers would be managed through the use of appropriate working practices and the use of Personal Protective Equipment (PPE). Construction workers will be made aware of the possibility of encountering contaminated soils in made ground through toolbox talks. Safe working procedures will be implemented, good standards of personal hygiene will be observed and appropriate levels of PPE and respiratory protective equipment (RPE) will be provided and utilised as necessary, thereby minimising the risk of exposure to potentially contaminated soils, ground gas and groundwater.

143. The impacts are predicted to be of local spatial extent (localised to the work areas), of short term duration, of intermittent occurrence and high reversibility (occurring only during the works). The magnitude of effect is therefore, considered to be low.

144. Human health is of high importance, therefore the sensitivity of human health as a receptor (construction workers, site operatives and general public (off-site)) is considered to be high. The impact would therefore be **moderate adverse**.

145. Mitigation will therefore consist of a Site and Excavated Waste Management Plan (SWMP), to ensure that any waste arising is closely monitored and that waste prevention, re-use or recycling opportunities are maximised (Appendix 19.2). The appropriate waste management route is confirmed following a waste hierarchy assessment.

146. A written scheme (based on the Model procedures for the management of land contamination, CLR11) for the management of contamination of any land and groundwater would be submitted and approved by the local authority. The document will also provide procedures to follow in the event of encountering unexpected contamination and will include proposals to deal with any waste soils excavated during the works.

147. Following the implementation of mitigation, the residual impact is predicted to be **minor adverse**, which is not significant in EIA terms.

148. Further discussion of human health can be found in Chapter 27 Human Health.

19.7.5.7 Impact 7: Sterilisation of mineral resources.

19.7.5.7.1 Onshore cable route, onshore project substation, landfall and National Grid substation extension

149. The onshore project area crosses numerous mineral safeguarding areas and installation of cables within these areas would prevent future extraction of sand and gravels. There are 1.77km² of mineral safeguard areas within the onshore project footprint and as a worst case it is assumed that this whole area would be sterilised. The ground investigation works undertaken for the project confirmed that the study area is underlain by sand deposits.

150. The impacts are predicted to be permanent and large scale. It is predicted that the impact would affect the receptor directly. The magnitude of effect is therefore considered to be high.

151. Mineral safeguarding areas are considered to be of regional importance. The sensitivity of the receptor is considered to be medium.

19.7.5.7.2 Significance of impact

152. The overall significance of the impact on mineral recourse availability during the construction works is considered to be **major adverse** (due to the high magnitude of effect and the medium receptor sensitivity), based on the worst case scenario. Mitigation will therefore consist of a Materials Management Plan (MMP), which will be developed post-consent and include information regarding the coordination of planning, sourcing, purchasing, moving, storing and controlling materials in sustainable manner, for example reusing materials on site where possible. The contractor will have to comply with the MMP during construction. Following this, it is predicted that the magnitude of effect will be reduced to low; therefore, the impact would be **minor adverse**, which is not significant in EIA terms.

19.7.5.7.3 Future works and mitigation

153. This worst case estimate will be discussed with the MPA in the context of aggregate resources available in the local area and the cost effectiveness of pre-excavating and using the material for construction purposes within the project and reinstating the cable trench with imported backfill. Dependent on the outcome of consultation post-consent, further quantification of resource quality and value may be undertaken. The agreed construction approach will be set out in a MMP to be followed during construction, which would also deal with excavated waste management.

19.7.5.8 Impact 8: Impacts on shallow groundwater due to changes to the hydraulic regime as a result of the construction works

19.7.5.8.1 Onshore cable route, onshore project substation, landfall and National Grid substation extension

154. There is possibility that the hydraulic regime of the local area will be affected by the project. Backfilling the cable trench with less compacted soil could potentially influence the groundwater regime by altering porosity and creating preferential groundwater flow pathways.

155. The shallow groundwater within the superficial deposits are considered to be of medium sensitivity. The impacts are predicted to be of local spatial extent (localised to the work areas), of short term duration, of intermittent occurrence and high reversibility (occurring only during the works). The magnitude is therefore considered to be low.

156. Due to the medium sensitivity of the receptor and the low magnitude of effect, the overall impact during the construction works is therefore considered to be of **minor adverse** significance. No further mitigation is therefore anticipated.

19.7.6 Potential Impacts during Operation

157. There are unlikely to be any significant additional impacts from the operation of the project. Routine Operation and Maintenance (O&M) activities will follow standard procedures therefore minimising any potential impacts. Non-routine maintenance will be subject to robust and effective planning and risk assessment procedures. As discussed previously, impacts during O&M are scoped out of the ES in accordance with the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016) and PEIR consultation (December 2017).

19.7.7 Potential Impacts during Decommissioning

158. This section describes the potential impacts of the decommissioning of the onshore infrastructure with regards to impacts on ground conditions. Further details are provided in Chapter 5 Project Description.

159. No decision has been made regarding the final decommissioning policy for the onshore cables, as it is recognised that industry best practice, rules and legislation change over time. It is likely the cables would be pulled through the ducts and removed, with the ducts themselves left in situ.

160. In relation to the onshore project substation, the programme for decommissioning is expected to be similar in duration to the construction phase. The detailed activities and methodology would be determined later within the project lifetime, but are expected to include:

- Dismantling and removal of outside electrical equipment from site located outside of the onshore project substation buildings;
- Removal of cabling from site;
- Dismantling and removal of electrical equipment from within the onshore project substation buildings;
- Removal of main onshore project substation building and minor services equipment;
- Demolition of the support buildings and removal of fencing;
- Landscaping and reinstatement of the site (including land drainage); and
- Removal of areas of hard standing.

161. Whilst details regarding the decommissioning of the onshore project substation are currently unknown, considering the worst case scenario which would be the removal and reinstatement of the current land use at the site, it is anticipated that the impacts would be similar or less than to those during construction.

162. The decommissioning methodology would need to be finalised nearer to the end of the lifetime of the project so as to be in line with current guidance, policy and legislation at that point. Any such methodology would be agreed with the relevant authorities and statutory consultees. The decommissioning works could be subject to a separate licencing and consenting approach.

19.8 Cumulative Impacts

163. The assessment of cumulative impact has been undertaken here as a two stage process. Firstly, all the impacts from previous sections have been assessed for potential to act cumulatively with other projects. This summary assessment is set out in Table 19.16.

Table 19.16 Potential cumulative impacts

Impact		Potential for cumulative impact	Rationale
Construction			
1	Impacts to coast line, including designated geological sites.	Yes	Impacts to interest features of designated sites may be exacerbated by other projects.
2	Contamination of secondary aquifers as a result of construction activities.	Yes	Impacts to secondary aquifers may be exacerbated by other projects.
3	Impacts on groundwater quality in the Principal Aquifer (including SPZ areas) due to open cut trench construction.	Yes	Impacts to Principal Aquifer including SPZ areas may be exacerbated by other projects.
4	Impacts on groundwater quality in the Principal Aquifer (including SPZ	Yes	Impacts to Principal Aquifer including SPZ

Impact		Potential for cumulative impact	Rationale
	areas) resulting from trenchless crossing technique (e.g. HDD) conduit construction and piling.		areas may be exacerbated by other projects.
5	Impacts on the quantity and quality of surface waters fed by groundwater during construction.	Yes	Impacts to surface water may be exacerbated by other projects.
6	Impacts to human health, including construction workers and public during any excavations associated with construction.	No	The impacts will be confined to the work area.
7	Sterilisation of mineral resources.	Yes	Impacts to Mineral Safeguard Areas may be exacerbated by other projects.
8	Impacts on shallow groundwater due to changes to the hydraulic regime as a result of the construction works	Yes	Impacts to groundwater may be exacerbated by other projects.
Operation			
As discussed previously, impacts during O&M are scoped out of the ES as agreed during the scoping stage (see Table 19.2).			
Decommissioning			
The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator. A decommissioning plan will be provided. As such, cumulative impacts during the decommissioning stage are assumed to be the same as those identified during the construction stage.			

164. The second stage of the CIA is an assessment of whether there is spatial or temporal overlap between the extent of potential effects of the onshore infrastructure and the potential effects of other projects scoped into the CIA upon the same receptors. To identify whether this may occur, the potential nature and extent of effects arising from all projects scoped into the CIA have been identified and any overlaps between these and the effects identified above. Where there is an overlap, an assessment of the cumulative magnitude of effect is provided.

165. The projects identified for potential cumulative impacts with Norfolk Vanguard have been discussed during ETG meetings with stakeholders and the full list has been agreed in consultation with local authorities.

166. Table 19.17 summarises those projects that have been considered for the CIA due to their temporal or spatial overlap with the potential effects arising from the project. Where the impacts of these projects have the potential for cumulative effects on

ground conditions and contamination, the rationale column of the table identifies these.

Table 19.17 Summary of projects considered for the CIA in relation to ground conditions and contamination

Project	Status	Development period	[2]Distance from Norfolk Vanguard (km)	Project definition	Project data status	Included in CIA	Rationale
National Infrastructure Planning							
Norfolk Boreas Offshore Wind Farm	Pre-Application	Expected construction 2026	0 – projects are co-located	Pre-application outline only	High	Yes	Overlapping proposed project boundaries may result in impacts of a direct and / or indirect nature on groundwater quality and resources during construction. The projects are located in the same bedrock Principal Aquifer.
Hornsea Project Three Offshore Wind Farm	Pre-Application	Expected construction date 2021	0 - cable intersects project	Full PEIR available: http://hornseaproject3.co.uk/Documents-library/PEIR-Documents	High	Yes	The onshore export cable route corridor will overlap the Norfolk Vanguard onshore corridor route around Reepham. The application is expected to be submitted to the Planning Inspectorate Q2 2018. Overlapping proposed project boundaries may result in impacts of a direct and / or indirect nature on groundwater quality and resources during construction. The projects are located in the same bedrock Principal Aquifer.
Dudgeon Offshore Wind Farm	Commissioned	Constructed	0	http://dudgeonoffshorewind.co.uk/	High	No	No cumulative effects on onshore geology and ground conditions are likely, as the Dudgeon project is completed, and therefore there is no potential for construction-phase

[2] Shortest distance between the considered project and Norfolk Vanguard – unless specified otherwise.

Project	Status	Development period	[2]Distance from Norfolk Vanguard (km)	Project definition	Project data status	Included in CIA	Rationale
							cumulative impacts to occur.
A47 corridor improvement programme – North Tuddenham to Easton	Pre-application	Expected construction date 2021-23	2.5	https://infrastructure.planninginspectorate.gov.uk/projects/eastern/a47-north-tuddenham-to-easton/	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
A47 corridor improvement programme – A47 Blofield to North Burlingham	Pre-application	Expected construction date 2021-22	25	https://infrastructure.planninginspectorate.gov.uk/projects/eastern/a47-blofield-to-north-burlingham/	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
A47 corridor improvement programme – A47 / A11 Thickthorn	Pre-application	Expected construction date 2020-21	18	https://infrastructure.planninginspectorate.gov.uk/projects/eastern/a47a11-thickthorn-junction/	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
Norwich Western Link	Pre-application	2022	2.8	https://www.norfolk.gov.uk/roads-and-transport/major-projects-and-improvement-plans/norwich/norwich-western-link/timeline	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
Third River Crossing (Great Yarmouth)	Pre-application	Expected to start in 2020	28	https://www.norfolk.gov.uk/roads-and-transport/major-projects-and-improvement-plans/great-	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.

Project	Status	Development period	[2]Distance from Norfolk Vanguard (km)	Project definition	Project data status	Included in CIA	Rationale
				yarmouth/third-river-crossing			
King's Lynn B Power Station amendments	Pre-application	Construction expected 2018-2021	28	https://www.kingslynnbccgt.co.uk/	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
NNDC							
PF/17/1951 Erection of 43 dwellings and new access with associated landscaping, highways and external works, and amendments to substation)	Awaiting decision	Anticipated Q2 2018	0.7	Application available: https://idoxpa.north-norfolk.gov.uk/online-applications/applicationDetails.do?activeTab=summary&keyVal=_NNORF_DCAPR_92323	High https://idoxpa.north-norfolk.gov.uk/online-applications/files/A8C1C7C650E0F2DC5A24090A08D1AD9E/pdf/PF_17_1951-Site_Location_Plan-342482.pdf	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
Bacton Gas Terminal Extension	Approved	Approved 20/09/2016. Expires 20/09/2019	3.0	Approved PDS available https://idoxpa.north-norfolk.gov.uk/online-applications/applicationDetails.do?activeTab=summary&keyVal=_NNORF_DCAPR_88689	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
Bacton Gas Terminal	Approved.	Approved	2.5	Approved PDS available	Medium	No	No cumulative effects on onshore

Project	Status	Development period	[2]Distance from Norfolk Vanguard (km)	Project definition	Project data status	Included in CIA	Rationale
Coastal Protection		18/11/2016. Expires 18/11/2019		https://idoxpa.north-norfolk.gov.uk/online-applications/applicationDetails.do?activeTab=summary&keyVal=_NNORF_DCAPR_88689			ground conditions and contamination are likely. Foundations may be required but it is expected that any foundation design would meet any regulatory requirements regarding protection of surface waters and groundwater.
Bacton and Walcott Coastal Management Scheme	Approved.	Expected construction date 2018	1.0	Approved PDS available	Medium	No	No cumulative effects on onshore ground conditions and contamination are likely.
Breckland Council							
21-31 new dwellings in Necton (BLR/2017/0001/PIP)	Awaiting decision	Not known. Application submitted November 2017.	1.0	http://planning.breckland.gov.uk/OcellaWeb/showDocuments?reference=BLR/2017/0001/PIP&module=pl	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
4-8 new dwellings in Necton (BLR/2017/0002/PIP)	Awaiting decision	Not known. Application submitted November 2017.	1.0	http://planning.breckland.gov.uk/OcellaWeb/showDocuments?reference=BLR/2017/0002/PIP&module=	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
70 dwellings (3PL/2016/0298/D) (Phase 2 of 3PL/2012/0576/O)	Approved (21/09/16)	Not known. Application submitted March 2016.	6.4	http://planning.breckland.gov.uk/OcellaWeb/planningDetails?reference=3PL/2016/0298/D&from=planningSearch	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.
98 dwellings at Swans Nest with access from Brandon Road	Awaiting decision (due 30/03/2018)	Not known. Application submitted Jan	6.4	http://planning.breckland.gov.uk/OcellaWeb/planningDetails?reference=	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and

Project	Status	Development period	[2]Distance from Norfolk Vanguard (km)	Project definition	Project data status	Included in CIA	Rationale
(3PL/2017/1351/F) (Phase 3 of 3PL/2012/0576/O)		2016.		3PL/2017/1351/F&from=planningSearch			contamination are likely.
175 dwellings with access at land to west of Watton Road, Swaffham (3PL/2016/0068/O) (Swans Nest Phase B)	Awaiting decision (due 13/10/2017)	Not known. Application submitted Jan 2016.	6.4	http://planning.breckland.gov.uk/OcellaWeb/planningDetails?reference=3PL/2016/0068/O	Medium	No	Due to distance, nature and scale of the project no cumulative effects on onshore ground conditions and contamination are likely.

167. As identified in Table 19.17, through one of its subsidiaries, Vattenfall Wind Power Ltd is developing the Norfolk Boreas Offshore Wind Farm (herein the 'Norfolk Boreas project'). The offshore project area for Norfolk Boreas is located to the north of Norfolk Vanguard East, and the DCO submission for Norfolk Boreas is expected to follow approximately a year behind the Norfolk Vanguard DCO submission. The development of Norfolk Boreas will use the same onshore cable route as Norfolk Vanguard. Ducts will be installed along the onshore cable route for Norfolk Boreas at the same time as Norfolk Vanguard.

168. In summary, the following projects will be assessed for potential direct cumulative impacts:

- Norfolk Boreas Offshore Wind Farm; and
- Hornsea Project Three.

19.8.1 Cumulative Impacts during Construction

169. Norfolk Boreas and Hornsea Project Three are likely to include relevant mitigation measures embedded within their design. These measures should prevent significant adverse impacts on ground conditions or contamination occurring as a result.

170. Trenching for Norfolk Boreas and Hornsea Project Three will likely be shallow and is therefore unlikely to affect surface water and groundwater receptors. The Principal Aquifer is unlikely to be impacted cumulatively, as Norfolk Boreas and Hornsea Project Three are unlikely to require deep piling to the Chalk aquifer through the superficial deposits (and hence there is no pathway). Construction for Norfolk Boreas, Norfolk Vanguard and Hornsea Project Three may potentially take place at the same time, which could lead to a larger land take and increased potential for impacts on secondary aquifer water quality should two contamination events occur at the same time during the construction phase. However, it is anticipated that this will be managed by appropriate mitigation measures. It is considered unlikely that there would be any cumulative effects on human health associated with the listed projects as any impacts identified in the assessment are only related to the construction stage and will be minimised by adoption of mitigation measures.

19.8.2 Cumulative Impacts during Operation

171. As discussed previously, impacts during O&M are scoped out of the ES in accordance with the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016) and PEIR consultation (December 2017), therefore no cumulative impacts will occur.

19.8.3 Cumulative Impacts during Decommissioning

172. Decommissioning of Norfolk Boreas and Hornsea Project Three may potentially take place at the same time as the Norfolk Vanguard project. The detail and scope of the decommissioning works for the Norfolk Vanguard project will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator. A decommissioning plan will be provided. As such, cumulative impacts during the decommissioning stage are assumed to be the same as those identified during the construction stage.

19.9 Inter-relationships

173. It should be noted that this chapter has the potential to interact with other chapters (Table 19.18).

Table 19.18 Chapter topic inter-relationships

Topic and description	Related Chapter	Section where addressed	Rationale
Impacts to coast line, including designated geological sites	Chapter 8 Marine Geology, Oceanography and Physical Processes	Section 19.7.5.1	The project could indirectly impact designated geological sites by affecting erosion and deposition processes.
Impacts to coast line, including designated geological sites	Chapter 9 Marine Water and Sediment Quality	Section 19.7.5.1	The project could indirectly impact designated geological sites by affecting erosion and deposition processes.
Impacts on the quantity and quality of surface waters fed by groundwater during construction	Chapter 20 Water Resources and Flood Risk	Section 19.7.5.4	Any project-related impacts on the quantity and quality of surface waters could impact upon hydrologically-connected groundwaters.
Impacts on human health, including construction workers and public during any excavations associated with construction	Chapter 27 Human Health	Section 19.7.5.6	The project could impact on human heath if construction workers or public are exposed to PCOCs during construction activities.

19.10 Interactions

174. The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts as a result of that interaction. The worst case impacts assessed within the chapter take these interactions into account and for the impact assessments are considered conservative and robust. For clarity the areas of interaction between impacts are

presented in Table 19.1, along with an indication as to whether the interaction may give rise to synergistic impacts.

Table 19.19 Interaction between impacts

Potential interaction between impacts Construction	1 Coastal erosion	2 Damage to designated geological sites	3 Drainage	4 Changes to quantity and quality of surface waters	5 Risk to human health f
1 Coastal erosion	-	Yes	Yes	Yes	No
2 Damage to designated geological sites	Yes	-	No	No	No
3 Drainage	Yes	No	-	Yes	No
4 Changes to quantity and quality of surface waters	Yes	No	Yes	-	No
5 Risk to human health from contaminated land	No	No	No	No	-
Operation					
Impacts during operation are scoped out of the ES in accordance with the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016).					
Decommissioning					
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.					

19.11 Summary

175. There are no designated sites of geological or geomorphological importance in close proximity to the landfall, onshore cable route, onshore project substation or National Grid substation extension.

176. Provided mitigation measures (both embedded and additional) are in place to prevent ground and groundwater pollution and interconnection of aquifer units in the footprint of the project, the project is predicted to have only **minor adverse** impacts in relation to ground conditions and contamination. A summary of the findings of the ES that have been completed for ground conditions and contamination is presented in Table 19.20.

Table 19.20 Potential impacts identified for ground conditions and contamination

Potential impact		Receptor	Value/ sensitivity	Magnitude	Significance	Mitigation	Residual impact
Construction							
1	Impacts to coastline, including designated geological sites	Coastline and designated geological sites	High	Negligible	Negligible	None needed	Negligible
2	Impacts of construction may cause contamination of secondary aquifers	Secondary aquifers	Low - Medium	Medium	Minor - Moderate adverse	Section 19.7.1 and Section 19.7.5.2	Minor adverse
3	Impacts of open cut trench construction may affect the groundwater quality of the Principal aquifer including at SPZ areas	Principal Aquifer including at SPZ areas	High	Low	Moderate adverse	Section 19.7.1 and Section 19.7.5.3	Minor adverse
4	Impacts of trenchless crossing technique conduit construction and piling may affect the groundwater quality of the Principal Aquifer, including conduit construction within an SPZ areas.	Principal Aquifer including at SPZ areas	Low	High	Moderate adverse	Section 19.7.1 and section 19.7.5.4	Minor adverse
5	Impacts of construction may affect the quantity and quality of surface waters fed by groundwater	Surface water	Low-high	Medium	Minor- Moderate adverse	Section 19.7.1	Minor adverse

Potential impact		Receptor	Value/ sensitivity	Magnitude	Significance	Mitigation	Residual impact
6	Impacts to human health, including construction workers and general public during any excavations associated with construction.	Human health.	High	Low	Moderate adverse	Section 19.7.1.	Minor adverse
7	Sterilisation of mineral resources.	Mineral safeguard areas.	Medium	High	Major adverse	Section 19.7.1	Minor adverse
8	Impacts on shallow groundwater due to changes to the hydraulic regime as a result of the construction works	Shallow groundwater	Low	Low	Minor adverse	Section 19.7.1	Minor adverse
Operation							
Impacts during operation are scoped out of the ES in accordance with the Norfolk Vanguard EIA Scoping Report.							
Decommissioning							
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.							
Cumulative							
No cumulative effects on onshore geology and ground conditions are likely as the project will meet all regulatory requirements in regards to protection of surface and groundwater (as discussed in section 19.8).							

19.12 References

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