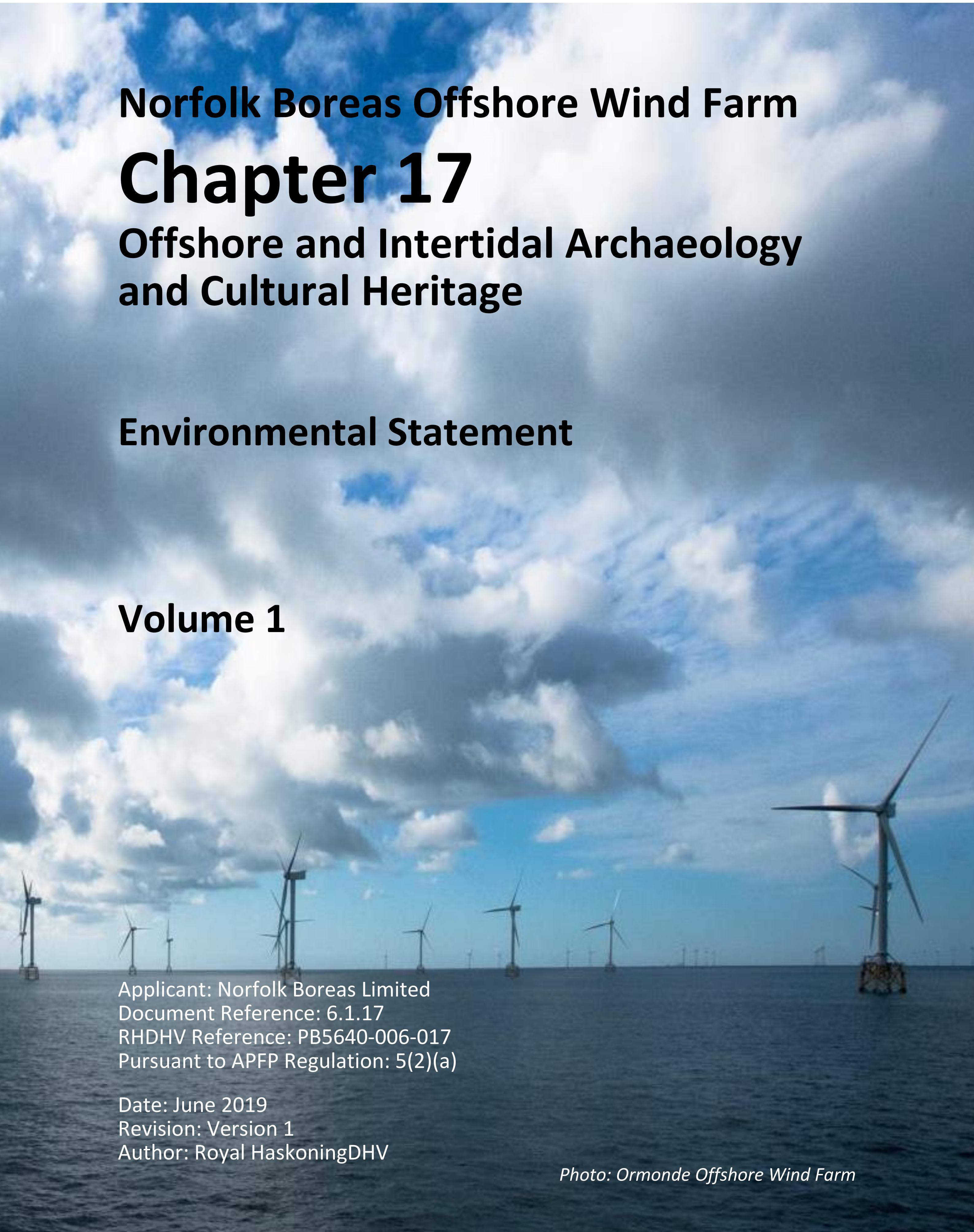

Norfolk Boreas Offshore Wind Farm

Chapter 17

Offshore and Intertidal Archaeology and Cultural Heritage

Environmental Statement

Volume 1

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Table of Contents

Tables

Plates

Figures (Volume 2)

Appendices (Volume 3)

Glossary of Acronyms

AEZ	Archaeological Exclusion Zones
AHOB	Ancient Human Occupation of Britain
BP	Before Present
cal. BP	Calibrated years Before Present (1950) (Radiocarbon Dates)
DCO	Development Consent Order
DEFRA	Department for Environment, Food and Rural Affairs
DML	Deemed Marine Licence
EIA	Environmental Impact Assessment
EPP	Evidence Plan Process
ES	Environmental Statement
ETG	Expert Topic Group
Fugro	Fugro Survey B. V. (geophysical and geotechnical survey contractor)
GIS	Geographical Information Systems
HDD	Horizontal Directional Drilling
HSC	Historic Seascape Characterisation
KA	Kilo annum (thousand years ago)
LVIA	Landscape and Visual Impact Assessment
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MIS	Marine Isotope Stage
MMO	Marine Management Organisation
NHER	Norfolk Historic Environment Record
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NRHE	National Record of the Historic Environment
NSIPs	Nationally Significant Infrastructure Project
nT	nanoTesla
OSL	Optically stimulated luminescence
PAB	Pathways to Ancient Britain
PEIR	Preliminary Environmental Information Report
ROV	Remote Operated Vehicle
UKHO	United Kingdom Hydrographic Office
UXO	Unexploded Ordnance
WCS	Worst Case Scenario
WSI	Written Scheme of Investigation

Glossary of Terminology

Aviation archaeology	The remains of crashed aircraft and archaeological material associated with historic aviation activities.
Geoarchaeology	The application of earth science principles and techniques to the understanding of the archaeological record. Includes the study of soils and sediments and of natural physical processes that affect archaeological sites such as geomorphology, the formation of sites through geological processes and the

	effects on buried sites and artefacts.
Glacial/interglacial	A glacial period is a period of time within an ice age that is marked by colder temperatures and glacier advances. Interglacial correspond to periods of warmer climate between glacial periods. There are three main periods of glaciation within the last 1 million years, the Anglian, the Wolstonian and the Devensian which ended about 12,000 years ago. The Holocene period corresponds to the current interglacial.
Historic seascape character	The attributes that contribute to the formation of the historic character of the seascape.
Marine isotope stage	Marine isotope stages are alternating warm and cool periods in the Earth's paleoclimate, deduced from oxygen isotope data reflecting changes in temperature derived from data from deep sea core samples.
Maritime archaeology	The remains of boats and ships and archaeological material associated with prehistoric and historic maritime activities.
Mesolithic	10000 to 4000 BC The Middle Stone Age, falling between the Palaeolithic and Neolithic and marking the beginning of a move from a hunter gatherer society towards a food producing society.
Norfolk Boreas site	The Norfolk Boreas wind farm boundary. Located offshore, this will contain all the wind farm array.
Norfolk Vanguard OWF sites	Term used exclusively to refer to the two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West (also termed NV East and NV West) which will contain the Norfolk Vanguard arrays.
Offshore cable corridor	The corridor of seabed from the Norfolk Boreas site to the landfall site within which the offshore export cables will be located.
Offshore electrical platform	A fixed structure located within the Norfolk Boreas site, containing electrical equipment to aggregate the power from the wind turbines and convert it into a suitable form for export to shore.
Offshore project area	The area including the Norfolk Boreas site, project interconnector search area and offshore cable corridor.
Offshore service platform	A platform to house workers offshore and/or provide helicopter refuelling facilities. An accommodation vessel may be used as an alternative for housing workers.
Optically stimulated luminescence	OSL is a scientific technique which dates the last time quartz sediment was exposed to light and providing a precise date for the burial of a geological deposit.
Palaeoenvironmental analysis	The study of sediments and the organic remains of plants and animals to reconstruct the environment of a past geological age.
Palaeogeographic features	Features seen within sub-bottom profiler data (buried) and multibeam bathymetry data (sea floor) interpreted as representing prehistoric physical landscape features such as former river channels (palaeochannels).
Palaeolithic	500000 to 10000 BC The Old Stone Age defined by the practice of hunting and gathering and the use of chipped flint tools. This period is usually divided into Lower, Middle and Upper Palaeolithic.
Project interconnector cable	Offshore cables which would link either turbines or an offshore electrical platform in the Norfolk Boreas site with an offshore electrical platform in one of the Norfolk Vanguard sites.
Project interconnector search area	The area within which the project interconnector cables would be installed.
Seabed features	Features seen on the seafloor in the sidescan sonar or multibeam bathymetry data which are interpreted to represent heritage assets, or potential heritage assets. Also includes magnetic anomalies which may represent shallow buried ferrous material of archaeological interest.

Seabed prehistory	Archaeological remains on the seabed corresponding to the activities of prehistoric populations that may have inhabited what is now the seabed when sea levels were lower.

17 OFFSHORE AND INTERTIDAL ARCHAEOLOGY AND CULTURAL HERITAGE

17.1 Introduction

1. This chapter of the Environmental Statement (ES) sets out existing baseline conditions for offshore and intertidal archaeology and cultural heritage within the Norfolk Boreas offshore project area, including the landfall below Mean High Water Springs (MHWS). This chapter also assesses the potential impacts to offshore and intertidal archaeological receptors from the proposed project and details the embedded mitigation which will be applied.

2. The approach to assessment for this chapter takes account of industry standards and guidance (see section 17.4.1) with specific reference to the National Planning Policy Framework (NPPF), the Marine Policy Statement and to the relevant National Policy Statements (NPS):

- Overarching NPS for Energy (EN-1) (July 2011); and
- NPS for Renewable Energy Infrastructure (EN-3) (July 2011).

3. The methodology has also been informed by consultation with Historic England and Norfolk County Council's Historic Environment Service (see section 17.4.1).

4. Vattenfall Wind Power Limited (VWPL) (the parent company of Norfolk Boreas Limited) is also developing Norfolk Vanguard, a 'sister project' to Norfolk Boreas. Norfolk Vanguard's development schedule is approximately one year ahead of Norfolk Boreas and as such the Development Consent Order (DCO) application was submitted in June 2018.

5. Norfolk Vanguard may undertake some enabling works for Norfolk Boreas, but these are only relevant to the assessment of impacts onshore. This assessment does however include interconnector cables between the Norfolk Boreas and Norfolk Vanguard projects (herein, 'project interconnector cables'). If Norfolk Vanguard does not proceed then the project interconnector cables would not be required.

6. A summary of the known and potential offshore and intertidal archaeological resource within the boundary of the project is presented in section 17.6 with respect to:

- Seabed prehistory (i.e. archaeological remains on the seabed corresponding to the activities of prehistoric populations that may have inhabited what is now the seabed when sea levels were lower);
- Maritime archaeology (i.e. the remains of boats and ships and archaeological material associated with prehistoric and historic maritime activities);
- Aviation archaeology (i.e. the remains of crashed aircraft and archaeological material associated with historic aviation activities);

- Historic seascape character (i.e. the attributes that contribute to the formation of the historic character of the seascape); and
- Buried archaeology (including palaeoenvironmental deposits) within the intertidal zone below MHWS.

7. Baseline conditions within the Norfolk Boreas site have been established through a review of geophysical and geotechnical data undertaken by Wessex Archaeology. The technical reports authored by Wessex Archaeology which present the results of this work are provided in Appendix 17.2, Appendix 17.3, Appendix 17.5, Appendix 17.6 and Appendix 17.7.

8. The primary source of information for the assessment of offshore archaeology within the offshore cable corridor and the project interconnector search area is the archaeological desk-based assessment prepared by Wessex Archaeology to inform the Norfolk Vanguard Environmental Impact Assessment (EIA). The technical report presenting the full results of this desk-based assessment is provided in Appendix 17.4.

9. The approach to impact assessment adopted for this chapter is detailed in section 17.4. The results of the impact assessment are presented in sections 17.7.3 to 17.7.5.

17.2 Legislation, Guidance and Policy

10. A detailed summary of the legislation, policy and guidance applicable to the assessment of offshore and intertidal archaeology is presented in section 2 of Appendix 17.4.

11. In demonstrating adherence to industry good practice, this chapter has been compiled with respect to available archaeological guidance for offshore development including:

- The Setting of Heritage Assets: Historic Environment Good Practice Advice in Planning Note 3 (Second Edition) (Historic England, 2017);
- Chartered Institute for Archaeologists' Standard and Guidance for Historic Environment Desk-Based Assessments (2014a) and Code of Conduct (2014b);
- Marine Geophysical Data Acquisition, Processing and Interpretation – guidance notes (Historic England, 2013);
- Offshore Geotechnical Investigations and Historic Environment Analysis: Guidance for the Renewable Energy Sector (Gribble and Leather, 2011);
- Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy (Oxford Archaeology, 2008);
- Historic Environment Guidance for the Offshore Renewable Energy Sector. Guidance (Wessex Archaeology, 2007); and

- Code for Practice for Seabed Development (Joint Nautical Archaeology Policy Committee (JNAPC), 2006).

12. In the absence of an industry standard methodology for heritage impact assessment within the framework of EIA, the assessment methodology adopted takes account of overarching principles presented in policy and guidance:

- NPPF (Ministry of Housing, Communities and Local Government, 2018);
- Marine Policy Statement (HM Government, 2011);
- Overarching NPS for Energy (EN-1) and NPS for Renewable Energy Infrastructure (EN-3) (DEFRA, 2011); and
- Conservation Principles: Policy and Guidance for Sustainable Management of the Historic Environment (Historic England, 2008).

13. The NPSs are the principal decision-making documents for Nationally Significant Infrastructure Projects (NSIPs). Table 17.1 sets out how specific policies relevant to the historic environment are addressed within this chapter.

Table 17.1 NPS Guidance for the Historic Environment

NPS Requirement	NPS Reference	ES Reference
EN-1 Overarching NPS for Energy		
"As part of the ES the applicant should provide a description of the significance of the heritage assets affected by the proposed development and the contribution of their setting to that significance. The level of detail should be proportionate to the importance of the heritage assets and no more than is sufficient to understand the potential impact of the proposal on the significance of the heritage asset."	Paragraph 5.8.8	The significance and value of the archaeological receptors considered in this chapter of the ES, including the contribution of setting to that significance is detailed in section 17.7.5. Issues relating to the setting of onshore heritage assets have been considered as part of Chapter 28 Onshore Archaeological and Cultural Heritage.
"Where a development site includes, or the available evidence suggests it has the potential to include, heritage assets with an archaeological interest, the applicant should carry out appropriate desk-based assessment and, where such desk-based research is insufficient to properly assess the interest, a field evaluation. Where proposed development will affect the setting of a heritage asset, representative visualisations may be necessary to explain the impact."	Paragraph 5.8.9	This chapter of the ES is based upon the results of a desk-based assessment which identifies the presence of archaeological receptors within the offshore study area (see section 17.6).
"The applicant should ensure that the extent of the impact of the proposed development on the significance of any heritage assets affected can be adequately	Paragraph 5.8.10	This chapter of the ES provides an account of the potential impacts of Norfolk Boreas upon heritage assets and their significance (section 17.7).

NPS Requirement	NPS Reference	ES Reference
understood from the application and supporting documents."		
EN-3 NPS for Renewable Energy Infrastructure		
"Consultation with the relevant statutory consultees (including English Heritage or Cadw) should be undertaken by the applicants at an early stage of the development."	Paragraph 2.6.140	Consultation has been undertaken with relevant statutory consultees, as outlined in section 17.3 and Appendix 17.1. Consultation will be on going throughout the development process.
"Assessment should be undertaken as set out in section 5.8 of EN-1. Desk-based studies should take into account any geotechnical or geophysical surveys that have been undertaken to aid the windfarm design."	Paragraph 2.6.141	The assessment has been undertaken in accordance with section 5.8 of EN-1, as detailed above. Geophysical and geotechnical studies have underpinned the assessment (section 17.6 and Appendix 17.2, 17.3, 17.4, 17.5, 17.6, 17.7 and 17.8).
"The assessment should also include the identification of any beneficial effects on the historic marine environment, for example through improved access or the contribution to new knowledge that arises from investigation."	Paragraph 2.6.142	Any beneficial effects to the offshore archaeology and cultural heritage resource resulting from the proposed Norfolk Boreas project have been identified and incorporated as part of section 17.7.
"Where elements of an application (whether offshore or onshore) interact with features of historic maritime significance that are located onshore, the effects should be assessed in accordance with the policy at section 5.8 of EN-1."	Paragraph 2.6.143	Potential impacts of the proposed Norfolk Boreas project upon onshore heritage assets have been considered in Chapter 28 Onshore Archaeology and Cultural Heritage.

14. This assessment has also been prepared in accordance with the East Inshore and East Offshore Marine Plans (DEFRA 2014), which outlines the objective 'to conserve heritage assets, nationally protected landscapes and ensure the decisions consider the seascape of the local area'. This objective recognises the need to consider whether developments are appropriate to the area they will be located in and have an influence upon, and seeks to ensure that, as far as possible, the value of such assets and characteristics are not compromised. Policies specific to heritage assets are outlined in Table 17.2.

Table 17.2 Summary of East Inshore and East Offshore Marine Plans

Plan policies specific to heritage assets	Norfolk Boreas assessment
Policy SOC2: Proposals that may affect heritage assets should demonstrate, in order of preference: That they will not compromise or harm elements which contribute to the significance of the heritage asset How, if there is compromise or harm to a heritage asset, this will be minimised How, where compromise or harm to a heritage asset cannot be minimised it will be mitigated against or The public benefits for proceeding with the proposal if it is not possible to minimise or mitigate compromise or harm to the heritage asset	The primary method of mitigation when dealing with the archaeological resource as set out in this chapter is the precautionary principle, based on the prevention of damage to receptors by putting in place protective measures rather than attempting to repair damage. Avoidance by means of Archaeological Exclusion Zones (AEZ) will serve to ensure that such assets will not be compromised. Potential archaeological receptors are safeguarded or the effects upon them minimised by means of mitigation measures outlined in section 17.7.2.

17.3 Consultation

15. Consultation specific to offshore archaeology and cultural heritage which has informed the preparation of this ES is detailed in Appendix 17.1. The Appendix also outlines how the comments have informed the ES or, if this is not the case, a response to the comment is provided. Specific consultation responses comprise:

- The Planning Inspectorate Scoping Opinion to the Norfolk Boreas Scoping Report (Royal HaskoningDHV 2017);
- Consultation with Historic England on the Norfolk Boreas Offshore Archaeology Method Statement (Royal HaskoningDHV, 2018 unpublished);
- The Expert Topic Group (ETG) meeting held 8th March 2018;
- Historic England's Section 42 response to the PEIR; and
- The ETG meeting held 1st February 2019.

16. Account has also been taken of specific correspondence from Historic England (dated 5th and 11th June 2018) concerning the application of Optically Stimulated Luminescence (OSL) dating techniques to acquired core samples. Furthermore, account has also been taken of consultation for Norfolk Vanguard, including Historic England's Written Representation to the DCO submission.

17. Feedback received during this consultation process has been incorporated into the ES wherever possible. However, in order to allow the timely preparation of this ES a cut-off date of the 20th March has been applied for incorporating new information into the ES chapter. Full details of the project consultation process are presented within Chapter 7 Technical Consultation.

17.4 Assessment Methodology

17.4.1 Impact Assessment Methodology

18. Chapter 6 EIA Methodology details the general impact assessment methodology, and the following sections describe more specifically the methodology used to assess the potential impacts of the project on onshore archaeology and cultural heritage. The impact assessment methodology for offshore and intertidal archaeology and cultural heritage is consistent with that outlined in the Offshore Archaeology Method Statement (Royal HaskoningDHV, 2018), as agreed with Historic England, and rests on the notion that the matrix-based approach must be qualified through descriptive analysis (e.g. a narrative) and professional judgement.

19. This section details the methodology broadly used to determine the significance of the impacts of the offshore and intertidal works of the project on archaeological receptors (herein referred to as heritage assets). The assessment criteria and assignment of significance with respect to offshore and intertidal archaeology and cultural heritage considerations are based on available standards and guidance (see section 17.2), good practice, consultation (see Appendix 17.1) and on professional judgement.

20. The impact assessment methodology adopted for offshore and intertidal archaeology and cultural heritage defines those assets likely to be impacted by the project. The assessment is not limited to direct physical impacts, but also assesses potential indirect impacts associated with changes to physical processes, changes to the setting of heritage assets and historic seascape character and impacts to site preservation conditions from drilling fluid breakout and from heat loss from installed cables.

21. More specifically the impact assessment presents:

- The perceived heritage importance (in many cases associated with heritage significance, including the contribution that setting makes that significance) of any heritage assets identified as being affected;
- The anticipated magnitude of effect (change) upon those assets and their settings (where relevant);
- The significance of any identified impacts upon those assets and their settings; and
- The level of any harm (or benefit) and loss of heritage significance.

22. The impact assessment methodology adopted may differ from the standard approach adopted more generally within this ES, for other technical disciplines. The standardised and tailored EIA matrices will provide a useful guidance framework for the expert judgement of suitably experienced and qualified heritage practitioners

based on the heritage specific legislation, policy and guidance documents available (see section 17.2 above), and using the fundamental concepts from the NPPF of benefit, harm and loss.

23. As stated in section 17.1, different scenarios (see Chapter 5 project description for detail) are not relevant for the assessment of offshore archaeology (Chapter 6 EIA Methodology), however the worst case does include project interconnector cables which could only be required if Norfolk Vanguard is constructed.

17.4.1.1 Sensitivity (Heritage Significance / Importance)

24. The sensitivity of a receptor (heritage asset) is a function of its capacity to accommodate change and reflects its ability to recover if it is affected. However, while impacts to a heritage asset's setting or character can be temporary, impacts which result in damage or destruction of the assets themselves, or their relationship with their wider environment and context, are permanent. Once damaged or destroyed a heritage asset cannot recover. For this reason, the sensitivity of heritage assets is determined by their heritage significance (archaeological importance). On this basis, the assessment of the significance of any identified impact is largely a product of the heritage importance of an asset (rather than its sensitivity) and the perceived magnitude of the effect on it, assessed and qualified by professional judgement.

25. An assessment of effects on an asset involves an understanding of the heritage importance of the asset and in the case of an effect on the setting of that asset, the contribution that the setting makes to the heritage importance (or heritage significance) of the asset. Policy sets out that the level of detail should be proportionate to the significance of the heritage asset and no more than is sufficient to understand the potential impact of the project (NPPF paragraph 189, 2018).

26. The categories and definitions of heritage importance described in Table 17.3 do not necessarily reflect a definitive level of importance of an asset. They are intended to provide a provisional guide to the assessment of perceived heritage importance, which is to be based upon professional judgement incorporating the evidential, archaeological, historical, aesthetic, architectural and communal heritage values of the asset or assets.

27. Archaeological assessments that may alter the perceived heritage significance of an asset may be undertaken pre- and post-consent and can include the archaeological assessment of further geophysical and geotechnical data, ground truthing using Remote Operated Vehicles (ROVs) or divers or further desk-based research (e.g. on individual historic wrecks).

28. Establishing heritage importance (or likely heritage importance) of an asset or group of assets, and the related impact significance by considering the perceived magnitude of effect on the asset or assets, assists in the development of appropriate mitigation approaches. It is important to note that the heritage importance of an asset can be amended or revised as more information comes to light.

29. Where uncertainty occurs, the precautionary approach is to assign high heritage significance (importance). This precautionary approach represents good practice in archaeological impact assessment and reduces the potential for impacts to be under-estimated.

Table 17.3 Indicative criteria for determining heritage importance

Heritage Significance (Importance)	Definitions/Example Assets
High (perceived International/National Importance)	Assets of acknowledged international/national importance (e.g. World Heritage Sites, Scheduled Monuments, Protected Wreck Sites and undesignated assets of equivalent quality and importance). Assets that can contribute significantly to acknowledged international/national research objectives.
Medium (perceived Regional Importance)	Assets that contribute to regional research objectives. Assets with regional importance, educational interest or cultural appreciation.
Low (perceived Local Importance)	Assets that contribute to local research objectives. Assets with local importance, educational interest or cultural appreciation. Assets that may be heavily compromised by poor preservation and/or poor contextual associations.
Negligible	Assets with no significant importance or archaeological/historical interest.
Unknown	The importance/existence/level of survival of the asset has not been ascertained (or fully ascertained/understood) from available evidence.

30. It is important that there is a narrative behind the assessment, for example as a modifier (qualifier) for the heritage importance assigned to an asset, or the perceived magnitude of effect on the asset.

17.4.1.2 Magnitude

31. The classification of the magnitude of effect on heritage assets takes account of such factors as:

- The physical scale and nature of the anticipated disturbance; and
- Whether specific features or evidence would be lost which are fundamental to the historic character and integrity of a given asset, including its understanding and appreciation.

32. Both direct and indirect impacts on heritage assets are considered relevant. Impacts may be adverse or beneficial. Depending on the nature of the impact and the

duration of development, impacts can also be temporary and/or reversible or permanent and/or irreversible.

33. The finite nature of archaeological remains means that physical impacts are almost always adverse, permanent and irreversible; the 'fabric' of the asset and, hence, its potential to inform our historical understanding, will be removed. By contrast, effects upon the setting of heritage assets will depend upon the scale and longevity of the development and the sensitivity with which the landscape is re-instated subsequent to decommissioning, if applicable.

34. The indicative criteria used for assessing the magnitude of adverse effect with regard to archaeology and cultural heritage are presented in Table 17.4 below.

Table 17.4 Indicative criteria for assessing adverse magnitude of effect

Magnitude	Definition
High	Total loss of or substantial harm to an asset.
Medium	Partial loss of, harm to or alteration of an asset which will substantially affect its significance.
Low	Minor loss of or alteration to an asset which leave its current significance largely intact.
Negligible	Minor alteration of an asset which does not affect its significance in any notable way.

35. The magnitude of positive effect with regard to archaeology and cultural heritage directly relates to the level of public value associated with an individual effect. Benefits may correspond directly to the project itself where a project will enhance the historic environment (e.g. through measures which will improve the setting of a heritage asset or public access to it, or through indirect impacts which provide additional protection to an exposed site on the seabed through increased sediment cover) or ensure that a direct impact is avoided where possible (e.g. by ensuring archaeological / cultural heritage input into the iterative project design process so that route refinement / micrositing can be factored into the application boundary). Alternatively, benefits may occur on the basis of data gathering exercises undertaken for the purpose of a project which will enhance public understanding by adding to the archaeological record (e.g. through the accumulation of publicly available data). The measure of positive effect (high / medium / low) is, therefore, necessarily situational and specific to a given site, area or subject. For this reason, magnitude of positive effect is discussed within the narrative of the assessment according to criteria defined on a case-by-case basis, and not defined by overarching indicative criteria as for adverse magnitude of effect in Table 17.4.

17.4.1.3 Impact significance

36. Following the identification of the heritage importance of the receptor (heritage asset), and the magnitude of the impact (effect / change), it is possible to determine

the significance of the impact using the matrix presented Table 17.5 below and the definitions presented in Table 17.6.

Table 17.5 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*

Table 17.6 Impact Significance Definitions

Impact Significance	Definition
Major	May equate to substantial harm or total loss of the value of a designated heritage asset (or asset potentially worthy of designation) such that development may not be consented unless substantial public benefit is delivered by the project. Effective/acceptable mitigation options are still likely to be possible, to offset and/or reduce residual impacts to satisfactory levels.
Moderate	Less than substantial harm to the significance of a designated heritage asset (or asset potentially worthy of designation) such that the harm should be weighed against the public benefit delivered by the development to determine consent. Effective/acceptable mitigation options are likely to be possible, to offset and/or reduce residual impacts to satisfactory levels.
Minor	Harm to a designated or non-designated heritage asset that can be adequately compensated through the implementation of a programme of industry standard mitigation measures.
Negligible	Impact that is nil, imperceptible and not significant.
No Impact	No change, therefore no impact in receptor condition.

37. For the purposes of this chapter of the EIA, 'major' and 'moderate' impacts are generally deemed to be significant (in EIA terms). In addition, whilst minor impacts are not significant in their own right, it is important to distinguish these from other non-significant (negligible) impacts as they may contribute to significant impacts cumulatively or through interactions between heritage assets or elements of the historic environment (historic landscape/seascape).

38. Embedded mitigation (for example where potential impacts to known heritage assets are avoided through AEZs and micro-siting through design) is referred to and included prior to initial assessment of impacts. If the impact does not require

mitigation (or no mitigation is possible) the residual impact will remain the same. If, however, specific mitigation is required then there an assessment of the post-mitigation residual impact is provided.

39. With regard to beneficial impact, as outlined for magnitude in section 17.4.1.2 above, definitions are dependent upon the level of public value relevant to a given area, site or subject and are discussed within the narrative on a case by case basis.

17.4.2 Historic Seascape Character

40. The approach to the consideration of historic seascape character differs to that outlined above for heritage assets. The historic character of the seascape is described in terms of ability to accommodate change. For this reason, an approach is required which recognises the dynamic nature of the seascape and how all aspects of the landscape, no matter how modern or fragmentary, are treated as part of historic landscape character. It is not meaningful, therefore, to assign a level of heritage importance to these aspects of landscape character. Neither is it meaningful to assign a measure of magnitude in order to understand the nature of the potential changes. Rather, this change is expressed as a narrative description of the seascape character and its ability to accommodate change arising from the project.

17.4.3 Cumulative Impact Assessment

41. The general method for cumulative impact assessment is set out in Chapter 6 EIA Methodology.

42. Cumulative impacts may occur where archaeological receptors also have the potential to be impacted by other existing, consented and/or proposed developments or activities. This includes consideration of the extent of influence of changes to marine physical processes (see Chapter 8) arising from the proposed project alone and those arising from the proposed project cumulatively or in combination with other offshore wind farm developments (particularly East Anglia THREE, East Anglia ONE and Norfolk Vanguard due to their proximity to the project).

43. The cumulative impact assessment has been carried out in accordance with the document Guidance for Assessment of Cumulative Impacts on the Historic Environment from Offshore Renewable Energy issued by COWRIE (Oxford Archaeology 2008).

44. Cumulative impacts are considered in section 17.8.

17.4.4 Transboundary Impact Assessment

45. The general method for transboundary impact assessment is set out in Chapter 6 EIA Methodology.

46. Transboundary impacts may be relevant to offshore archaeology and cultural heritage where wrecks of non-British, European nationality are subject to impact from development and may therefore fall within the jurisdiction of another country. Transboundary impacts may also occur if the cumulative effects of changes to physical processes have the potential to impact archaeology across extended sea areas. In addition, there is potential for developments, individually and cumulatively, to affect larger-scale archaeological features such as palaeolandscapes and to affect the setting of heritage assets and historic landscapes/seascapes which may also extend across these boundaries. This may also include sensitivities in conjunction with local community groups and interests.

47. Transboundary impacts are considered in section 17.9.

17.5 Scope

17.5.1 Study Area

48. The study area comprises the Norfolk Boreas site, the offshore cable corridor, including the landfall up to MHWS, and the project interconnector search area (Figure 17.1). The project interconnector search area corresponds to the potential area within which buried offshore cables linking an offshore electrical platform in the Norfolk Boreas site with an offshore electrical platform in the Norfolk Vanguard site could be sited. This area partially overlaps with the offshore cable corridor.

49. Geophysical and geotechnical data assessed by Wessex Archaeology for the Norfolk Boreas project covers the Norfolk Boreas site and a spur from the main offshore cable corridor to the site (Appendix 17.2) the part of the project interconnector search area immediately south of the site (Appendix 17.3).

50. The assessment carried out by Wessex Archaeology for Norfolk Vanguard (Appendix 17.4) covers the offshore cable corridor (which is shared by both projects) and the parts of the project interconnector search area which correspond to Norfolk Vanguard East OWF site (NV East) and Norfolk Vanguard West OWF site (NV West).

17.5.2 Data Sources

51. The assessment of the existing environment presented in section 17.6 is informed by the results of the work undertaken by Wessex Archaeology as presented in the following technical reports:

- Appendix 17.2: Norfolk Boreas Offshore Windfarm Archaeological Assessment of Geophysical Data;
- Appendix 17.3: Norfolk Boreas Offshore Windfarm Archaeological Assessment of Geophysical Data - Addendum;

- Appendix 17.4: Norfolk Vanguard Offshore Wind Farm Marine Archaeological Technical Report;
- Appendix 17.5: Norfolk Boreas Offshore Windfarm Stage 1 Geoarchaeological Review;
- Appendix 17.6: Norfolk Boreas Offshore Wind Farm Stage 2 Geoarchaeological Review;
- Appendix 17.7: Norfolk Boreas Offshore Wind Farm Stage 3 Geoarchaeological Assessment;
- Appendix 17.8: Norfolk Boreas Offshore Windfarm Stage 4 Paleoenvironmental Assessment; and
- Norfolk Vanguard geoarchaeological assessment Stages 1, 2, 3 and 4 (Wessex Archaeology, 2017, 2018a, 2018b, 2019).

52. The technical reports authored by Wessex Archaeology for Norfolk Boreas (Appendix 17.2, Appendix 17.3, Appendix 17.5, Appendix 17.6, Appendix 17.7, and Appendix 17.8) were informed by the following data sources:

- Geophysical survey datasets acquired by Fugro within the Norfolk Boreas site between May and August 2017 and within the offshore cable corridor between September and November 2016;
- Geotechnical (vibrocore) logs acquired by Fugro from 50 locations within the Norfolk Boreas site in 2017;
- Geophysical survey data previously acquired over NV East by EMU Limited (EMU) in 2012;
- Known wreck and obstruction locations and information for the study area provided by the United Kingdom Hydrographic Office (UKHO); and
- Past reports and assessments undertaken by Wessex Archaeology for projects from the former East Anglia Zone.

53. The technical report authored by Wessex Archaeology (Appendix 17.4) was informed by the following data sources:

- Geophysical survey and geotechnical data acquired for the project by Fugro Survey B. V. (Fugro) between September and November 2016 over NV West and the offshore cable corridor;
- Geophysical survey data previously acquired over NV East by EMU Limited (EMU) and over the eastern end of the offshore cable corridor by Coastline Surveys Ltd in 2012;
- UKHO data for charted wrecks and obstructions;
- The National Record of the Historic Environment (NRHE) maintained by Historic England, comprising data for terrestrial and marine archaeological sites, find spots and archaeological events;

- The National Heritage List for England maintained by Historic England, comprising data of designated heritage assets including sites protected under the Protection of Military Remains Act 1986 and the Protection of Wrecks Act 1973;
- The Norfolk Historic Environment Record (NHER), comprising a database of all recorded terrestrial and marine archaeological sites, find spots and archaeological events within the county and offshore;
- The HSC report for East Yorkshire to Norfolk (Newcastle University, 2014);
- The Coastal and Intertidal Zone Archaeology Network (Citizens) project database of archaeological find spots;
- Relevant mapping including Admiralty Charts, historic maps and Ordnance Survey; and
- Relevant documentary sources and grey literature held by Wessex Archaeology, and those available through the Archaeological Data Service and other websites.

54. Full details of the technical specifications of the acquired geophysical data can be found in section 2.2 of Appendix 17.2 and section 3.3 of Appendix 17.4 and are summarised in Table 17.7 below.

Table 17.7 Summary of Acquired Geophysical Data

Survey campaign		Line spacing	Data type and resolution	Data quality*	Suitability
Norfolk Boreas, Fugro 2017	*Fugro Pioneer*	Main line spacing of 100m, with cross lines at 1,000m	Sidescan sonar (typically 125m horizontal range)	Average	Overall of good quality, some lines affected by poor weather conditions.
			Multibeam bathymetry (1m resolution)	Good	Good standard for archaeological assessment
			Magnetometer	Average	Overall of good quality for archaeological assessment, some noise due to poor weather conditions And evidence of strong background geological noise.
			Sub-bottom profiler (hull-mounted Pinger)	Good	Some slight weather effects but where large sand dunes were not present small reflectors were clearly visible and good penetration was achieved.

Survey campaign		Line spacing	Data type and resolution	Data quality*	Suitability
NV West and offshore cable corridor, Fugro 2016	*Fugro Pioneer* (NV West and offshore section of offshore cable corridor)	Main line spacing of 100m, with cross lines run every 1,000m	Sidescan sonar (typically 125m horizontal range)	Variable	Overall suitable quality to support a robust archaeological assessment
			Multibeam bathymetry (1m resolution)	Good	Good standard for archaeological assessment
			Magnetometer	Average	Affected by noise and some background variation
			Sub-bottom profiler (hull-mounted pinger)	Good	Good standard for archaeological assessment
	RV *Discovery* (mid-section of offshore cable corridor)	Line spacing ranging from 50m to 100m, depending on the area.	Sidescan sonar (typically 75m horizontal range)	Variable	Overall suitable quality to support a robust archaeological assessment
			Multibeam bathymetry (1m resolution)	Good	Good standard for archaeological assessment
			Magnetometer	Average	Affected by noise and some background variation
			Sub-bottom profiler (hull-mounted pinger)	Variable	Cannot be guaranteed that all palaeogeographic features of archaeological potential have been identified
	Valkyrie (inshore section of offshore cable corridor)	Line spacings ranging from 15m to 75m, depending on the area	Sidescan sonar (25m horizontal range)	Variable	Overall suitable quality to support a robust archaeological assessment
			Multibeam bathymetry (1m resolution)	Good	Good standard for archaeological assessment
			Magnetometer	Average	Affected by noise and some background variation
			Sub-bottom profiler (hull-mounted pinger)	Variable	Cannot be guaranteed that all palaeogeographic features of archaeological potential have been identified

Survey campaign		Line spacing	Data type and resolution	Data quality*	Suitability
NV East, Emu 2012	MV *Aurelia*	Main line spacing of 100m, with cross lines acquired every 2,000m	Sidescan sonar (75m horizontal range)	Good	Some weather noise; on the whole suitable for archaeological assessment
			Multibeam bathymetry (1m resolution)	Good	Good standard for archaeological assessment
			Magnetometer	Variable	Affected by the geological composition of the site
			Sub-bottom profiler (pinger and sparker)	Average	High degree of swell on some lines; still deemed suitable for archaeological interpretation.
Eastern end of offshore cable corridor, Coastline Surveys Ltd 2012	MV *Flatholm*	Main line spacing of 100m, with cross lines acquired every 2,000m	Sidescan sonar (75m horizontal range)	Good (small number of lines Variable)	On the whole suitable for archaeological assessment
			Multibeam bathymetry (1m resolution)	Good	Good standard for archaeological assessment
			Magnetometer	Variable	Affected by the geological composition of the site
			Sub-bottom profiler (pinger and boomer)	Poor or very poor, with very few lines rated as 'Average' or 'Good'	Data affected by high degrees of swell and penetration and resolution of features is generally very low

*Wessex Archaeology criteria for assigning geophysical data quality rating (Appendix 17.4, Table 4)	
Good	Data which are clear and unaffected by weather conditions or sea state. The dataset is suitable for the interpretation of standing and partially buried metal wrecks and their character and associated debris field. These data also provide the highest chance of identifying wooden wrecks and debris.
Average	Data which are affected by weather conditions and sea state to a slight or moderate degree. The dataset is suitable for the identification and partial interpretation of standing and partially buried metal wrecks, and the larger elements of their debris fields. Wooden wrecks may be visible in the data, but their identification as such is likely to be difficult.
Variable	This category contains datasets with the quality of individual lines ranging from good to average to below average. The dataset is suitable for the identification of standing and some partially buried metal wrecks. Detailed interpretation of the wrecks and debris field is likely to be problematic. Wooden wrecks are unlikely to be identified.

17.5.3 Assumptions and Limitations

55. Data used to compile this report consists of primary geophysical and geotechnical survey data and secondary information derived from a variety of sources relevant to this assessment. The assumption is made that the secondary data, as well as that derived from other secondary sources, is reasonably accurate.

56. The records held by the UKHO, NRHE, NHER and the other sources used in this assessment are not a record of all surviving cultural heritage assets, rather a record of the discovery of a wide range of archaeological and historical components of the marine historic environment. The information held within these datasets is not complete and does not preclude the subsequent discovery of further elements of the historic environment that are, at present, unknown. In particular, this relates to buried archaeological features.

57. In their comments on the Norfolk Boreas PEIR (Appendix 17.1), Historic England stated that the line spacing used for the geophysical surveys (see Table 17.7) is generally larger than is recommended in their marine geophysics guidance (30m–50m, with cross lines at maximum up to 10 × the principal line spacing) (Historic England, 2013). They also draw attention to the quality of data (see Table 17.7) and in particular to the statement made by Wessex Archaeology in paragraph 3.3.26 of Appendix 17.4 that (with respect to the quality of the sub-bottom profiler data acquired by Fugro on-board the *Discovery* and *Valkyrie*) that it cannot be guaranteed that all palaeogeographic features of archaeological potential have been identified.

58. In recognition of this above comments, the following limitations with the geophysical data are acknowledged by Norfolk Boreas Limited:

- As stated in paragraph 2.4.3 of Appendix 17.3, a small part of the project interconnector search area between the Norfolk Boreas site and NV East is not covered by geophysical data (see Appendix 17.3 Figure 1). However, a pipeline runs through this area and consequently it is probable that any archaeology will already have been disturbed;
- While the geophysical data assessed for the purposes of this ES are described as being of good quality for archaeological assessment, or as generally suitable for archaeological assessment, some of the data has been affected by noise associated with bad weather and some background geological variation;
- The line spacings for the surveys are greater than those recommended by Historic England, although as acknowledged in the guidance, the techniques and survey strategies used for large area reconnaissance surveys are multi-purpose (Historic England 2013: 7) and (specifically with reference to sidescan sonar surveys) it is recognised that the recommended line spacings are for research

standards surveys, and will vary with the different purposes of offshore survey (Historic England, 2013: 19).

59. With direct reference to wind farm development, three types of surveys are identified in the Historic England (2013:19) guidance:

- pre-consent regional-scale surveys and EIA;
- engineering, archaeology and unexploded ordnance (UXO) surveys based on precise installation locations; and
- post-installation monitoring.

60. The geophysical survey and assessment undertaken to date corresponds to the first of these three surveys, with a clear commitment set out through the draft DCO and Outline WSI to undertake pre-construction archaeological assessment (the second type of survey) and post-construction monitoring (the third type of survey) (see Section 17.7.2 Embedded Mitigation). As stated in the Historic England (2013:7) guidance any multi-purpose survey (such as that undertaken in support of this ES) needs to be sufficient to give a clear indication of the archaeological potential of the area.

61. It is therefore the position of Norfolk Boreas Limited that the geophysical data acquired in support of this ES meets this requirement and that confidence in the data is sufficient to provide an accurate characterisation of the archaeological potential of the study area. The acquisition of further pre-construction data (post-consent) will provide additional information at a greater resolution on known heritage assets, paleogeographic features and geophysical anomalies with archaeological potential which in turn will inform the application of the Embedded Mitigation as set out in section 17.7.2. Pre-construction surveys will focus upon areas where works will be undertaken (including construction activities such as the placement of vessel anchors and pre-construction boulder and UXO clearance) incorporating micro-siting considerations to avoid known wrecks and geophysical anomalies identified as part of this ES, where possible.

17.6 Existing Environment

17.6.1 Seabed Prehistory

62. There are no known seabed prehistory sites within the study area. Prehistoric archaeology at the landfall at Happisburgh South is discussed in section 17.6.3.

63. The potential for prehistoric sites to be present within the study area, either exposed on the seabed or buried within seabed deposits, is primarily associated with surviving terrestrial features and deposits corresponding to times when sea levels were lower and hence prehistoric hominin populations may have inhabited what is now the seabed. Archaeological material may also be present within secondary

contexts, as isolated finds within deposits comprising material from terrestrial phases that may have been reworked by marine or glacial processes, for example.

64. A broad pattern of geological units within the study area has been interpreted by Wessex Archaeology based upon both marine geophysical (sub-bottom profiler) and geotechnical data (vibrocores). The interpretation undertaken for the Norfolk Vanguard project (Appendix 17.4 and Wessex Archaeology, 2017, 2018a, 2018b and 2019) identified eight different units within the Norfolk Vanguard offshore project area, while within the Norfolk Boreas site (Appendix 17.2, Appendix 17.3, Appendix 17.5, Appendix 17.6, Appendix 17.7 and Appendix 17.8), the data showed the presence of five units (and sub-units).

65. Interpretation of the data has also been carried out by Fugro in order to inform the projects design and engineering objectives. The interpretation of soil stratigraphy reported by Fugro broadly corresponds to that presented by Wessex Archaeology although there are slight differences.

66. The technical reports produced by Wessex Archaeology for Norfolk Boreas initially included reference to only the five units (and sub-units) seen in the Norfolk Boreas data (Appendix 17.2, Appendix 17.3, Appendix 17.5, Appendix 17.6 and Appendix 17.7). However, in order to provide consistency across the study area and across projects (Norfolk Boreas and Norfolk Vanguard), Wessex Archaeology have subsequently reported on all eight of the units seen across both projects (see Table 4 in Appendix 17.8). These unit definitions are set out in Table 17.8 presented stratigraphically with Unit 8, the youngest deposit, at the top and Unit 1, the oldest deposit, at the bottom, and unit numbers are consistent to both Norfolk Boreas and Norfolk Vanguard.

Table 17.8 Shallow-stratigraphy of the Norfolk Boreas project area (deposit model) with broad date ranges provided according to Marine Isotope Stage (MIS)

WA Unit	WA Unit Name Age (MIS)	Geophysical characteristics	Sediment type and depositional environment
8	Seabed sediments *Holocene post-transgression (MIS 1)*	Generally observed as a veneer or thickening into large sand wave and bank features up to 20 m in height. Boundary between surficial sediments and underlying units not always discernible.	Medium to coarse sand with frequent shell fragments – marine.
7c	Elbow Formation – intertidal *Early Holocene (MIS 1)*	Not identified within the geophysical data as deposit thickness is lower than geophysical data resolution.	Laminated sand, silt and clay – intertidal.

WA Unit	WA Unit Name Age (MIS)	Geophysical characteristics	Sediment type and depositional environment
7b	Elbow Formation – organic *Late Devensian to Early Holocene (MIS 2-1)*	Extensive areas of intermittent, relatively flat, high amplitude reflectors. Often associated with shallow channelling.	Peat ranging from strongly to weakly decomposed with plant fragments (reeds) roots and wood preserved – terrestrial/coastal wetland.
7a	Elbow Formation – fluvial *Late Devensian to Early Holocene (MIS 2-1)*	Small, shallow, infilled channels. Fill characterised as acoustically chaotic or transparent, or by sub-parallel internal reflectors. Incises into the top of Upper Brown Bank.	Sand with silt and clay laminations, occasionally organic, may comprise plant/root or shell fragments – fluvial/alluvial, possible reworking of older deposits.
6	Twente Formation – *Late Devensian (MIS 2)*	Not identified in shallow geophysical data	Not identified in geotechnical core logs.
5	Upper Brown Bank *Early-Mid Devensian (MIS 5d-3)*	Observed as a blanket deposit across much of the area, either acoustically transparent or characterised by sub-horizontal layered reflectors. Contains numerous internal erosion surfaces, occasional fluid escape structures, and areas of acoustic blanking.	Silty clay and clayey silt with closely spaced fine laminations. May be sandy in places or comprise sand partings/laminations – restricted marine/open estuary.
4	Lower Brown Bank/Eem Formation *Ipswichian to Early Devensian (MIS 5e-5d)*	Observed within large topographically controlled depressions. Characterised by low relief basal reflector and either an acoustically transparent or well-layered fill.	Not identified in geotechnical data.
3	Swarte Bank *Anglian (MIS 12)*	Not identified in shallow geophysical data.	Not identified in geotechnical data.
2	Yarmouth Roads *Early to Mid-Pleistocene (>MIS 13)*	Thick unit either seismically chaotic or containing numerous areas of well-defined cross cutting channel complexes characterised by layered sub-parallel internal reflectors. Top of unit generally a well-defined regional erosion surface.	Not identified in geotechnical data.
1	Westkapelle Ground Formation *Late Pliocene to Early Pleistocene (MIS 63-103)*	Not identified in shallow geophysical data within Norfolk Boreas site. In offshore cable corridor observed as acoustically unstructured unit with a generally well-defined basal reflector.	Deltaic silty clays and sands.

67. Wessex Archaeology has also interpreted a number of paleogeographic features from the sub-bottom profiler data which have been correlated with the geological units described above to provide a detailed description of the potential for prehistoric archaeology (Appendix 17.2, Appendix 17.3 and Appendix 17.4). Paleogeographic features of archaeological interest are discriminated by Wessex Archaeology in accordance with the definitions set out in Table 17.9.

Table 17.9 Wessex Archaeology's criteria discriminating relevance of palaeogeographic features to proposed scheme (Appendix 17.2 Table 5)

Archaeological Discrimination		Description
Archaeological	P1	Feature of probable archaeological interest, either because of its palaeogeography or likelihood for producing palaeoenvironmental material
	P2	Feature of possible archaeological interest

68. In order to inform the seabed prehistory baseline for this ES, the detailed descriptions provided for both Norfolk Boreas (Appendix 17.2, Appendix 17.3, Appendix 17.5, Appendix 17.6, Appendix 17.7 and Appendix 17.8) and Norfolk Vanguard (Appendix 17.4 and Wessex Archaeology, 2017, 2018a, 2018b and 2019) have been considered holistically against the locations of the interpreted paleogeographic features mapped in using Geographical Information Systems (GIS). The seabed prehistory baseline specific to the PEIR study area is presented below and illustrated on Figures 17.2 and 17.3.

69. Unit 1 (Westkapelle Ground Formation) was recorded by Wessex Archaeology within the offshore cable corridor only and is of no archaeological interest as this pre-dates the earliest occupation of the UK by hominins.

70. Unit 2 (Yarmouth Roads Formation) is present across the study area and is an extensive delta top deposit covering a large section of the Southern North Sea and deposited during the Cromerian (interglacial) prior to the Anglian Glaciation. The upper layers of this Unit are believed to be contemporaneous with the Cromer Forest Bed Formation onshore, within which the earliest evidence for prehistoric hominin activity in the UK has been discovered at Happisburgh and Pakefield (Parfitt et al., 2010; Parfitt et al., 2005) (see section 17.6.3).

71. There is potential for in-situ Lower Palaeolithic archaeological artefacts and in-situ and derived palaeoenvironmental material associated with these upper layers of the Yarmouth Roads Formation and this potential is highest in areas where channels have been observed. Within the sub-bottom profiler data Unit 2 has been seen with large, complex cross cutting internal channels in some areas. Due to the complexity it is not possible to map these channels individually and the channels are interpreted as a complex delta-top deposit rather than a single river channel.

72. The level of potential associated with Unit 2 is dependent upon which level of the Yarmouth Roads Formation is present as only the upper layers are considered to be of archaeological potential and these may have been removed by erosion. In order to understand this potential within the study, geoarchaeological assessment would be required to establish the age of the unit. Vibrocores acquired for the Norfolk Vanguard and Norfolk Boreas projects, however, did not penetrate far enough to sample this unit (Appendix 17.5, Appendix 17.6, Appendix 17.7 and Appendix 17.8 and Wessex Archaeology, 2017, 2018, 2018a and 2019).

73. Unit 3 (Swarte Bank Formation) is associated with the Anglian glaciation, a period when hominin presence was precluded by the subglacial environment, and is not considered to be of archaeological interest. Unit 3 was not definitively identified within the data by Wessex Archaeology although Fugro's interpretation of deeper stratigraphy using ultra high resolution (UHR), multi-channel data has indicated that it is present within the project interconnector search area in NV West.

74. Unit 4 (Lower Brown Bank / Eem Formation) is of uncertain age comprising either the shallow marine/intertidal Eem Formation laid down during the Ipswichian interglacial or lower deposits of the Brown Bank Formation, a lagoon deposit of Lower Devensian age. The marine Eem formation is of limited archaeological potential, although the unit may cover earlier Lower Palaeolithic land surfaces. The Lower Brown Bank deposits may contain in-situ and derived Middle Palaeolithic artefacts and intact organic material of palaeoenvironmental interest.

75. Within the eastern section of the project interconnector search area (in the area of NV East) this deposit has been recorded infilling a number of large depressions (75003, 75009, 75011, 75015, 75017, 75128 and 75129) (Figure 17.2). Within the western section (in the area of NV West) Unit 4 has only been tentatively, sporadically identified associated with thinner features which could not be individually mapped. Within the Norfolk Boreas site Unit 4 is more widespread but comprises a relatively thin layer (approximately 2 m thick) where present. In the southeast of the study area does Unit 4 thicken into a large deposit more in common with that seen in NV East. Features associated with Unit 4 are not recorded from the offshore cable corridor.

76. Unit 5 (Upper Brown Bank Formation) overlies Unit 4 as a blanket deposit (ranging from 3m thick up to 38m thick within one of the large channel features) overlying the whole of the Norfolk Boreas site (Figure 17.2) and project interconnector search area (Figure 17.3, Maps 1 and 2). Along the offshore cable corridor, Unit 5 overlies Unit 2 (and Unit 4 where present) but becomes more intermittent closer to shore, where earlier units outcrop at seabed, and is completely absent by approximately 30km from landfall (Figure 17.3, Maps 3 and 4).

77. The Brown Bank Formation is understood to have been deposited in an intertidal/lagoon environment during the Early or Mid Devensian at a time when an absence of archaeological evidence suggests that hominins may have been absent from Britain. There is, however, potential for Lower Palaeolithic artefacts and underlying land surfaces to be protected beneath the unit in-situ. There is further potential for Middle Palaeolithic artefacts associated with the channel edges (dependent on the age of the infill).

78. Wessex Archaeology have identified a number of internal erosion surfaces within Unit 5, possibly representing buried land surfaces created during periodic drying of lagoons:

- 7600, 7601 and 7689 within the Norfolk Boreas site (Figure 17.2);
- 75115 within the project interconnector search area (Figure 17.3, Map 2); and
- 75156, 75157, 75158, 75161 and 75162 within the offshore cable corridor (Figure 17.3, Map 3).

79. These erosion surfaces are overlain by relict dune features suggesting a significant time of aerial exposure as a terrestrial landscape. As such, these features of high archaeological potential. The geophysical data suggests a multi-period, multi-phase unit rather than a single continuous deposition of lagoon clay. The elongate nature of some of the dunes and their alignment may suggest a possible buried coastline. A further feature, a small area of coarse sediment deposit of Ipswichian or Devensian age (75127, Figure 17.3, Map 2) has also been interpreted as being a possible bank deposit or transgression feature associated with Unit 5.

80. A number of areas of acoustic blanking have also been identified within the Brown Bank Formation, found within both Unit 4 and Unit 5 (see Appendix 17.9 for a full list). These areas of blanking are interpreted to be accumulations of shallow (biogenic) gas indicating the presence of preserved organic material within the sediments that may be of value for palaeoenvironmental analysis. No gas escape indicators have been identified on the seabed and the gas is not considered to have migrated from deeper sources.

81. The results of the geoarchaeological assessment of samples from the Upper Brown Bank Formation by Wessex Archaeology are presented in full in Appendix 17.8. In summary, these results have demonstrated that:

- Brown Bank Formation (Unit 5) was deposited between 83.2 ± 9.5 and 69.8 ± 7.7 ka (MIS 5a-4), in an outer estuarine environment within a shallow marine embayment during a period of climatic instability characterised by cool (stadial) and warm (interstadial) periods, in the Early Devensian;
- The paleogeography of the Norfolk Boreas offshore project area was part of a shallow near-marine embayment fringed by open estuaries. During periods of

lower sea level associated with cool stadials, the Brown Bank embayment would have shallowed with some areas emerging creating a coastal plain along the margins of an estuary or restricted embayment/lagoon; and

- The Brown Bank embayment was a prominent feature in the southern North Sea during the Early Devensian, corresponding to a period of hiatus in the British archaeological record. The presence of this embayment would have created a significant geographic barrier to migration pathways through the southern North Sea during the Middle Palaeolithic and may in part explain the absence of hominins from Britain between MIS 6 and MIS 4.

82. Within the Norfolk Boreas site, at the top of Unit 5 Wessex Archaeology identified a layer classified as ‘undifferentiated’ based on the initial geoarchaeological data (VC016, VC047, Appendix 17.5 and Appendix 17.6). Overlying the Upper Brown Bank deposits, a silty fine to medium sand with occasional shell fragments and black mottles was observed in VC016 (1.37 m thick) and in VC047, Upper Brown Bank is overlain by a silty clay with shell fragments (0.89 m thick). These deposits are not typical of Upper Brown Bank based on previous descriptions of this unit. In the geophysical data, these areas appeared more acoustically chaotic than the rest of Unit 5, with numerous possible poorly defined, cross-cutting channel features which are poorly delineated within the data and have not been mapped. These were interpreted as possible Late Devensian/Early Holocene coastal or shallow water deposits, although it was also recognised that reworking may have occurred (Appendix 17.6).

83. In addition, a series of possible cut and fill features (a feature that has been cut into the geology and then filled in by sediment) have been identified using the sub-bottom profiler data from the Norfolk Boreas site, cut into the Brown Bank Formation (Unit 5). The features appear to comprise a single phase of fill, although the origin is uncertain, and Wessex Archaeology (Appendix 17.2) suggest that they could be of Devensian or Holocene date, either internal features within the Brown Bank or a later, eroded fluvial feature.

84. Following further geoarchaeological assessment (Appendix 17.7 and Appendix 17.8), the foraminifera and ostracod assemblage from these undifferentiated deposits in VC016 were found to show similar characteristics of Upper Brown Bank deposits (i.e. cold climate outer estuarine to marine species) suggesting the Undifferentiated deposits in this core are a sandier part of the Upper Brown Bank, possibly reflecting higher energy shallow water. In contrast, the microfauna from VC047 were different, comprising species that suggest a warmer climate. It has been concluded, therefore, that the presence of both warm and cool/cold climate indicators within Unit 5 may reflect climatic instability during the Early Devensian, with the “warm” species flourishing during interstadials and “cold” species during stadials (Appendix 17.8).

85. While the Brown Bank embayment appears to have been a persistent feature in the landscape (possibly representing a significant barrier to migration pathways through the southern North Sea during the Middle Palaeolithic) the Norfolk Boreas project area would have been partially exposed during periods of lower sea level (Appendix 17.8). This coastal setting, however, would also have been a challenging environment for hominin exploitation. Following the hiatus in the British archaeological record, the earliest evidence of reoccupation occurred at ~60 ka (MIS 3) after the southern North Sea is expected to have emerged creating a terrestrial landscape that may again have supported migration pathways from continental Europe into Britain. However, within the Norfolk Boreas offshore project area, there is a hiatus in the geological record of ~40,000 thousand years during the Upper Palaeolithic and the potential for preservation of archaeological material from this period is considered low. Furthermore, the lower parts of Unit 7a, comprise reworked Early Devensian marine foraminifera, suggesting erosion of the underlying Unit 5 deposits, although the exact process of erosion is unknown and could be related to river, wind or periglacial processes at any time during the Late Devensian.

86. Unit 6 (Twente Formation) is a thin layer of wind-blown sand which formed following the Last Glacial (Devensian) maximum and the retreat of the ice sheet. Elsewhere in East Anglia and on continental Europe these wind-blown deposits are associated with relatively high archaeological potential as even small sand ridges became foci for human habitation within low-lying wetlands. There is potential for in-situ archaeological material, palaeoenvironmental material associated with the Twente Formation which may also protect underlying surfaces. The potential extent of the Twente Formation based upon BGS data is illustrated in Figure 17.2 and Figure 17.3, Maps 1 and 2.

87. Initial assessment undertaken for Norfolk Vanguard indicated the possible presence of Twente Formation within three vibrocores from the north of NV West (VC075, VC076 and VC088) (Wessex Archaeology, 2018a). However, detailed analysis has subsequently shown that the observed sand was more likely to be of waterborne origin rather than wind-blown and, therefore, does not correlate to the Twente Formation. Unit 6 has not, therefore, been positively identified within the Norfolk Vanguard and Norfolk Boreas study areas.

88. Unit 7 comprises pre-transgression fluvial, estuarine and terrestrial deposits laid down in the Holocene and with high potential to contain in-situ and derived archaeological material, and palaeoenvironmental material.

89. A number of Holocene pre-transgression features have been identified by Wessex Archaeology within geophysical data from the study area including a distinct peat horizon (75029) and palaeochannels, along with a series of cut and fill features which could also represent eroded channel systems (see Appendix 17.9 for the full list).

These pre-transgression fluvial features (illustrated on Figure 17.2 and Figure 17.3, Maps 1, 2 and 3) are of high archaeological interest with regard to evidence of a former terrestrial environment possibly containing both in-situ or derived anthropogenic artefacts and preserved palaeoenvironmental material. These low-lying riverine and coastal landscapes would have been suitable for hominin occupation during the early Holocene and samples assessed from the peat deposit (75029) for the Norfolk Vanguard project indicate an Early Mesolithic date (VC074: 10226-9918 cal. BP and VC076: 10208-9911 cal. BP) (Wessex Archaeology, 2018c).

90. Within the Norfolk Boreas site Wessex Archaeology have subdivided Unit 7 into three sub-units (Appendix 17.8). The base unit is characterised by the series of small channel and cut, and fill features interpreted as Early Holocene fluvial channels which formed after the silting/drying up of the lagoon environment represented by Unit 5 (Figure 17.2). Of particularly interest is an extensive feature (7620, 7621 and 7622) seen in the multibeam-bathymetry data as a meandering sediment ridge. Wessex Archaeology suggest that this represents a channel with a fibrous peaty fill which was more resistant to erosion than the surrounding Unit 5 sediments into which it was cut. This feature has high potential to contain in-situ archaeological material.

91. The middle of the three sub-units described by Wessex Archaeology (Appendix 17.2) are peat deposits, indicative of a buried land surface in the Norfolk Boreas site. Three different types of peat have been identified within the vibrocores (Appendix 17.6) suggesting an evolution of the depositional environment over time. The geophysical data indicates that the peat is often directly associated with the Early Holocene fluvial channels described above, present as potential flood plain deposits, seen either side of the channels, or partially or wholly overlaying the channels, potentially developing once the channels had completely silted up. Overlying the peat is a third sub-unit comprising a layer of laminated sand, silt and clay interpreted as an intertidal/transgression layer. This is distinct from the modern seabed sediment Unit 8.

92. The results of the geoarchaeological assessment of samples from Unit 7 by Wessex Archaeology are presented in full in Appendix 17.8. In summary, these results have demonstrated that:

- Peat formation commenced at the very start of the Holocene at 9992 ± 51 BP (UBA-38190; 11710-11260 cal. BP) in VC032 and continued for a period of up to ~700 yrs according to Bayesian chronological modelling, creating an extensive wetland environment in and around a network of fluvial channels;
- The Late Devensian landscape was characterised by active river systems with reed and fen wetlands forming along the margins, and open grassland scattered with dwarf birch. As climate warmed in the Early Holocene, woodland remained

relatively open, but became dominated by pine, and later hazel with some oak and elm. Under rising sea levels, the coastline encroached, giving way to saltmarsh and tidal flats before final inundation;

- The presence of charcoal within peat deposits is evidence of repeated fire-events during the Early Holocene, although it is not possible to establish if these were caused by human activity. Despite the absence of known archaeological material, the potential for human activity within the extensive fluvial and wetland landscapes preserved at Norfolk Boreas is considered high; and
- A sea-level index point from VC032 indicates that the area now occupied by Norfolk Vanguard West became submerged shortly after c. 9700 cal. BP which agrees with sea-level and regional-paleogeographic models. Rates of sea-level rise were rapid (12-12 mm/yr) leaving the landscape little time to adjust; the palaeolandscape features appear to have drowned in-situ, possibly leading to their exceptional preservation.

93. The core samples from Norfolk Boreas are a unique discovery in representing a full sequence of deposits showing the environmental transition from a Late Devensian fluvial setting within open grassland (Unit 7a) through rapid climatic amelioration during the early Holocene (Unit 7b) represented by the formation of peat and the return of woodland (pine, then hazel dominated) followed by a switch to a saltmarsh to mudflat environment which marks inundation of the Norfolk Boreas project area under rising sea-levels (Unit 7c).

94. After initial human recolonization at ~60 ka (MIS 3) there is evidence of sporadic incursions of various cultural groups into the southern North Sea from ~15 ka to the start of the Holocene (Appendix 17.8). This corresponds to Unit 7a within the Norfolk Boreas offshore project area characterised by active rivers in the landscape which may have been exploited for resources, but also used as routeways to support migration. The potential for encountering in-situ or artefactual material within or along the margins of these channels is considered high.

95. The discovery of a widespread “peatland” (Unit 7b) along with peat-infilled and peat-fringed palaeochannels within a single site, is unique within the context of submerged landscape studies undertaken to date (Appendix 17.8). Furthermore, when combined with Norfolk Vanguard, a total of 85 km² of peat deposits have been discovered which could be considered one of the most significant finds in UK submerged landscape research in recent years. Peat development across Norfolk Boreas occurred from 9992 ± 51BP (UBA-38190; 11700-11260 cal. BP) to 8697 ± 45 BP (UBA-38189; 9980-9540 cal. BP) which is broadly contemporaneous with key early Mesolithic sites located along the North Sea coast. These fluvial and wetland landscapes may have provided a pathway for Mesolithic hominid groups moving into

Britain, driven by rising sea levels and landscape inundation. The potential for preservation of archaeological sites within this landscape is considered high.

96. The final inundation of the Norfolk Boreas offshore project area occurred sometime after ~9,700 cal. BP. This area, however, is located on the southern limb of what would have been the last land bridge between Britain and continental Europe (not including the Dogger Bank Island) and is therefore a key area for the study of the response of coastal communities to rapid rates of sea level rise, although this is difficult to perceive without archaeological evidence. Given the relatively short life-expectancy of Mesolithic people, however, it is unlikely coastal change would have been observable within a single generation.

97. Unit 8 comprises post-transgression marine sediments laid down during the Holocene and not considered to be of archaeological potential in themselves, although they could periodically bury and expose sites such as shipwrecks in areas of mobile sediment, and thicker sand deposits could protect earlier land surfaces. Within the Norfolk Boreas site this unit has been worked into a number of large banks, likely to be relict features from the Holocene marine transgression. Between the banks are eroded areas where the Brown Bank Formation outcrops at the seabed, and it is within one of these areas that the sediment ridge (7620, 7621 and 7622) has been exposed.

98. In summary, the key areas of potential for seabed prehistory within the study area comprise:

- Unit 1: no archaeological potential;
- Unit 2: potential for in-situ Lower Palaeolithic archaeological artefacts and in-situ and derived palaeoenvironmental material associated with upper layers if these have not been removed by erosion. This potential is highest in areas where channels have been observed;
- Unit 3: no archaeological potential;
- Units 4: the marine Eem formation is of limited archaeological potential, although the unit may cover earlier Lower Palaeolithic land surfaces. The Lower Brown Bank deposits may contain in-situ and derived Middle Palaeolithic artefacts and intact organic material of palaeoenvironmental interest;
- Unit 5: although the potential for the preservation of archaeological material is low, the Brown Bank embayment may have created a significant geographic barrier to migration pathways through the southern North Sea during the Middle Palaeolithic, correlating to a period of absence in the British archaeological record;

- Unit 6: potential for post-glacial Upper Palaeolithic in-situ archaeological material and palaeoenvironmental material (although the Twente Formation has not been positively identified);
- Unit 7: high potential for in-situ archaeological material and palaeoenvironmental material associated, in particular:
  - Unit 7a: potential to comprise in-situ and reworked archaeology is high, both within channels and along their margins;
  - Unit 7b: high preservation of palaeoenvironmental material. Potential to comprise Upper Palaeolithic or Early Mesolithic artefactual archaeology; and
  - Unit 7c: potential to comprise Early Mesolithic artefactual archaeology.
- Unit 8: not in itself considered to be of prehistoric archaeological potential (may protect buried land surfaces).

17.6.2 Maritime and Aviation Archaeology

99. There are several previously recorded wrecks and obstructions charted by the UKHO (described below) although there are no known aircraft crash sites within the study area. Furthermore, there are no sites within the study area that are subject to statutory protection from the Protection of Wrecks Act 1973, the Protection of Military Remains Act 1986 or the Ancient Monuments and Archaeological Areas Act 1979.

100. Sidescan sonar, multibeam bathymetry and magnetometer data interpreted by Wessex Archaeology has demonstrated the presence of a number of seabed features which have been identified as being of archaeological interest (A1) or potentially of archaeological interest (A2 and A3). The technical specifications for the acquired data are detailed in section 3.3 of Appendix 17.2 and are summarised in Table 17.7 above.

101. Seabed features of archaeological interest are discriminated by Wessex Archaeology in accordance with the definitions set out in Table 17.10.

Table 17.10 Wessex Archaeology's criteria discriminating relevance of seabed features to proposed scheme (Appendix 17.1 Table 2)

Archaeological Discrimination		Description
Non-Archaeological	U1	Not of anthropogenic origin
	U2	Known non-archaeological feature
	U3	Position of a recorded loss at which no physical wreck remains have ever been identified
Archaeological	A1	Anthropogenic origin of archaeological interest
	A2	Uncertain origin of possible archaeological interest
	A3	Historic record of possible archaeological interest – UKHO reference to feature that shows no trace on seabed

102. In total 556 features of archaeological interest or potential archaeological interest have been identified by Wessex Archaeology within data assessed for Norfolk Boreas (Appendix 17.2 and Appendix 17.3). For Norfolk Vanguard, Wessex Archaeology identified a total of 1,475 features (Appendix 17.4). For the purposes of this ES the datasets were combined and interrogated using GIS to identify only those features within the Norfolk Boreas site, offshore cable corridor and project interconnector search area. In total there are 1,425 features of archaeological potential within the Norfolk Boreas study area. These are summarised in Table 17.11 and the following text and presented as a gazetteer in Appendix 17.9. All features are discussed in detail in the corresponding technical reports for Norfolk Boreas (Appendix 17.2 and Appendix 17.3) and Norfolk Vanguard (Appendix 17.4).

Table 17.11 Seabed features of archaeological potential within the study area

Archaeological Discrimination	Number of seabed features				Total
	Norfolk Boreas site	Offshore cable corridor	Offshore cable corridor and Project interconnector search area	Project interconnector search area	
A1	14	25	1	3	43
A2	525	649	43	156	1,373
A3	3	0	0	1	4
U2	5	0	0	0	5
Total	547	674	44	160	1,425
Figure Reference	Figure 17.4	Figure 17.5 Maps 1 to 4	Figure 17.5 Maps 1 and 2	Figure 17.5 Maps 1 and 2	

103. Within the Norfolk Boreas site there are 14 seabed features discriminated as A1. Four of these are wrecks, all of which have previously been recorded by the UKHO including the wreck of the late 19th century paddle steamer *Koningin Regentes*

(7122) and four unknown vessels (7143, 7229 and 7419). The remaining ten (7012, 7153, 7237, 7295, 7395, 7407, 7409, 7411, 7413 and 7486) are classified as magnetic only anomalies with no sidescan sonar or multibeam bathymetry contacts. These anomalies are discriminated as A1 due to their high amplitudes which range from 973 nT (7411) up to 2790 nT (7407). All these anomalies have the potential to represent a significant amount of possible ferrous debris which may be buried or have no seabed surface expression.

104. Within the offshore cable corridor there are 25 seabed features discriminated as A1. Fifteen of these are wrecks which have previously been charted by the UKHO. Six are unknown vessels (70565, 70645, 70659, 70704, 70744 and 70954) and nine are identified as:

- Second World War British minesweeper HMS *Dunoon* (possibly) (70360);
- Early 20th century steamship *Phillipp M* (70459);
- Early 20th century steamship *Rye* (70617);
- Mid 20th century motor vessel *Trevethoe* (70639);
- Early 20th century steamship *Montferland* (70709);
- Mid-19th century schooner *Seagull* (70809);
- Mid-19th century steamship *Xanthe* (70834);
- Steamship *Sheaf Water* (70934); and
- Early 20th century steamship *Fulgens* (70962).

105. In addition to these wrecks there are 10 further A1 features comprising six pieces of debris (70460, 70618, 70640, 70784, 70832 and 70833), three debris fields (70785, 70810 and 70958) and a very large magnetic anomaly (70615).

106. Within the project interconnector search area there are three A1 features comprising an unidentified, partially buried wreck (70021), not previously charted by the UKHO, and two magnetic only anomalies (70058 and 71479).

107. There is a further named wreck which falls within the area where the project interconnector search area coincides with the offshore cable corridor:

- British trawler *Golden Oriole* (70342).

108. A total of 1,374 anomalies have been discriminated as A2 (uncertain origin of possible archaeological interest).

109. The types of features identified are summarised in Table 17.12 and described in detail in Appendix 17.1 and Appendix 17.4.

Table 17.12 Types of A2 features within the study area

Type of feature	Total in study area	Norfolk Boreas site	Offshore cable corridor	Offshore cable corridor and Project interconnector search area	Project interconnector search area
Debris	**126**	73	36	4	13
Debris Field	**52**	22	17	5	8
Seafloor Disturbance	**60**	46	3	1	10
Bright Reflector	**43**	19	14	3	7
Dark Reflector	**267**	95	100	10	62
Rope/Chain	**43**	11	30	-	2
Large object	**8**	8	-	-	-
Magnetic	**761**	244	445	19	53
Mound	**13**	7	4	1	1
Total	**1373**	**525**	**649**	**43**	**156**

110. Seabed features interpreted as A2 have been identified as being of possible anthropogenic origin and have the potential to represent archaeological material on the seabed of maritime or aviation origin. Magnetic only anomalies (without visible surface expression) have the possibility to be buried objects with ferrous content that are of archaeological potential.

111. There are four previously recorded features (A3) which have not been seen in the geophysical data. At two of these previously recorded locations is it considered unlikely that archaeological material is present, although it cannot be entirely discounted. 70079 is a single unidentified obstruction recorded by the UKHO within the project interconnector search area. This anomaly is recorded as a very small contact without an associated magnetic anomaly and hasn't been seen at this location in geophysical data since 1994. Similarly, 7089 within the Norfolk Boreas site was recorded by the UKHO as a fisherman's fastener recorded on a Danish fishery chart in 1992. Northing has been seen at this location in subsequent geophysical surveys.

112. At the remaining two A3 recorded locations it is considered possible that archaeological material could still be present. The record for 7181 within the Norfolk Boreas site corresponds to an identified geophysical anomaly with a large magnetic anomaly (2664 nT) which is consistent with a well head recorded on the Admiralty chart at this location. However, the UKHO record states that the installation of the drilling rig was impeded by an unknown obstruction buried below the seabed which was thought to be possible wreckage. It is therefore possible that archaeological material could still be present buried at this position. Any magnetic anomaly associated with this potential wreckage would be obscured by the larger anomaly

associated with the well-head. At the location of 7502 an obstruction was identified in 2004 and, although it has not been seen in the current data, as it is in an area of sand waves it is probable that if archaeological material is present then this would be buried.

113. The remaining five features have been discriminated as U2, all of which can be positively identified as known non-archaeological features. Feature 7401 is the wreck of the British supply vessel *Vulcan Service*, which sank in 1990 after colliding with a drilling rig. As the wreck is of recent date it is not of archaeological interest. The remaining four features (7400, 7402, 7403 and 7404) comprise two debris fields and two items of debris associated with the wreck of the *Vulcan Service*.

114. In addition to the known wrecks and anomalies described above, there is also potential for the presence of further maritime archaeological material to be present, dating from the Mesolithic period up to the present day, which has not previously been identified. A deposit of post-transgression Holocene marine sediment (Unit 8) is present across the study area which varies in thickness from a thin veneer to sand banks up to 15m thick. This sediment could periodically bury and expose archaeological material in areas of mobile sediment. An overview of maritime archaeological potential, summarised by Wessex Archaeology, is presented in Table 17.13.

Table 17.13 Summary of key areas of maritime potential (Appendix 17.1 Table 14)

Period	Summary
Pre-1508 AD	Low potential for material associated with prehistoric maritime activities. Prehistoric maritime activities include coastal travel, fishing and the exploitation of other marine and coastal resources. Vessels of this period include rafts, hide covered watercraft and log boats.
	Low potential for material associated with later prehistoric maritime activities, including seaworthy watercraft suitable for overseas voyages to facilitate trade and the exploitation of deep water resources. Such remains are likely to comprise larger boat types, including those representing new technologies such as the Bronze Age sewn plank boats which are associated with a growing scale of seafaring activities.
	Low potential for material of Romano-British date, associated with the expansion and diversification of trade with the Continent. Watercraft of this period, where present, may be representative of a distinct shipbuilding tradition known as 'Romano-Celtic' shipbuilding, often considered to represent a fusion of Roman and northern European methods.
	Low potential for material associated with coastal and seafaring activity in the 'Dark Ages', associated with the renewed expansion of trade routes and Germanic and Norse invasion and migration. Vessels of this period may be representative of new shipbuilding traditions such as the technique.

Period	Summary
	Low potential for material associated with medieval maritime activity, including that associated with increasing trade between the UK and Europe, the development of established ports around the southern North Sea and the expansion of fishing fleets and the herring industry. Vessels of this period are representative of a shipbuilding industry which encompassed a wide range of vessel types (comprising both larger ships and vernacular boats). Such wrecks may also be representative of new technologies (e.g. the use of flush-laid strakes in construction), developments in propulsion, development of reliable navigation techniques and the use of ordnance.
1509 to 1815	Medium potential for post-medieval shipwrecks representative of continuing technological advances in the construction, fitting and arming of ships, and in navigation, sailing and steering techniques. Vessels of this period continued to variously represent both the clinker techniques and construction utilising the flush-laid strakes technique.
	Medium potential for post-medieval shipwrecks associated with the expansion of transoceanic communications and the opening up of the New World.
	Medium potential for post-medieval shipwrecks associated with the establishment of the Royal Navy during the Tudor period and the increasing scale of battles at sea.
	Medium potential for post-medieval shipwrecks associated with continuing local trade and marine exploitation including the transport of goods associated with the agricultural revolution.
1816 to 1913	Higher potential for the discovery of shipwrecks associated with the introduction of iron and later steel in shipbuilding techniques. Such vessels may also be representative of other fundamental changes associated with the industrial revolution, particularly with regards to propulsion and the emergence of steam propulsion and the increasing use of paddle and screw propelled vessels.
	Higher potential for the discovery of shipwrecks demonstrating a diverse array of vernacular boat types evolved for use in specific environments.
	Higher potential for wrecks associated with large scale worldwide trade, the fishing industry or coastal maritime activity including marine exploitation.
1914 to 1945	Higher potential for the discovery of shipwrecks associated with the two world wars including both naval vessels and merchant ships. Wrecks of this period may also be associated with the increased shipping responding to the demand to fulfil military requirements. A large number of vessels dating to this period were lost as a result of enemy action.
Post- 1946	Potential for wrecks associated with a wide range of maritime activities, including military, commerce, fishing and leisure. Although ships and boats of this period are more numerous, loses decline due to increased safety coupled with the absence of any major hostilities. Vessels dating to this period are predominantly lost as a result of any number of isolated or interrelated factors including human error, adverse weather conditions, collision with other vessels or navigational hazards or mechanical faults.

115. Similarly, while there are no known aircraft crash sites within the study area, there is potential for the discovery of previously unknown aircraft material, also associated with Unit 8. Military aircraft crash sites are of particular importance as all aircraft lost in military service are automatically protected under the Protection of Military

Remains Act 1986. An overview of maritime archaeological potential, summarised by Wessex Archaeology, is presented in Table 17.14.

Table 17.14 Summary of key areas of aviation potential (Appendix 17.1 Table 14)

Period	Summary
Pre- 1939	Minimum potential for material associated with the early development of aircraft. Aircraft of this period may represent early construction techniques (e.g. those constructed of canvas covered wooden frames) or may be associated with the mass-production of fixed wing aircraft in large numbers during WWI.
	Minimum potential for material associated with the development of civil aviation during the 1920s and 1930s, associated with the expansion of civilian flight from the UK to a number of European and worldwide destinations.
1939 to 1945	Very high potential for WWII aviation remains, particularly as the east coast acted as a hub for hostile activity. Aircraft of this period are likely to be representative of technological innovations propelled by the necessities of war which extended the reliability and range of aircraft.
Post- 1945	Potential for aviation remains associated with military activities dominated by the Cold War, the evolution of commercial travel and recreational flying and the intensification of offshore industry (including helicopter remains). Aircraft of this period may be representative of advances in aerospace engineering and the development of the jet engine

116. Within the Norfolk Boreas site, one of the unidentified A1 wrecks (7143) is described in the associated UKHO record as a small unknown wreck, possibly an aircraft. However, Wessex Archaeology conclude that based on the form seen in the sidescan sonar data, it cannot be confirmed whether the anomaly represents an aircraft or not.

17.6.3 Intertidal Archaeology

117. Although long HDD will pass beneath the beach, the archaeological potential of the intertidal zone is included for completeness as it falls within the study area and connects the assessment undertaken for offshore and onshore (Chapter 28) archaeology and cultural heritage.

118. There are 17 previously recorded heritage assets within the intertidal zone (up to MHWS) at the landfall at Happisburgh South (Figure 17.6). These are described in detail in Appendix 17.4.

119. Thirteen of the records relate to find spots of prehistoric material on the beach (positions at which finds have previously been discovered and recorded but at which material is no longer present):

- 1001 to 1008, 1018 and 1025 are chance finds of prehistoric flint artefacts;
- 1010 relates to the Lower Palaeolithic lithic working and butchery site known as Happisburgh Site 1; and

- 1034 and 1035 are chance finds of Bronze Age artefacts on Happisburgh beach.

120. One of the records is a multi-period findspot (1033) with artefacts ranging in date from the prehistoric to post-medieval period.

121. Two of the records relate to medieval findspots: 1037, an early Saxon silver pyramid mount; and 1038, a late 12th or 13th century gold ring.

122. The final record, 1045, is the site of Happisburgh Low Lighthouse, one of two lighthouses erected in Happisburgh in 1791. By 1886 it is recorded that the lighthouse had fallen into the sea although a survey in 1980 noted that remains of part of the foundations still survived in-situ exposed in the cliff, although the majority of the remains lay on the beach or had been covered over by sand.

123. An intertidal walkover was carried out by Royal HaskoningDHV in November 2017 in order to ground truth the recorded locations of these intertidal assets. At the site of the Happisburgh low lighthouse (1045), scattered red brick was observed, dispersed in the broad location of the recorded position located behind the former, now ruined, breakwaters (Plate 17.1).

Plate 17.1 Potential remains of Happisburgh Low Lighthouse observed during site visit

124. No further remains were observed which could be formally correlated to a previously recorded heritage asset although scattered, brick, stone, breeze blocks and large flints were observed further along the beach just to the north west of the landfall (Plate 17.2).

Plate 17.2 Scattered debris relating to previously extant structures observed during site visit

125. Similarly, a borehole (BH17-L1A-05) drilled on the beach and monitored by Wessex Archaeology (Appendix 28.3) comprised 1.8m of coarse beach sand containing fragments of brick, interpreted as having resulted from a former or denuded brick built structure (e.g. a pillbox). Military features are prevalent along this stretch of coastline and the former locations of (now demolished) features such as pillboxes, Second World War coastal defences, a coastal battery and a machine gun post are recorded in the vicinity of the landfall however, these features are now outside the study area (see Appendix XIII and Figure 17 of Appendix 17.4).

126. In order to confirm if any further, more recent finds are known from the intertidal area, the CITiZAN baseline dataset of coastal and intertidal sites and features was also accessed. As the database is updated regularly by project members and volunteers this provides an opportunity to take advantage of recently collected information. However, no further finds are recorded from within the intertidal zone at the landfall, with the only record being that of a Palaeolithic flint implement, 'found in the parish of Happisburgh' and already captured in the HER data (1025).

127. In addition to the 17 previously recorded assets there is further potential for archaeological material to be present buried within the intertidal zone. Of particular significance is the potential for prehistoric material.

128. Lower Palaeolithic sites excavated at Happisburgh and at Pakefield on the Suffolk coast represent the earliest known evidence for Hominin activity in the UK dating from *c.* 800,000 and 700,000 BP respectively. Both sites pre-date the earliest known

glaciation of the UK and the finds and palaeoenvironmental evidence discovered within the Cromer Forest Bed Formation at these locations are of international importance for studies of the Palaeolithic. Approximately 800m further north along the coast from the landfall, severe wave erosion in May 2013 exposed a series of elongated hollows identified as Hominin footprints within an extensive area of laminated sediments on the foreshore. This exposed surface was formed between 1 million and 0.78 million years ago, making the Happisburgh features the oldest known hominin footprints found outside of Africa.

129. The exposed footprints (1017 in Appendix 17.4) and other early hominin sites at Happisburgh were investigated between 2005 and 2013 by the Ancient Human Occupation of Britain (AHOB) project. These sites have pushed back the known record of human occupation of northern Europe by at least 350,000 years and continuing erosion of the coastline is expected to reveal further evidence which will contribute to our understanding of the earliest human occupation of northern latitudes. The potential for further Palaeolithic material of international importance to be present is, therefore, considered to be high where Cromer Forest Bed Formation survives in-situ.

130. However, no deposits resembling the Cromer Forest-Bed Formation were encountered at the landfall during onshore ground investigations for the Norfolk Vanguard Project (Appendix 28.3). Sands clays and gravels recorded beneath surface deposits (topsoil and beach sand) are understood to be glacial in origin with a likely origin correlating to suggestions from the AHOB team that a large doline-type geological feature (sinkhole or solution feature) is present, infilled with glacial deposits. The geoarchaeological assessment of the onshore cores concludes that if Cromer-Forest-Beds do survive, they are likely to be found at significant depth (> 20mbgl). The potential for in-situ Palaeolithic archaeological material to be encountered at the landfall is, therefore, anticipated to be low given the depths of glacial till seen in the boreholes. This is discussed further with respect to potential impact of HDD at the landfall in section 17.7.6below.

17.6.4 Historic Seascape Character and Setting

131. The Historic Seascape Character (HSC) of coastal and marine areas around England has been mapped through a series of eight separate projects funded by Historic England and undertaken between 2008 to 2015. The study area is located within the East Yorkshire to Norfolk HSC, undertaken by the projects team of the School of History, Classics and Archaeology at Newcastle University (2014). This has since been followed by an initiative to consolidate the existing projects into a single national database (LUC, 2017a, 2017b, 2017c). The programme uses GIS to map data that can be queried to identify the key cultural processes that have shaped the historic seascape within a given area.

132. The consolidated national GIS dataset was mapped against the study area to identify the primary cultural processes which have shaped the historic seascape of the study area. This includes both the current character types and the previous (prehistoric and historic) character types for which information is available. The accompanying character texts were used to identify the primary values and perceptions for each character type summarised in Table 17.15 below.

Table 17.15 HSC – primary cultural processes in the study area

Present Broad Character Types	Present Character Sub-Types	Present Perceptions
Cultural Topography (Intertidal)	Sandy foreshore (Happisburgh)	Many sandy foreshores are visited for leisure and form one of the principle areas by which most people engage directly within the intertidal and marine zones. The distribution of sand varies, giving potential in some areas for the occasional exposure of buried ancient land surfaces, occupation layers and structures, and associated palaeoenvironmental deposits. In England, this character type remains highly valued as a place for inspiration and recreational activities.
Cultural Topography (Marine)	Coarse sediment plains, Fine sediment plains, Mud plains and Sand banks with sand waves	The marine cultural topography overall is highly valued due to its biodiversity and habitat ranged and has high archaeological potential, and can contribute to our understanding of past landscape use. These four types of seabed sediments each provide distinct preservation conditions for wrecks and implications for the potential form and survival of underlying palaeolandscapes.
	Palaeolandscapes	Value is becoming more positive on these remains and resource due to growing interest in submerged landscapes fuelled by the media and popular culture. Developing interest within certain sectors of society who come into contact with the resource (e.g. fishermen and aggregate dredgers). Submerged landscapes are becoming increasingly recognised and valued within the archaeological community.
Communications	Submarine telecommunication cables	Submarine telecommunications cables are mostly undetected in the marine environment. However, they are a highly reliable form of transferring information and are critical to our present-day life. They can be perceived as obstacles to certain sea users such as fishermen and dredgers.

Present Broad Character Types	Present Character Sub-Types	Present Perceptions
Fishing	Bottom trawling, Longline, Drift netting, Seine netting and Fixed netting	Commercial fishing has long been important to this region and the industry remains a distinctive element of the East Anglian coastal character. Generally fishing fleets today have distinct fishing grounds, predominantly within 10 km of their home port. As such the local fishermen from each area know their particular area intimately. From a recreational point of view the traditional fishing industry has now taken on an almost 'quaint' character, a memory of better days.
Energy Industry	Hydrocarbon Installation, Hydrocarbon pipeline, Hydrocarbon field (gas) and Submarine power cable	The North Sea as a whole has always been important to the energy industry, most notably for its natural oil and gas resources which have been heavily exploited since the 1960s. More recently nuclear power and renewable energy sources have become viewed as more important as a result of increasing concerns about CO_2 emissions from energy generation using fossil fuels. The North Sea and in particular the East Anglian coast has remained crucial to these newer energy industries.
Navigation	Maritime safety – lighthouse (Happisburgh), shoals and flats and Buoyage	Overall maritime safety features are considered both invaluable and locally characteristic of this area, although those located wholly offshore will only be known to small sectors of the community. The coastal landscape is dotted with daymarks and lighthouses which are now seen as particularly iconic.
	Navigation route	Navigation activity has always been important to the East Anglian region economy and coastal character. For centuries communities have made their living from their proximity to the North Sea and its connecting routes, linking East Anglia to other parts of Britain and to the continent. Navigation activities are deeply ingrained in the psyche of the local communities.

133. The setting of a heritage asset is described as the surroundings in which a heritage asset is experienced (Historic England, 2017). Elements of a setting may make a positive or negative contribution to the significance of an asset, may affect the ability to appreciate that significance or may be neutral.

134. The assessment of setting for onshore heritage assets from intertidal and offshore (nearshore) construction, operation and decommissioning are addressed in Chapter 28 (Onshore Archaeological and Cultural Heritage) and are not considered further in this chapter.

135. The assessment of setting for offshore heritage assets for this project is focused on the physical setting (i.e. historic associations and character) rather than the ways in which views, for example, contribute to the significance of an asset. Historic England's guidance on setting (2017) notes how the setting of buried heritage assets

may not be readily appreciated by a casual observer, but retains a presence in the landscape. In the case of submerged heritage assets, although some wreck sites have a setting which can be experienced and appreciated within their seascape, by divers or visitors on boat trips for example (e.g. wreck sites at the Needles on the Isle of Wight) most submerged archaeological sites are not 'readily appreciated by a casual observer'.

136. Within the Norfolk Boreas site, all but one of the wrecks and anomalies are currently unidentified and as such there is no further information which can be used to ascertain the contribution the setting makes to their significance. Similarly, all of the wrecks and anomalies within the project interconnector search area and six of the wrecks and all the anomalies within the offshore cable corridor are unidentified and without additional information.

137. The wrecks *Seagull* (70809) and *Xanthe* (70834) are both 19th century wreck sites lost by chance through isolated collision events, and their setting is limited to the immediate vicinity of the wrecks and not considered to contribute to the significance of the wrecks as heritage assets.

138. The study *East Coast War Channels in the First and Second World War* (Firth, 2014) examines the spatial extent of navigation channels and minefields between the Thames and the Scottish border during both wars and the heritage assets that are associated with these channels. Together with the presence of military installations within the intertidal zone, the context of the East Coast war channels represents the wider setting of 20th century military activity within which the study area is located. There are three wrecks lost during WWI, *Koningin Regentes* (7122), *Golden Oriole* (70342) and *Fulgens* (70962) both sunk in 1915, and seven during WWII HMS *Dunoon* (70360), *Philipp M* (70459), *Rye* (70617), *Trevethoe* (70639), *Montferland* (70709) and *Sheaf Water* (70934). The use and loss of the wrecks against the wider backdrop of hostile military action along the east coast means that their setting should be considered to contribute to their significance.

139. There is also potential for the presence of wrecks associated with battles of the Anglo-Dutch wars which, if discovered, may be considered to have a setting as part of this wider Anglo-Dutch conflict. For example, a total of 20 Dutch ships and two English vessels were lost during the Battle of Lowestoft (1665) with three Dutch ships and four ships from the combined English and French fleet lost at the Battle of Sole Bay (1672). The location of both of these battles is recorded to the south of the study area.

140. Of the 17 previously recorded heritage assets within the intertidal zone, 16 relate to findspots of material no longer present at the recorded locations and their setting is not therefore considered to contribute to the significance of those assets. Similarly,

the Happisburgh Low lighthouse (1045) was destroyed due to sea erosion and is no longer in-situ, represented by surviving masonry sections and rubble on the beach only, and its setting is not considered to contribute to its significance. The setting of intertidal heritage assets is therefore not considered further within this report.

17.6.5 Anticipated Trends in Baseline Character

141. The existing environment for offshore archaeology and cultural heritage as set out above has been shaped by a combination of factors, with the most prevalent being changes in global sea levels and associated climatic and environmental conditions which have affected the burial and preservation of prehistoric archaeology, and latterly that of maritime and aviation archaeology.

142. Although sea levels are comparatively stable at present, cycles of burial and exposure resulting from marine physical processes, including storm events which can result in the stripping of shallow sediment from the seabed and beach, have an ongoing effect upon the preservation of archaeological material. Exposed heritage assets are at greater risk from erosion and degradation as a result of the effects of physical processes than those which remain buried and are consequently provided with greater protection from continued sediment cover. These cycles of burial and exposure are anticipated to continue although the effect upon individual heritage assets is difficult to predict as this will depend upon site specific conditions and will vary depending upon the nature of any exposed archaeology.

143. Sea-level rise and climate change are two predominant factors thought to contribute to the rapid coastal erosion at this stretch of coastline, with historical records indicating the loss of over 250m of land between 1600 and 1850 at Happisburgh[1]. The parish of Whimpwell (formerly to the east of Happisburgh), has long since eroded away with many once terrestrial heritage assets lost to the sea. Cliff erosion in particular is therefore of heightened public concern in East Anglia and is having an adverse impact in terms of the erosion and exposure of archaeological remains from the cliffs. This trend is anticipated to continue although archaeology which is exposed, investigated and recorded to professional standards may also be considered a public benefit in terms of understanding of the archaeological record, as at Happisburgh and Pakefield for example.

144. Within the study area there has been minimal previous impact associated with sea-use and development activity. The HSC has recorded the presence of submarine telecommunication cables, hydrocarbon installations and submarine power cables. Previous impacts are also likely to have occurred through fishing activities. Damage

[1] http://www.bgs.ac.uk/landslides/happisburgh.html

caused by trawling and nets snagged on wrecks, for example, are a primary cause of damage to archaeological materials in the marine environment.

145. Given that the study area extends across a marine area, fishing is likely to continue in most areas. Whilst fishing activities have the potential to result in the gradual degradation and/or disturbance of archaeological remains, due to the longevity of fishing activity within and surrounding the offshore project area, physical impacts upon archaeological remains are considered likely to have largely already occurred. This may have resulted in their loss in part or to disturbing the relationship between assets and their wider surroundings. Given modern improvements in navigation accuracy (GPS), the effective identification and recording of the locations of potential obstructions (such as wrecks) on the seabed and a desire to avoid interactions during fishing to prevent damage to fishing equipment, it is anticipated that ongoing impacts are less likely to occur in the future. Further impacts are, however, possible which may result in new and further loss and / or disturbance, especially where trawling is employed. The degree of impact from fishing, however, is difficult to predict based on available data and ability to anticipate the extent of future fishing activities.

146. The installation of modern infrastructure, such as submarine cables and pipelines, within the offshore project area and the surrounding areas has also shaped the existing environment, with the historic environment having been and continuing to be vulnerable to the impacts of development in both a physical (direct) and non-physical (indirect e.g. relating to the setting of heritage assets or impacts associated in changes to physical processes) manner. With regards to physical impacts, developments undertaken to date have often resulted in the discovery of heritage assets, comprising wrecks and aircraft and associated debris, identified through geophysical survey for example. Those identified and archaeologically recorded to date are included within the baseline conditions described above.

147. However, due to the policy trend in the UK (see section 17.2), which recognises that heritage assets are an irreplaceable resource, it is anticipated that whilst the development of modern infrastructure could result in changes to buried archaeological remains, the information acquired from any archaeological site or feature subject to direct impact will be retained and made publicly available following proportionate mitigation approaches. Development also presents opportunities to develop and further enhance the archaeological record.

There is a requirement in UK policy to take into account the desirability of sustaining and enhancing the significance of heritage assets and their setting. As such, the historic character and setting of heritage assets may be subject to change, although the degree of change will depend on the public benefit of proposed developments as part of a weighted approach to decision making, in order for sustainable development to take place and for heritage assets to be safe-guarded in a manner that is both proportionate and appropriate to the significance of known assets, as well as any new sites / remains identified, their level of survival, as well as other factors.

The baseline conditions for offshore archaeology and cultural heritage (particularly with respect to non-designated sub-surface remains) are therefore considered to be subject to a gradual decline on the basis of the effects of physical processes, ongoing marine activities and development within the offshore project and surrounding areas, although the degree to which any change is likely to occur is difficult to predict based on information available to date. The sensitivity of offshore archaeology and cultural heritage as a non-renewable resource has been considered within this chapter and informs the embedded and ongoing mitigation strategy to be further developed and adopted by the project post-consent (see section 17.7.2) so that impacts can be avoided, reduced or offset, as and where appropriate.

17.7 Potential Impacts

17.7.1 Types of Impact

148. Potential impacts to heritage assets within the study area include both direct and indirect impacts.

149. Direct impacts to heritage assets, either present on the seafloor or buried within seabed deposits, may result in damage to, or total destruction of, archaeological material or the relationships between that material and the wider environment (stratigraphic context or setting). These relationships are crucial to developing a full understanding of an asset. Such impacts may occur if heritage assets are present within the footprint of elements of the proposed scheme (i.e. foundations or cables) or within the footprint of activities such as seabed clearance, anchoring or the placement of jack up barges.

150. The proposed project also has the potential to directly and indirectly change the hydrodynamic and sedimentary process regimes, both locally and regionally. Changes in coastal processes can lead to re-distribution of erosion and accretion patterns, while changes in tidal currents, for example, may affect the stability of nearby morphological and archaeological features. Indirect impacts to heritage assets may occur if buried heritage assets become exposed to marine processes, due to increased wave/tidal action for example, as these will deteriorate faster than those protected by sediment cover. Conversely, if increased sedimentation results in an exposed site becoming buried this may be considered a beneficial impact.

151. Indirect impacts to setting may occur if a development affects the surroundings in which a heritage asset is experienced. Similarly, impacts to the historic seascape

character may occur with the introduction of new elements causing a change in that character which may affect present perceptions of that seascape across an area.

152. Following consultation with Historic England, two further types of impact have also been assessed relating to the potential effects upon site preservation conditions; the potential for drilling fluid breakout during HDD (section 17.7.6.5) and impacts due to heat loss from electrical cables (section 17.7.7.5).

17.7.2 Embedded Mitigation

153. Norfolk Boreas Limited 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.

154. 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) including engineering requirements, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

155. An Outline Written Scheme of Investigation (WSI) setting out the methodology for all proposed embedded mitigation has been prepared as part of the DCO application (document reference 8.6). The WSI takes account of the standards and guidance presented in *Model Clauses for Archaeological Written Schemes of Investigation: Offshore Renewables Projects* (The Crown Estate, 2010). The full WSI will be completed in consultation with Historic England.

156. In order to prevent significant impacts, the following mitigation has been embedded in the project design and will be secured through conditions that will later be set out in the DCO (and DML):

- 50m AEZs around the extents of known wreck sites and anomalies of archaeological interest (A1s) within which no development related activities will take place;
- 50m AEZs around the recorded point locations of previously recorded sites that have not been seen in the geophysical data (A3s) but at which archaeological material is likely to be present, possibly buried;
- Avoidance where possible of identified anomalies (A2s) by micro-siting of design;
- Avoidance by micro-siting where possible of previously recorded sites that have not been seen in the geophysical data (A3s) and at which the presence of

surviving material is considered unlikely, although it cannot be entirely discounted;

- Further investigation of any identified anomalies (A2s) and previously recorded sites (A3s) that cannot be avoided by micro-siting of design;
- Further examination of potential prehistoric deposits including geoarchaeological recording of core samples, deposit modelling and archaeological input into any future sampling programme/s;
- In the event of impact to potential sites, the establishment of a formal protocol to ensure that any finds are promptly reported, archaeological advice is obtained, and any recovered material is stabilised, recorded and conserved;
- Watching briefs where seabed material is brought to the surface, for example during pre-lay grapnel runs;
- Watching briefs for any intrusive works carried out in the landfall zone (during long HDD); and
- The archaeological assessment of any further geophysical data.

157. As stated above, the primary means of preventing impacts to known heritage assets is avoidance. It is also noted that proposed AEZs may be reduced, enlarged or removed in agreement with Historic England if further relevant information becomes available. However, unless modified by agreement, it is important that AEZs are retained throughout the project lifetime and monitoring of AEZs may be required by the regulator to ensure adherence both during construction and in the future operation of the wind farm.

158. If anomalies cannot be avoided then additional work may be required to further investigate the nature and extent of anomalies, to establish the archaeological interest and to record them prior to removal. The methodology for such works will be set out post-consent in a WSI in accordance with the outline WSI (see document reference 8.6) and agreed with Historic England prior to works commencing. Historic England will also be consulted on the scope of all further post-consent geophysical and geotechnical surveys undertaken for the project in order to ensure that the data generated are sufficiently robust to enable professional archaeological interpretation and analysis.

159. In order to account for unexpected discoveries of archaeological material during construction, operation and decommissioning, a formal protocol will be established. It is recommended that if any objects of possible archaeological interest are encountered, that they should be reported using the established *Protocol for Archaeological Discoveries: Offshore Renewables Projects (The Crown Estate, 2014)* (ORPAD). This will establish whether the objects are of archaeological interest and recommend appropriate mitigation measures where necessary.

17.7.3 Monitoring

160. An In-Principle Monitoring Plan has been submitted as part of the DCO application (document reference 8.12). The In Principle Monitoring Plan confirms that the primary mechanism for delivery of monitoring for offshore archaeology is through agreement on the offshore WSI (as required under Condition 14(1)(h) of DCO Schedules 9 and 10; Condition 9(1)(h) of DCO Schedules 11 and 12 and Condition 7 (1)(g) of DCO Schedule 13). The offshore WSI will be agreed with Historic England and the MMO. An outline offshore WSI (document reference 8.6) has been submitted with the DCO application.

17.7.4 Worst Case

161. The worst-case scenario for archaeology below MHWS is based upon the general assumption that the greatest potential footprint for the project represents the greatest potential for direct impacts (e.g. damage / destruction) to surviving archaeological material. This equates to:

- The greatest potential area of direct contact with the sea floor/landfall zone;
- The maximum number of locations at which direct contact may occur (e.g. maximum number of foundations, cables, jack up feet or anchors); and
- The greatest volume of disturbed seabed sediments and intertidal deposits.

162. The worst-case scenario for indirect impacts equates to those aspects of the development which result in the greatest potential for increased scour and sediment stripping across an area as a result of changes to physical processes. Conversely, those aspects of the development which result in the greatest increase in sediment deposition also represent the greatest potential effect in terms of the beneficial impact of increased protection for archaeology.

163. The worst-case scenario for the disturbance of setting and character equates to the maximum intrusive effect (e.g. number and type of new infrastructure elements, height of infrastructure) for the longest duration.

164. Offshore infrastructure for Norfolk Boreas includes wind turbines, offshore electrical platforms, service platforms, met masts, array cables, interconnector cables or project interconnector cables and offshore export cables (see Table 17.16).

165. Norfolk Boreas may be constructed as a single phase or two phases with a total export capacity of up to 1800MW. This may affect the construction programmes as detailed in Chapter 5 Project Description. However, the infrastructure requirements are the same for each phase and therefore the phasing scenarios would have no effect on archaeology.

166. The full construction window is expected to be up to approximately four years, although this may include periods of no on site construction activity.

167. The layout of the wind turbines would be defined post-consent but a range of 10MW to 20MW wind turbines is included in the project design envelope in order to future proof the DCO to accommodate foreseeable advances in wind turbine technology. For 1,800MW there could be up to 180 x 10MW turbines or 90 x 20MW turbines (or any other configuration within this range).

168. The worst-case assumptions relevant to the assessment of archaeology below MHWS are set out in Table 17.16. The parameters for the worst-case scenarios are based upon the project description included in Chapter 5 and take account of the embedded mitigation described in section 17.7.2 above. As the embedded mitigation includes the avoidance of known heritage assets (through AEZs or through micro-siting) where possible, impacts arising from the project layout would only become relevant if known heritage assets could not be avoided.

169. The worst-case layout will be that which corresponds to the most number of known heritage assets which cannot be avoided. As this is location specific, this cannot be known until after the layout is defined. For this reason, the worst case for the project as a whole (i.e. the maximum overall potential disturbance of the seabed from individual parameters across the project) is considered in Table 17.16.

Table 17.16 Worst Case Assumptions

Impact	Parameter	Notes
Construction		
Direct impact to known heritage assets	Seabed preparation	Direct impacts to known heritage assets are not anticipated to occur due to the application of embedded mitigation comprising: • AEZs around A1 and certain A3 anomalies prohibiting development activities within their boundaries; and • Micro-siting by design to avoid A2 and certain A3 anomalies.
	Installation of Wind Turbine foundations	
	Installation of ancillary infrastructure	
	Installation of offshore cabling	
	Seabed contact by legs of jack-up vessels and / or anchors (installation)	
	Cable installation at the landfall	
Direct impact to potential heritage assets	Disturbance footprints in the Norfolk Boreas site due to cable laying operations, jack-up operations and seabed preparation works for turbine foundations	Maximum total seabed preparation area for 1,800MW capacity: • 180 x 10MW GBS foundations (requiring prep area for a circle approximately 50m in diameter) = 353,429m^2. • Two offshore electrical platforms seabed preparation = 15,000m^2 (75m x 100m per platform) • One service platform based on 60m diameter seabed preparation = 7,500m^2 (75m x 100m per platform)

Impact	Parameter	Notes
		• Two met masts based with 40m diameter seabed preparation = 2,513m^2 • Array cable pre-sweeping/pre-grapnel run (20m x 600,000m) = 12,000,000m^2 • Interconnector pre-sweeping/pre-grapnel run (20m x 60,000m) = 1,200,000m^2 • Export cable pre-sweeping within the wind farm site (30m x 50,000m) = 1,500,000m^2 • Jack up vessel footprints assuming 2 vessel movements per turbine = 285,120m^2 • Vessel anchor footprints (one vessel anchoring per turbine) = 27,000m^2 • Jack up vessel footprints assuming 2 vessel movements per offshore platform and met mast = 7,920m^2 • Boulder clearance = 4,123m^2 = (105 boulders of up to 5m diameter removal and set down) **Worst case scenario total disturbance footprint based on seabed preparation for foundations = 15,400,544m^2**

	Seabed preparation and cable installation in the offshore cable corridor	• Boulder clearance = 864m^2 (up to 22 boulders of 5m diameter removal and set down)
		• Export cable pre-sweeping/pre-grapnel = 72,000m^2
		• Maximum temporary disturbance for cable installation by ploughing = 6,000,000m^2 based on:
		  ○ Maximum total export cable trench length of 200km.
		  ○ Maximum width of temporary disturbance is approximately 30m, based on the disturbance impact for ploughing of a 10m wide trench with approximately 10m of spoil either side for each export cable
		• Anchor placement = 600m^2 (based on four cable joints, two per cable pair with a footprint of 150m^2 each, assuming up to 6 anchors per vessel)
		
		Worst case scenario total disturbance footprint – 6,073,032m^2

	Installation of Wind Turbine Generators	Total worst-case turbine footprint (1,800MW) with scour protection, based on 180 x 10MW GBS foundations (circular area on 200m with foundation and scour protection) = 5,654,867m^2.
	Installation of ancillary infrastructure	• Maximum number of met masts = 2 on 20m diameter at seabed with scour protection (7,854m^2 per foundation, total 15,708m^2) • Maximum number of LIDAR = 2 on 10m monopile foundations (total footprint 157m^2) • Maximum number of anchored wave buoys = 2 (total footprint 300m^2) • Maximum number of offshore electrical platforms = 2 with scour protection (total footprint 35,000m^2) • Maximum number of service platform = 1 with scour protection (total footprint 17,500m^2)

Impact	Parameter	Notes
	Installation of offshore cabling	Cable installation footprints are described above. In addition, the following cable protection may be required: Export cables - estimated 20km per cable pair; • 40km length; • 0.2km² area. Project interconnector (within the project interconnector search area) • 92km length; • 1.84km² area; Crossings • 11 cable crossings and 2 pipeline crossings per cable pair anticipated within the offshore cable corridor = 0.026m². • Up to 10 crossings are estimated for the array cables which would have an area of = 0.01km² • Up to 10 crossings per cable anticipated within the project interconnector search area = 0.01km² Cable protection may be required at each of the landfall HDD exit points. This would entail one mattress (6m length x 3m width x 0.3m height) plus rock dumping (5m length x 5m width x 0.5m height) at each exit point (up to two cable pairs) resulting in a footprint of 36m²
	Cable installation at the landfall	The installation process for the ducts and cables will not involve any works taking place on the beach or intertidal zone. The HDD will pass under the cliffs and exit at an offshore location beyond 5.5m below LAT (Lowest Astronomical Tide) with approximately 1000m drill length, classified as a 'long HDD'. The maximum target depth of drill is 20m.
Indirect impact to heritage assets from changes to physical processes	2A. Sediment deposited from plume created by seabed preparation	The worst case for archaeology equates to the worst case for marine physical processes (see Chapter 8 Table 8.16)
	2B. Sediment deposited from plume created by drill arisings and fate of aggregated drill arisings that are not suspended during foundation installation	
	4A. Changes in seabed level due to deposition from the suspended sediment plume during export cable installation	
	4B. Changes in seabed level due to disposal of sediment from sand wave levelling	

Impact	Parameter	Notes
	4C. Interruptions to bedload transport caused by sand wave levelling	
	6A. Sediment deposited from plume created by array cable installation	
	6B. Sediment deposited from plume created by project interconnector cable installation,	
	7A. Jack-up footprints	
	7B. Anchor footprints	
Impacts to the setting of heritage assets and historic seascape character	Activities associated with construction	Maximum construction duration of approximately 3 years. Up to 1180 vessel movements.
Operation		
Direct impact to potential heritage assets	Maintenance in the Norfolk Boreas site	Direct impacts to known heritage assets are not anticipated to occur due to the retention of AEZs throughout the project lifespan and restriction of activities to red line boundary. Maintenance of wind turbines would be required during O&M. An estimate of up to two locations visited per day during O&M using a jack up vessel with a footprint of 792m^2 which would lead to a total area of up to 0.58km^2 per year (assumes large jack up with six legs).
	Cable repairs and reburial	Unplanned repairs and reburial of cables may be required during O&M: • Estimated export cable reburial at 5 year intervals; • Reburial of 25% of the array cable is estimated every 5 years; and • One interconnector (either the interconnector or the project interconnector) repair per year is estimated.
Indirect impact to heritage assets from changes to physical processes	1. Changes to tidal currents created by presence of wind turbines	The worst case for archaeology equates to the worst case for marine physical processes (see Chapter 8 Table 8.16):
	2. Changes to waves created by presence of wind turbines	
	3. Sediment plume and changes to bedload sediment transport created by presence of wind turbines	
	4. Seabed morphology	
	5A. Seabed morphology and sediment transport within the Norfolk Boreas site	
	5B. Seabed morphology and	

Impact	Parameter	Notes
	sediment transport within the Project Interconnector search area	
	6. Seabed morphology and sediment transport along offshore export cables	
	7A. Repairs/Reburial	
	7B. Jack-up footprints	
	7C. Anchor footprints	
Impacts to the setting of heritage assets and historic seascape character	Presence of wind farm infrastructure Activities associated with operations and maintenance	Maximum number of wind turbines = 180 (based on 10MW turbines) Maximum height of wind turbines = 350 (Max upper blade tip above HAT (m) based on 20MW turbines) Indicative total number of vessel movements per year = 480 during operation and maintenance
Decommissioning		
Direct impact to known heritage assets	Complete removal of foundations and associated infrastructure	Direct impacts to known heritage assets are not anticipated to occur due to the retention of AEZs throughout the project lifespan and restriction of activities to red line boundary
	Seabed contact by legs of jack-up vessels and / or anchors on vessels during installation	
Direct impact to potential heritage assets	Removal of foundations and associated infrastructure	Removal of all part of the foundations (those above seabed level), removal of some or all of the array cables, interconnector cables, and offshore export cables. Scour and cable protection would likely be left in-situ. Impacts will be less than during the construction phase.
	Seabed contact by legs of jack-up vessels and / or anchors on vessels during installation	As with construction, the worst-case scenario is: • Vessel anchor footprints (one vessel anchoring per turbine) = 27,000m^2 • Jack up vessel footprints assuming 2 vessel movements per offshore platform = 7,920m^2
Indirect impact to heritage assets from changes to physical processes	Seabed morphology. Similar to construction.	The worst case for archaeology equates to the worst case for marine physical processes (see Chapter 8 Marine Geology, Oceanography and Physical Processes, Table 8.16).
Impacts to the setting of heritage assets and historic seascape character	Complete removal of wind farm and infrastructure	Impacts will be less than during the construction phase. Maximum change to historic seascape character

170. The project design envelope on which the ES is based was “frozen” in January 2019 to allow the DCO to be completed and submitted in June 2019.

17.7.5 Heritage Significance

171. A narrative description of the assessment of importance for the heritage assets described in section 17.6 from the study area (excluding the Norfolk Boreas site) is included in section 9 of Appendix 17.4. In addition, based upon the information available to date, the offshore archaeological baseline within the Norfolk Boreas site comprises:

- 190 palaeogeographic features of probable/possible archaeological interest (P1 and P2);
- 17 recorded wrecks (A1 and A3);
- 525 geophysical anomalies of possible archaeological interest (A2);
- Potential for the discovery of prehistoric sites and artefacts from the lower Palaeolithic to the Mesolithic;
- Potential for the discovery maritime related archaeological material from the late Mesolithic to the present; and
- Potential for the discovery of aviation related archaeological material from the 20th century.

172. The importance of prehistoric features and potential discoveries of prehistoric archaeological and palaeoenvironmental material for the Norfolk Boreas site is the same as that described in section 9 of Appendix 17.4 for the rest of the study area. Similarly, the importance of unknown wrecks and obstructions and geophysical anomalies of possible archaeological interest (A1s, A2s and A3s) and of potential maritime and aviation discoveries is also as described in section 9 of Appendix 17.4.

173. The results of the assessment of importance are presented in Table 17.17. For the purposes of assessment, the importance of potential discoveries has been defined as high importance for in-situ sites and finds and medium importance for isolated finds within secondary contexts. However, each individual discovery would be considered independently and any requirements for further data gathering or analysis would be considered on a case by case basis according to the heritage significance of the discovery.

174. The only heritage asset within the Norfolk Boreas site not addressed within Appendix 17.4 and which requires further detailed narrative description is the single, identified wreck *Koningin Regentes* (7122) which is considered to be of high importance as an asset with the potential to contribute significantly to acknowledged national research objectives. This high importance is associated with the following key characteristics:

- Build (technology): example of a paddle-steamer constructed in the late 19th century at a time when paddle steam was largely superseded by the screw propeller;
- Build (historical associations): constructed in 1895 by Fairfield Shipbuilding and Engineering Co. Ltd, in Govan, Scotland, Glasgow's largest shipyard;
- Use: Initially used as a ferry between the Netherlands and the UK, during the First World War the ship was refitted for use as a hospital ship, operating between Rotterdam and Boston in Lincolnshire;
- Loss: On 6th June 1918 HS *Koningin Regentes* was repatriating prisoners of war torpedoed by the German submarine UB-107 and sank with the loss of seven lives.
- Survival: Significant structural remains are known to survive. The wreck was seen in the geophysical data as a large, broken-up but compact wreck with visible deck structure and a magnetic anomaly of 2440nT indicating the presence of a significant amount of ferrous material. In 2010, divers reported that the structure was broken and scattered, with the paddles still showing above the seabed.

Table 17.17 Assessment of importance of heritage assets

Asset Type	Definition		Importance
Potential in-situ prehistoric sites	Primary context features and associated artefacts and their physical setting (if found)		High
	Known submerged prehistoric sites and landscape features with the demonstrable potential to include artefactual material		High
Potential submerged landscape features	Other known submerged palaeolandscape features and deposits likely to date to periods of prehistoric archaeological interest with the potential to contain in-situ material		High
Potential derived Prehistoric finds	Isolated discoveries of prehistoric archaeological material discovered within secondary contexts		Medium
Potential palaeoenvironmental evidence	Isolated examples of palaeoenvironmental material		Low
	Palaeoenvironmental material associated with specific palaeolandscape features or archaeological material		High
Known maritime heritage assets	Named wrecks (A1)	*Koningin Regentes* (7122); *Golden Oriole* (possibly) (70342); HMS *Dunoon* (possibly) (70360); *Phillipp M* (70459); *Rye* (70617); *Trevethoe* (70639); *Montferland* (70709); *Seagull* (70809); *Xanthe* (70834); *Sheaf Water* (70934); *Fulgens* (70962)	High
	Un-named wrecks (A1)	7143; 7229; 7419; 70565; 70645; 70659; 70704; 70744; 70954; 70021	High
	Magnetic anomalies (A1)	7012; 7153; 7237; 7295; 7395; 7407; 7409; 7411; 7413; 7486; 70058; 70615; 71479	High
	Debris fields (A1)	70460; 70618; 70640; 70784; 70832; 70833; 70785; 70810; 70958	High
	Previously recorded wrecks not seen in	7089; 7181; 7502; 70079	High

Asset Type	Definition		Importance
	geophysical data (A3)		
Additional anomalies	Anomalies identified by geophysical assessment that could be of anthropogenic totalling 1,373 (A2)		High
Potential wrecks	Wrecks within the study area that are yet to be discovered		High
Potential derived maritime finds	Isolated artefacts lost from a boat or ship or moved from a wreck site		Medium
Potential aircraft	Aircraft within the study area that are yet to be discovered		High
Potential derived aviation finds	Isolated artefacts lost from an aircraft or moved from a crash site		Medium
Intertidal assets	Primary context features and associated artefacts (in-situ or derived) associated with early prehistoric activity (as previously discovered at Happisburgh).		High
	Findspots	Previously recorded findspots within the study area consisting of single or multiple finds located within the intertidal zone.	Negligible
	Structures	Structures of a vernacular nature including: sea defences; and lighthouse	Low
Potential derived intertidal finds	Isolated artefacts discovered within the intertidal zone (excluding those associated with early prehistoric activity as stated above).		Medium

17.7.6 Potential Impacts during Construction

17.7.6.1 Direct impact to known heritage assets

175. With the application of the embedded mitigation as set out in section 17.7.2, it is anticipated that all direct impacts to known heritage assets as a result of the project would be avoided where possible.

176. AEZs are recommended for all of the 43 A1 wrecks and anomalies and two of the four identified A3 locations at which the presence of buried remains is considered likely.

177. For each of the 21 wrecks and one of the debris fields (70785) the recommended AEZs comprise 50m around the extents of the wrecks as seen in the data. Two further debris fields (70810 and 70958) and four items of debris (7460, 70640, 70832 and 70833), likely to be related to the wrecks, are covered by the AEZs recommended for the wrecks themselves.

178. The remaining 15 A1 anomalies comprise two small objects of debris associated with very high magnetic anomalies (70618 and 70784) and 13 magnetic only anomalies (7012, 7153, 7237, 7295, 7395, 7407, 7409, 7411, 7413, 7486, 70058, 70615, 71479). The recommended AEZs comprise 50m around the recorded point locations. Similarly, the recommended AEZs for two of the four A3 records comprise 50m around the recorded point location.

179. As stated above, proposed AEZs may be reduced, enlarged or removed in agreement with Historic England if further relevant information becomes available post-consent.

180. The known heritage assets described above are illustrated on Figures 17.4 and 17.5 and detailed in Table 17.18 below.

Table 17.18 Recommended AEZs within the study area

Area	WA ID	Type	Position		Recommendation
			Easting	Northing	
Norfolk Boreas site	7012	A1 Magnetic	484357	5874120	50m around point location
	7122	A1 Wreck	491727	5872289	50m around extents
	7143	A1 Wreck	492759	5861314	50m around extents
	7153	A1 Magnetic	491824	5885902	50m around point location
	7181	A3 Recorded Obstruction	495427	5869436	50m around point location
	7229	A1 Wreck	499363	5868328	50m around extents
	7237	A1 Magnetic	497859	5866964	50m around point location
	7295	A1 Magnetic	499266	5875753	50m around point location
	7395	A1 Magnetic	501554	5879165	50m around point location
	7407	A1 Magnetic	501685	5877229	50m around point location
	7409	A1 Magnetic	501698	5877152	50m around point location
	7411	A1 Magnetic	501493	5876942	50m around point location
	7413	A1 Magnetic	501800	5876555	50m around point location
	7419	A1 Wreck	504730	5875044	50m around extents
	7486	A1 Magnetic	504114	5886610	50m around point location
	7502	A3 Recorded Obstruction	506253	5880785	50m around point location
Offshore cable corridor	70360	A1 Wreck	466386	5846784	50m around extents
	70459	A1 Wreck	446041	5844450	50m around extents
	70460	A1 Debris	446039	5844401	Covered by AEZ for 70459
	70565	A1 Wreck	431217	5841986	50m around extents
	70615	A1 Magnetic	429652	5846468	50m around point location
	70617	A1 Wreck	429617	5846348	50m around extents
	70618	A1 Debris	429562	5846957	50m around point location
	70639	A1 Wreck	428802	5847632	50m around extents
	70640	A1 Debris	428758	5847714	Covered by AEZ for 70639
	70645	A1 Wreck	428283	5848091	50m around extents
	70659	A1 Wreck	426967	5850445	50m around extents
	70704	A1 Wreck	422267	5849082	50m around extents
	70709	A1 Wreck	421671	5849182	50m around extents
	70744	A1 Wreck	419288	5849507	50m around extents
	70784	A1 Debris	415366	5849564	50m around point location
	70785	A1 Debris field	415354	5849572	50m around extents
	70809	A1 Wreck	413550	5850143	50m around extents
	70810	A1 Debris field	413518	5850156	Covered by AEZ for 70809
	70834	A1 Wreck	412105	5850354	50m around extents

Area	WA ID	Type	Position		Recommendation
			Easting	Northing	
	70832	A1 Debris	412148	5850351	Covered by AEZ for 70834
	70833	A1 Debris	412143	5850353	Covered by AEZ for 70834
	70934	A1 Wreck	406929	5852021	50m around extents
	70954	A1 Wreck	406125	5853694	50m around extents
	70962	A1 Wreck	406058	5852977	50m around extents
	70958	A1 Debris field	406085	5852987	Covered by AEZ for 70962
Offshore cable corridor and project interconnector search area	70342	A1 Wreck	477521	5849048	50m around extents
Project interconnector search area	70021	A1 Wreck	496438	5859769	50m around extents
	70058	A1 Magnetic	494268	5856763	50m around point location
	71479	A1 Magnetic	464147	5851155	50m around point location

181. For features assigned an A2 discrimination, and those A3 recorded locations at which the presence of buried material is considered unlikely (7089 and 70079), AEZs are not recommended at this time, although the positions of these features would be avoided through the scheme design (micro-siting) where possible. The archaeological assessment of pre-construction survey data, including further high resolution geophysical data undertaken for the purposes of UXO identification, will clarify the nature and extent of these anomalies and the scheme design would be modified to avoid heritage assets where possible. The margin of error in the positional accuracy of the geophysical data which informs micro-siting will be established following the archaeological assessment of the pre-construction geophysical data and based upon the final design footprint.

182. If features cannot be avoided, then additional work may be required to establish the archaeological interest of the feature (e.g. investigation of individual anomalies (ground truthing) through ROV and/or diver survey) and to record features prior to removal, as appropriate. The approach to such works will be set out post-consent in a WSI in accordance with the outline WSI (document reference 8.6) and agreed with Historic England prior to works commencing. A detailed method statement for any archaeological works would be agreed in advance of works commencing with the MMO in consultation with Historic England.

183. Within the intertidal zone, all known intertidal assets, such as the remains associated with the Happisburgh Low Lighthouse (1045) as observed during the walkover survey, will be avoided through the use of long HDD which will pass below the beach sands (minimum target penetration 10m).

184. In summary, Norfolk Boreas Limited has committed to the application of AEZ for all known A1 and two of the A3 locations, and the avoidance of A2 anomalies (where possible), two of the A3 locations and previously recorded heritage assets at the

landfall. For all A1 and A3 anomalies and heritage assets at the landfall there will therefore be **no direct impact** to known heritage assets during construction. For all those A2 anomalies which can be avoided there will be **no direct impact**, and where avoidance is not possible appropriate mitigation (to be agreed post-consent) will reduce the significance of direct impacts to acceptable levels.

17.7.6.2 Direct impact to potential heritage assets

185. It is not possible to avoid heritage assets that have not yet been discovered (potential heritage assets). Therefore, unavoidable direct impacts may occur if archaeological material is present within the footprint of the development associated with the following activities:

- Seabed preparation (including UXO and boulder clearance);
- Installation of wind turbine foundations;
- Installation of ancillary infrastructure;
- Installation of offshore cabling;
- Seabed contact by legs of jack-up vessels and / or anchors; and
- Cable installation at the landfall.

186. The importance, and hence sensitivity, of potential heritage assets is summarised in Table 17.17 above.

187. In-situ prehistoric, maritime and aviation sites are assessed as being of potentially high importance. The magnitude of effect is also assessed as potentially high. In practice, the magnitude of the effect will not be fully understood until after the potential heritage asset has been encountered and the impact has occurred. Therefore, as a precautionary approach, it should be assumed that total loss or substantial harm is possible and in accordance with the definitions in Table 17.4, the potential magnitude of effect can also be high. In accordance with the significance matrix in Table 17.5, direct impacts to potential in-situ heritage assets could be of major adverse significance.

188. However, the embedded mitigation set out in section 17.7.2 includes the measures outlined below, in order to reduce the level of harm to features through reducing, remedying and offsetting potential impacts.

189. With regard to potential in-situ prehistoric sites, submerged landscape features and palaeoenvironmental evidence, a number of palaeogeographic features of archaeological potential have already been identified within the project area, along with sediments of archaeological and palaeoenvironmental interest recovered within geotechnical samples acquired for the project (see section 17.6.1).

190. A programme of geoarchaeological assessment has been undertaken to provide an account of the successive environment within the study area and a model of

environmental change over time. The results of this work, including a deposit model, are included in Appendix 17.5, Appendix 17.6, Appendix 17.7 and Appendix 17.8. The assessment has revealed a sequence of peat and associated minerogenic deposits representing the long-term (~3500 yr) development of a diachronous land surface forming under the background influence of climate, environmental and physical changes occurring across the Late Devensian and Early Holocene. This is an important record from an area of the southern North Sea which formed the last land bridge between Britain and continental Europe.

191. Further examination of potential prehistoric deposits through the assessment of pre-construction geotechnical and geophysical data will further contribute to the body of scientific data available for the study of seabed prehistory within the East Coast region. If in-situ prehistoric sites are identified as a result of such work then mitigation measures to record and/or protect such sites would be agreed in consultation with Historic England.

192. Similarly, the archaeological assessment of any further geophysical survey data as relevant to further identifying and understanding the nature of seabed features which may represent previously unidentified maritime or aviation heritage assets is also anticipated to form part of any pre-construction mitigation requirement for offshore archaeology.

193. Further reduction of potential impacts can also be achieved by means of receiving prompt archaeological advice in the event of a discovery and by recording and conserving any objects that have been disturbed. This is of particular relevance, for example, where discoveries of multiple chance finds from a specific location might be indicative of a wider debris field representing previously unknown in-situ archaeological material. In a marine environment, this is often achieved by means of implementing a protocol for reporting finds of archaeological interest. It is therefore proposed that if any objects of possible archaeological interest are recovered, that they should be reported using the established *Protocol for Archaeological Discoveries: Offshore Renewables Projects (The Crown Estate, 2014)* (ORPAD). This will establish whether the recovered objects are of archaeological interest and recommend appropriate mitigation measures where necessary.

194. The Protocol for Archaeological Discoveries is also the primary means of mitigation relevant to isolated discoveries of archaeological material discovered within secondary contexts (chance finds). Isolated artefacts, either of prehistoric, maritime or aviation origin within reworked deposits may be considered less sensitive to change than in-situ material, as their relationship with their context or physical setting is less relevant to understanding their significance. The sensitivity of isolated finds is therefore considered to be medium. The magnitude of the effect is assessed to be low as, through the means of the protocol, artefacts brought to the surface

(during seabed preparation for example) will be retained for further assessment and provided with conservation as necessary to secure the long-term stabilisation of the artefact as proportionate to its significance. Although removal from the marine context will still result in the destruction of that contextual relationship, albeit a secondary context (i.e. not in-situ), isolated artefacts have limited capacity to accommodate physical changes or influences therefore resulting in only a minor loss of, or alteration to, key characteristics, features or elements. The impact significance is therefore considered to be **minor**.

195. At the landfall, there is potential for the presence of archaeological material buried within intertidal deposits, associated with the Happisburgh Low lighthouse and military installations from WWI and WWII, for example. Potential in-situ material should be considered to be of possible high importance. The borehole BH17-L1A-05 demonstrated the presence of 1.8m of beach sand above the glacial tills within which archaeological remains could be buried (Appendix 28.3).

196. However, the use of long HDD at the landfall means that no works will take place on the beach or within intertidal zone, with the HDD passing under the cliffs and exiting at an offshore location in a water depth greater than 5.5m below LAT (up to 1000m in total drill length, minimum target depth of the drill is 10m below surface level to a maximum target depth 20m below the surface). Therefore, there will be no impacts to potential archaeological remains within the upper beach sand deposits.

197. Similarly, as described in section 17.6.3, due to the presence of an interpreted geological sinkhole, potential for encountering Palaeolithic archaeological material within this maximum 20m depth is anticipated to be low. However, the results of further ground investigations within the project boundary, to be planned post-consent in consultation with the steering group including members of the AHOB and Pathways to Ancient Britain (PAB) project teams, will contribute to a greater understanding of the deposits within the wider study area. Further requirements for geoarchaeological assessment will be established in consultation with the steering group, Historic England and Norfolk County Council's Historic Environment Service. The approach to geoarchaeological assessment to be undertaken post-consent is set out in the draft Outline WSI (Appendix 17.6).

198. In summary, although direct impacts to potential heritage assets (if present within the footprint of the development) are unavoidable, through the application of appropriate mitigation (e.g. further measures to reduce the level of harm through reducing, remedying and offsetting potential impacts and the implementation of a ORPAD) the residual impact is assessed as **minor adverse**.

17.7.6.3 Indirect impact to heritage assets from changes to physical processes

199. Potential indirect impact to heritage assets from changes to physical processes is assessed with reference to section 8.7.6 (Potential Impact during Construction) of Chapter 8 Marine Physical Processes.

200. During construction, increased sediment concentrations have the potential to deposit sediment and hence raise the seabed elevation. Within the immediate vicinity of activities there is therefore potential for the creation of 'mounds', as coarser sediments fall rapidly to the seabed (although this change in elevation is within the natural change to the bed caused by sand waves and sand ridges and hence the blockage effect on physical processes would be negligible). Dispersion of finer grained material as part of a sediment plume results in only minimal deposition across a wider area; such deposition also has the potential to become re-mobilised thus reducing the effect further. The potential for beneficial effects upon archaeological receptors from increased sediment cover is therefore considered to be **negligible**.

201. During construction there is also potential for jack-up legs and anchors to leave indentations on the seabed. As the leg is retracted, some of the sediment would return to the hole via mass slumping and, over the longer term, the indentation would become shallower and less distinct due to infilling. If present within the footprint of the jack-ups or anchors, then heritage assets may be subject to direct impact of sediment deposition, as discussed above. Further impact from prolonged exposure within the indentations, however, is not anticipated to occur as any exposed archaeological material would become re-covered. It is therefore considered that there will be **no impact** upon archaeological receptors from exposure within indentations.

202. At the landfall, the selection of long HDD for cable installation will result in no effect upon the beach and nearshore zone, and hence no long-term effect on sediment transport processes. There will therefore be **no impact** upon archaeological receptors from changes in suspended sediment concentrations and coastal morphology at the landfall.

17.7.6.4 Changes to the setting of heritage assets and historic seascape character

203. The historic character of the study area and the setting of marine heritage assets will be temporarily affected during the construction phase by the presence of vessels, personnel and infrastructure associated with construction activities. The worst-case scenario anticipates that construction activities could have a duration of approximately four years, although this may include periods of no on site construction activity.

204. Construction activities may change perceptions of character with respect to the primary cultural processes which have been established and spatially defined through the HSC, as set out in Table 17.15 above. Overall, the local seascape character around and within the study area is considered to be of medium archaeological importance due to the area's important and prolonged maritime history and its continued use today. However, construction activities and additional vessel traffic would occur in the context of one of the busiest shipping channels between south east England and mainland Europe and furthermore, there is already an influence on the seascape from the existing features of the nearby gas rigs and their service vessels. The assessed capacity of each of the character sub-types to accommodate change during construction is set out in Table 17.19 below.

Table 17.19 Capacity of perceptions of character to accommodate change during construction

Character Sub-Types)	Perception of Character and Capacity for Change	Assessed Capacity to Accommodate Change
Sandy foreshore (Happisburgh)	Although there will be no impact to the foreshore from HDD, archaeological works above MHWS at the HDD entry point may result in short term disturbance of people's experience of the beach as a place for inspiration and recreational activities. However, as set out in Chapter 30 (Tourism and Recreation) at the landfall, long HDD avoids the need for closures of the coastal path and the beach at Happisburgh. In addition, the location of the landfall was selected to avoid the key local assets of the Norfolk Coast AONB and the Norfolk Broads National Park. This change is therefore considered to be short term and low impact.	Short term, low impact change for beach users (see Chapter 30, Tourism and Recreation)
Coarse sediment plains, Fine sediment plains, Mud plains and Sand banks with sand waves	The primary perceptions which associate marine cultural topography and palaeolandscapes with high archaeological potential could be enhanced through the accumulation of publicly available data in the event of unexpected discoveries reported through ORPAD during construction activities.	Potential beneficial change
Palaeolandscapes		
Submarine telecommunication cables	As submarine telecommunications cables are mostly undetected in the marine environment it is unlikely that perceptions of this character type would be altered by construction activities.	No change

Character Sub-Types)	Perception of Character and Capacity for Change	Assessed Capacity to Accommodate Change
Bottom trawling, Longline, Drift netting, Seine netting and Fixed netting	The study area does not include areas where the heritage of the fishing industry is particularly perceived by the public (e.g. historic fishing ports, historic fleets or vessels) or of importance to tourism, for example. There will, however be a change associated with the construction of an offshore wind farm, and consequently, the perception of historic seascape character held by fisherman themselves may change. Chapter 14 (Commercial Fisheries) identifies that loss of fishing grounds is the principal concern of fishermen and measures to mitigate impacts upon commercial fisheries will be implemented, including, for example, the use of rolling, temporary safety zones and the agreement of mutually acceptable terms with affected fishermen.	A change to the historic seascape character will occur, although measures to ensure continued access to fishing grounds as a primary concern of fisherman will be implemented (see Chapter 14).
Hydrocarbon Installation, Hydrocarbon pipeline, Hydrocarbon field (gas) and Submarine power cable	Overall, perceptions of the North Sea energy industry place greater emphasis upon nuclear power and renewable energy. The HSC states that Britain has the best offshore wind resource in Europe and the marine zone of East Anglia is well placed to take advantage of this. Changing perceptions associated with the construction of Norfolk Boreas are therefore likely to be seen as part of this natural progression for energy generation and as a positive change from fossil fuels to renewable energy.	Potential beneficial change
Maritime safety – lighthouse (Happisburgh), shoals and flats and Buoyage	There are two known lighthouses at the location of the landfall; the destroyed Happisburgh Low lighthouse and the extant Grade II listed Happisburgh Lighthouse onshore. As stated by the HSC, overall the area has a long history of maritime safety features which is at risk of being forgotten if not fully recorded. Short term construction activities at the landfall, however, are considered unlikely to result in a meaningful change to the perceived character.	No change
Navigation route	Construction activities and additional vessel traffic would occur in the context of one of the busiest shipping channels between south east England and mainland Europe and it is anticipated that no change to the perception of this character type would occur as a result of construction activities.	No change

205. The table above demonstrates that for most character sub-types, perceptions of historic character will remain unchanged or will result in a potential beneficial change. One exception is change to fishermen’s perception of historic seascape character associated with changes to fishing activities and the change in character of traditional fishing grounds. The effects on Commercial Fisheries are assessed in Chapter 14 including the effects of temporary displacement. A change to historic seascape character, however, will still occur associated with the construction of the offshore wind farm. The nature of this change is considered further in section 17.7.7.4 (operation impacts) below.

206. Similarly, short term disturbance of the character at the landfall has been minimised through the selection of a location which avoids the key local assets of the Norfolk Coast AONB and the Norfolk Broads National Park and a technique (long HDD) which avoids the need for closures of the coastal path and the beach at Happisburgh. This indicates that the character has capacity to accommodate this short-term change.

207. Considering setting, section 17.6.4 identifies how military wrecks within the study area collectively represent important features within a wider military seascape character and as such, their setting should be considered to contribute to their significance. During construction, activities associated with the installation of the wind farm infrastructure will result in a temporary disturbance to the setting of these military wrecks. Based upon professional judgement, however, this short-term, non-physical and reversible change to the wider military seascape character will not result in measurable harm to the significance of these heritage assets.

17.7.6.5 Impacts to site preservation conditions from drilling fluid breakout

208. During HDD, drilling fluid (a combination of water and natural clays such as bentonite) will be employed to lubricate the drilling process and cool the drill head. Bentonite is a common drilling fluid employed for HDD and is a naturally occurring clay which, when mixed with water, provides a gel like lubricant known as ‘drilling mud’ for the drilling process. The drilling mud typically contains less than 3-6% solids by volume and weight to water ratio. Bentonite typically has a neutral pH level of 7.0 – 9.5, similar to that of water/seawater.

209. Fluid pressures will be monitored throughout the drilling process to minimise the potential for breakout of the drilling fluid and an action plan will be developed and procedures adopted during the drilling activity to respond to any drilling fluid breakout. High level studies have indicated that the total worst-case drilling fluid losses to the sea could be up to 300m^3 per duct (noting that ~95% of this fluid is water). Moreover, ground investigations and geoarchaeological assessments have shown that if the Cromer Forest Bed deposits associated with potential Palaeolithic archaeology are still extant, they are expected to occur beneath the glacial tills at significant depth (> 20mbgl) and beneath the HDD target depths.

210. The potential for drilling fluid to breakout and spread into/coat archaeological deposits, features and materials thereby causing a negative effect upon site preservation is assessed as **negligible**.

17.7.7 Potential Impacts during Operation

17.7.7.1 Direct impact to known heritage assets

211. With the application of the embedded mitigation set out in section 17.7.2, and the retention of AEZs throughout the project lifespan, it is anticipated that all direct

impacts to known heritage assets will be avoided. Therefore, there will be **no direct impact** to known heritage assets during operation.

17.7.7.2 Direct impact to potential heritage assets

212. Direct impacts to potential heritage assets may occur if archaeological material is present within the footprint of jack-ups or vessel anchors deployed during planned or unscheduled maintenance activities. As for construction activities, impacts should be considered to have the potential to be of major adverse significance, although the application of embedded mitigation is anticipated to reduce this to **minor adverse**.

213. There will be **no direct impacts** at the landfall during the operation phase as there will be no disturbance of intertidal deposits.

17.7.7.3 Indirect impact to heritage assets from changes to physical processes

214. Indirect impacts to heritage assets from changes to physical processes are assessed with reference to section 8.7.7 (Potential Impact during Operation) of Chapter 8 (Marine Physical Processes).

215. During the operational phase of the proposed project, there is potential for the presence of the wind turbine foundations to cause changes to the tidal and wave regimes due to physical blockage effects. These changes could potentially affect the sediment regime and/or seabed morphology. The worst-case magnitude of effect upon tides is assessed as low (near-field) and negligible (far-field), and for waves as low (near-field) and negligible (far-field). The changes would be both low in magnitude and largely confined to local wake or wave shadow effects attributable to individual wind turbine foundations and therefore would be small in geographical extent. The potential for indirect impacts to archaeological receptors as a result of sediment stripping caused by changes to physical processes is, as a worst case, anticipated to be **negligible**.

216. In addition, there is potential for the temporary presence of engineering equipment, such as jack-up barges or anchored vessels, to have local effects on the hydrodynamic and sediment regimes during maintenance activities. However, the effects of the jack-up legs on waves, tides and sediment transport would be localised (since the legs are small) and would be temporary in nature. Once the maintenance activities are complete, the jack-up barges would be removed and no permanent effects on marine physical processes would remain. It is therefore concluded that there will be **no impact** upon archaeological receptors indirectly as a result of this effect.

17.7.7.4 Changes to the setting of heritage assets and historic seascape character

217. The anticipated design life of the wind farm is approximately 30 years and the presence of the turbines during this operational phase will introduce a clear change to both the visual setting and the character of the seascape.

218. The setting of military wrecks within the study area, which collectively represent important features within a wider military seascape character, will be subject to disturbance during the operational phase from the presence of vessels, personnel and infrastructure associated with maintenance activities and by the presence of wind turbines and associated infrastructure. Based upon professional judgement, however, this disturbance will occur within a baseline setting already influenced by existing gas rigs and passing shipping vessels in this area and will not result in harm to the significance of these assets when compared to the baseline environment, therefore reducing the sensitivity and potential magnitude of change.

219. As for construction above, maintenance activities and the presence of the wind farm infrastructure may change perceptions of character with respect to the primary cultural processes which have been established and spatially defined through the HSC and set out in Table 17.15. The assessed capacity of each of the character sub-types to accommodate change during operation is set out in Table 17.20 below.

Table 17.20 Capacity of perceptions of character to accommodate change during operation

Character Sub-Types)	Perception of Character and Capacity for Change	Assessed Capacity to Accommodate Change
Sandy foreshore (Happisburgh)	The presence of landfall infrastructure will remain largely undetectable and therefore not perceived by the public. No change to perceptions of the foreshore are anticipated.	No change
Coarse sediment plains, Fine sediment plains, Mud plains and Sand banks with sand waves	The presence of the installed infrastructure may result in a change to the perception of these marine areas as being of high archaeological potential. The physical presence of cables and foundations, for example, will limit ease of access for future research within the project areas thereby reducing the perceived archaeological potential. This change will however be offset by the accumulation of publicly available data acquired by the project prior to construction which is considered to be of public value.	Publication of data and completion of archaeological works to acceptable professional standards will help offset potential adverse impacts.
Palaeolandscapes		
Submarine telecommunication cables	As submarine telecommunications cables are mostly undetected in the marine environment there will be no change to perceptions of historic character.	No change

Character Sub-Types)	Perception of Character and Capacity for Change	Assessed Capacity to Accommodate Change
Bottom trawling, Longline, Drift netting, Seine netting and Fixed netting	The distance of the Norfolk Boreas wind farm from the coast, and the minimal above ground infrastructure at the coast, means that the project will be largely undetectable by the public and historic perceptions of the traditional fishing industry, which the HSC described as having taken on a 'quaint' character, a memory of better days, will remain largely unchanged. There will be a change associated with the presence of (and operation of) an offshore wind farm, and consequently, the perception of historic seascape character held by fisherman themselves may change. Chapter 14 (Commercial Fisheries) identifies that loss of fishing grounds in the principal concern of fishermen themselves. Once constructed, however, the wind farm and cable corridor area would be open to fishing access. In order to maintain fishing access, all cables will be buried to prevent interaction with fishing gear, or provided with cable protection where burial is not possible. There will also be a minimum separation of 680m between wind turbines within rows, and a minimum of 680m between each row, and these would be arranged in a regular pattern to assist vessel transit.	A change to the historic seascape character will occur, although measures to address any loss of fishing grounds as a primary concern of fisherman will be implemented (see Chapter 14).
Hydrocarbon Installation, Hydrocarbon pipeline, Hydrocarbon field (gas) and Submarine power cable	Overall, perceptions of the North Sea energy industry place greater emphasis upon nuclear power and renewable energy. The HSC states that Britain has the best offshore wind resource in Europe and the marine zone of East Anglia is well placed to take advantage of this. Changing perceptions associated with the presence of Norfolk Boreas are likely to be seen as part of this natural progression for energy generation and as a positive change from fossil fuels to renewable energy.	Potential beneficial change
Maritime safety – lighthouse (Happisburgh), shoals and flats and Buoyage	The presence of landfall infrastructure will remain largely undetectable and therefore not perceived by the public. No change to perceptions of maritime safety are anticipated.	No change
Navigation route	Maintenance activities and additional vessel traffic would occur in the context of one of the busiest shipping channels between south east England and mainland Europe and it is anticipated that no change to the perception of this character type would occur.	No change

220. Table 17.20 demonstrates that for most character sub-types, perceptions of historic character will remain unchanged as a result of the proposed project, or will result in a potential beneficial change. The exceptions are changes in perception of historic seascape character associated with traditional fishing grounds and the archaeological potential of the marine cultural topography. The assessment of Commercial Fisheries in Chapter 14 describes how the offshore infrastructure will be designed to allow fishing activities to resume once construction is completed. A

change to historic seascape character associated with the presence of the installed infrastructure will still occur, although measures to allow continuity in fishing activities indicate that this change can be accommodated. The potential change to perceptions of the marine cultural topography is anticipated to be offset by the public value of the data generated from the project, dependent upon publication of data and completion of archaeological works to acceptable professional standards.

17.7.7.5 Impacts to site preservation conditions from heat loss from installed cables

221. For the offshore export cables, at full load, total heat loss per meter for a pair of large HVDC cables is roughly 100W/m. For the inter array cables, at full load, total heat loss per meter is 150W/m.

222. The thermal properties of sediment structure and final engineering design (e.g. cable types, install depths, installed capacity, technology, stabilised backfill) will determine the maximum heat loss and subsequent dissipation of heat through sediments. However, heat dissipation will be localised to the area immediately around the cables and ducts.

223. As the effect of heat loss is restricted to the immediate vicinity of the cables, and as all known heritage assets will be avoided through design as part of the embedded mitigation for the project (see section 17.7.6.1 above) there will be **no impact** to known heritage assets associated with the heat loss from cables. With regard to potential heritage assets, the area affected from heat loss will be spatially no greater than the footprint of direct impacts from cable installation. As the deposits within which potential archaeology could be buried will already have been disturbed as part of the construction phase, and appropriate mitigation applied (see section above), there will be **no further impact** during operation associated with the heat loss from cables.

17.7.8 Potential Impacts during Decommissioning

224. The scope of the decommissioning works is not yet known, however decommissioning works may involve removal of the accessible installed components. This is outlined in section 5.4.19 of Chapter 5 Project Description and the detail will be agreed with the relevant authorities at the time of decommissioning and be subject to separate licencing based on best available information at that time. Offshore, decommissioning is likely to include removal of all of the wind turbine components, part of the foundations (those above seabed level) and removal of some or all of the array cables, interconnector or project interconnector cables, and offshore export cables. Scour and cable protection would likely be left in-situ.

17.7.8.1 Direct impact to known heritage assets

225. With the application of the embedded mitigation as set out in section 17.7.2 the retention of AEZs throughout the project lifespan, it is anticipated that all direct impacts to known heritage assets will be avoided. Therefore, there will be **no direct impact** to known heritage assets during decommissioning.

17.7.8.2 Direct impact to potential heritage assets

226. The scope of the decommissioning works would most likely involve removal of the accessible installed components. With regards to offshore cables, general UK practice would be followed; that is buried cables would be cut at the ends and left in-situ, with the exception of the intertidal zone across the beach where the cables would otherwise be at risk of becoming exposed over time.

227. As for construction and operation, direct impacts to potential heritage assets may occur if archaeological material is present within the footprint of jack-ups or vessel anchors deployed during decommissioning activities. Such impacts should be considered to have the potential to be of major adverse significance although the application of embedded mitigation is anticipated to reduce this to acceptable levels (**minor adverse**).

17.7.8.3 Indirect impact to heritage assets from changes to physical processes

228. The following impact is assessed with reference to section 8.7.8 (Potential Impact during Decommissioning) of Chapter 8 Marine Physical Processes.

229. During the decommissioning phase, there is potential for wind turbine foundation and cable removal activities to cause changes in suspended sediment concentrations and/or seabed or shoreline levels as a result of sediment disturbance effects. The magnitude of effects would be comparable to, or less than, those identified for the construction phase. Accordingly, given that **no impact** was assessed for the identified marine physical processes receptors during the construction phase, it is anticipated that **no impact** can also be concluded for the decommissioning phase.

17.7.8.4 Changes to the setting of heritage assets and historic seascape character

230. With the removal of the wind turbines and associated infrastructure a further change will occur with decommissioning. The presence of vessels, personnel and infrastructure associated with decommissioning activities will also temporarily affect the setting and character of the project area. However, based upon professional judgment, these temporary and reversible changes to setting and character during decommissioning are not considered likely to result in harm to the significance of heritage assets within the study area.

17.8 Cumulative Impacts

231. There are a large number of constructed/consented and planned offshore wind farms, aggregate dredging licence areas, oil and gas licences and licensed disposal sites within 100km (for example) of Norfolk Boreas. Of these, only Norfolk Vanguard overlaps with Norfolk Boreas in terms of footprint and, as Norfolk Vanguard is subject to the same embedded mitigation as Norfolk Boreas, comprising the avoidance of known heritage assets wherever possible, then there is no pathway for cumulative direct impacts on the known heritage assets identified in section 17.6 of this ES.

232. With respect to unavoidable impacts to potential heritage assets, and to the settings of heritage assets and the historic character of the study area, cumulative impacts are possible. However, as the extent of these potential heritage assets which could be subject to cumulative impact are unknown, it is not possible to identify which constructed/consented or planned projects would have the potential to have a cumulative impact with Norfolk Boreas. Therefore, a definitive list of projects assessed as part of this chapter is not provided as part of this CIA. Rather the potential for cumulative impact is discussed as a broad narrative in sections 17.8.1 and 17.8.2 below. It is acknowledged that strategic analysis in relation to the cumulative impact of multiple planned offshore arrays and overall numbers of turbines would facilitate greater understanding of the cumulative effect of offshore wind development within the North Sea, although this is considered beyond the scope of assessment for an individual project. However, Norfolk Boreas Limited are committed to making data from the Norfolk Boreas Project available should a request for data be made to them for such a strategic study.

233. The cumulative impact assessment for marine physical processes is set out in section 8.8 of Chapter 8 Marine Physical Processes. The assessment below takes account of the results of this assessment in identifying the potential for indirect cumulative impact to heritage assets from the effect of marine physical processes and from sediment plumes and deposition.

234. Table 17.21 summarises the project specific impacts identified in section 17.7, alongside their potential to act cumulatively with other projects.

Table 17.21 Potential cumulative impacts

Impact	Potential for cumulative impact	Data confidence	Rationale
Construction - Direct impact to known heritage assets	No	High	Direct cumulative impacts to known heritage assets are not anticipated to occur due to the avoidance of known archaeological sites and features identified through EIA for constructed and planned projects as part of the

Impact	Potential for cumulative impact	Data confidence	Rationale
			consenting process.
Construction - Direct impact to potential heritage assets	Yes	Low (as yet unknown heritage assets)	Although the effect of unavoidable impacts will be mitigated by agreed measures as part of the consenting process for each of the constructed and planned projects, the impacts will still have occurred and permanent damage or destruction will have taken place. The assessment of cumulative impacts, therefore, needs to consider the effect of multiple unavoidable impacts from multiple projects upon the archaeological resource. This is discussed further in section 17.8.1
Construction - Indirect impact to heritage assets from changes to physical processes	No	High	The marine physical processes assessment in section 8.8 of Chapter 8 concludes that the potential cumulative impact is negligible. This is considered insufficient to have a detectable impact upon heritage assets from additional sediment cover or increased scour, for example.
Construction - Impacts to the setting of heritage assets and historic seascape character	Yes	High	Across the region, changes to the setting of heritage assets and historic seascape character will occur cumulatively as a result of the construction of multiple projects. This is discussed further in section 17.8.2.
Operation - Direct impact to known heritage assets	No	High	Direct cumulative impacts to known heritage assets are unlikely to occur due to the retention of AEZs throughout the life of constructed and planned projects.
Operation - Direct impact to potential heritage assets	Yes	Low (as yet unknown heritage assets)	There is potential for multiple unavoidable impacts associated with operations and maintenance activities (e.g. cable repairs and vessel anchors/jack up legs) during the operation phases of multiple projects. This is discussed further in section 17.8.1.
Operation - Indirect impact to heritage assets from changes to physical processes	No	High	As described in Chapter 8 Marine Physical Processes, modelling for East Anglia ONE demonstrates that changes in tidal currents and waves due to the presence of foundation structures comparable to those proposed for Norfolk Vanguard are both small in magnitude and localised in spatial extent. The potential cumulative impact for marine physical processes between Norfolk Boreas, East Anglia THREE and Norfolk Vanguard is therefore considered to be negligible. There is therefore no potential for cumulative indirect impacts upon heritage assets.

Impact	Potential for cumulative impact	Data confidence	Rationale
Operation - Impacts to the setting of heritage assets and historic seascape character	Yes	High	Across the region, changes to the setting of heritage assets and historic seascape character will occur cumulatively as a result of the presence of multiple constructed projects. This is discussed further in section 17.8.2.
Decommissioning - Direct impact to known heritage assets	No	High	Direct cumulative impacts to known heritage assets are not anticipated to occur due to the retention of AEZs throughout the life of constructed and planned projects.
Decommissioning - Direct impact to potential heritage assets	Yes	Low (as yet unknown heritage assets)	There is potential for multiple unavoidable impacts associated with decommissioning considered cumulatively with activities associated with other projects. This is discussed further in section 17.8.1.
Decommissioning - Indirect impact to heritage assets from changes to physical processes	No	High	As for Construction.
Decommissioning 4 Impacts to the setting of heritage assets and historic seascape character	Yes	High	Changes to the setting of heritage assets and historic seascape character will occur cumulatively although the nature of this change will depend upon the decommissioning plans for multiple projects. This is discussed further in section 17.8.2.

17.8.1 Cumulative direct impact to potential heritage assets

235. There is potential for cumulative direct impacts to discrete (potential) heritage assets within the offshore cable corridor and project interconnector search area from both Norfolk Vanguard and Norfolk Boreas.

236. As discussed in section 17.7.6.2 above, it is not possible to avoid heritage assets that have not yet been discovered (potential heritage assets) and, therefore, unavoidable direct impacts may occur if archaeological material is present. As the importance, and hence sensitivity, of potential heritage assets is potentially high (see Table 17.17 above), and the magnitude of effect is also potentially high, this could result in an impact of **major adverse** significance.

237. However, the specific mitigation which will be applied for both projects (as set out in section 17.7.2) is expected to reduce the level of harm through reducing, remedying and offsetting these potential impacts for both projects. Therefore, the potential cumulative impact is considered to be **minor adverse**. Cumulative direct impacts upon discrete (potential) heritage assets with other projects are not anticipated to occur as the footprints of projects do not overlap.

238. However, the extents of palaeolandscapes from various periods are largely unmapped and may either be confined within a project area, or may extend beyond the bounds of a project. For example, the assessment of sub-bottom profiler data within the study area has demonstrated the presence of landscape features which form part of the wider North Sea palaeolandscape and the submerged landscape of Doggerland in the Southern North Sea.

239. Similarly, multiple unexpected discoveries of maritime or aviation finds, including newly identified wrecks or crashed aircraft which may be impacted during offshore activities could result in a negative cumulative impact upon the overall in-situ maritime/aviation archaeological resource of the region. As an example, multiple unexpected impacts to wrecks associated with First and Second World War East Coast war channels (see paragraph 138) could result in a physical depreciation of the in-situ archaeological resource relating to those war channels. This could correspond to a reduction in the heritage significance of those wrecks when considered in terms of their group value and associations if material is repeatedly lost as multiple impacts occur.

240. If multiple unavoidable impacts occur during the construction, operation or decommissioning of multiple projects, then cumulative impacts may occur and it is possible that unique aspects of former landscapes, or of the in-situ maritime and aviation archaeological resource, may be lost as a result. In addition, if a site is damaged or destroyed, comparable sites elsewhere may increase in importance as a result of greater rarity and any future direct impacts will be of greater significance.

241. However, together with the accumulation of archaeologically interpreted geophysical and geotechnical data carried out for offshore developments in recent years, the information provided by chance discoveries is already seen to be contributing significantly to a greater understanding of the offshore archaeological resource. As such, any unavoidable impacts and the data and records produced in mitigating their effects can also be regarded as a significant, beneficial cumulative effect. Any positive effect, however, must be demonstrated by the completion of studies to professional archaeological standards and the results produced must be made publicly available.

242. It is acknowledged that strategic analysis in relation to the cumulative impact of multiple constructed and planned projects would facilitate greater understanding of the cumulative effect of offshore wind development within the North Sea. Although this is considered beyond the scope of an individual project Norfolk Boreas Limited are committed to making data from the Project available should a request for data be made to them for such a strategic study.

17.8.2 Cumulative impacts to the setting of heritage assets and historic seascape character

243. The cumulative impact to the setting and character of onshore heritage assets from intertidal and offshore (nearshore) activities are addressed in Chapter 28 (Onshore Archaeology and Cultural Heritage).

244. The introduction of the Norfolk Boreas project into the existing study area will result in a change to the historic seascape character and to the setting of marine heritage assets, particularly in terms of the wider 20th century military setting of the east coast region. The impact assessment concludes that the setting and character offshore is already influenced by existing gas rigs and passing shipping vessels in this area, thereby reducing the potential for measurable harm to significance of heritage assets which have a setting which contributes to their significance.

245. Perceptions of character with respect to the primary cultural processes which have been established and spatially defined through the HSC are set out in Table 17.15, and the expected changes associated with construction and operation are set out in Table 17.19 and Table 17.20. This assessment demonstrated that only loss of fishing grounds and the loss of archaeological potential associated with the marine cultural topography are likely to results in a potential meaningful change in perceptions of the historic character within the study area. Overall, and based upon professional judgement, the presently perceived historic character, therefore, is considered to have high capacity to accommodate the change.

246. However, within a 100km boundary of Norfolk Boreas there are 13 further offshore wind farm projects within UK waters and 11 further EU offshore wind projects, 29 marine aggregate dredging areas, the Deborah gas storage project and 118 oil and gas licences and 15 offshore disposal projects. The installed or planned infrastructure and associated activities required for all these projects, when considered together, indicates the potential for a significant cumulative change from a historically perceived, open North Sea seascape to a seascape characterised by industrial infrastructure and activities. In particular, with respect to the large number of planned offshore wind farm projects, perceptions of historic seascape character may change to reflect a perception of the southern North Sea as associated primarily with offshore renewables.

247. While the presently perceived historic character might be considered to have high capacity to accommodate change, it should be acknowledged that within 100km of Norfolk Boreas (and across the southern North Sea as a whole), cumulative impacts to the setting of heritage assets and historic seascape character will occur as a result of the construction of multiple projects. Whether this is considered a negative or positive effect may be entirely dependent upon individuals and whether or not they perceive a seascape associated with offshore renewables as a negative or positive change.

248. The National Historic Seascape Characterisation project character area text for ‘Energy Industry’ states that renewable energy generation produces strong and sometimes polarised views (LUC, 2017a, 2017b and 2017c). Renewable energy complexes are often seen as, ‘high profile visually-intrusive features impinging on familiar and highly valued landscape and seascape’ adding to levels of noise, smell and activity in traditionally ‘tranquil’ settings. By those who see renewable energy as a solution of global concern in sustainable development, however, renewable sources, ‘may be perceived as benign symbols of hope’.

17.9 Transboundary Impacts

249. Transboundary impacts stemming from changes to marine physical processes have been scoped out (see Chapter 8). Tidal ellipses show that all movement is in a north south direction and so will not cross the international boundary.

250. Transboundary archaeological impacts may occur if wrecks or aircraft of non-British, European nationality are subject to impact from development. Such wrecks may fall within the jurisdiction of another country, and may include, for example, foreign warships lost in UK waters. As the implementation AEZs will prevent direct impacts to known archaeological receptors, transboundary impacts to known wrecks and aircraft are not expected to occur. It is possible that potential wrecks or aircraft from other countries may be subject to impact, if unexpected discoveries occur, although the archaeological assessment of pre-construction geophysical survey data in combination with the implementation of ORPAD reduces the likelihood of significant impacts occurring. If wrecks or aircraft of non-British nationality are discovered during the course of the development, further advice will be sought regarding the legal status of the remains in their country of origin.

251. In recent decades there have been considerable advances in research of submerged landscapes and it has been recognised that offshore wind activities represent a significant opportunity to both acquire data, and to implement targeted survey and sampling to inform understanding of North Sea submerged landscapes in accordance with co-ordinated strategies across national boundaries. For example, the potential for Mesolithic discoveries within the Dogger Bank and Outer Silver Pit areas of the

UK sector should extend into the Elbe palaeovalley in the German Bight and the Danish sector south West of the Skagerrak where it connects to the Mesolithic archaeology in the straits connecting the Skagerrak with the Baltic Sea (Cohen et al. 2017: 176). Equally, Palaeolithic archaeology investigated in association with aggregate extraction in the southern North Sea is similarly expected to be found in the Belgian sector and the south west of the Dutch sector associated with the palaeovalleys of the Rhine and the Meuse.

252. Similarly, initiatives such as the MACHU (Managing Cultural Heritage Underwater) project recognise the value of an integrated approach to North Sea underwater cultural heritage in both management and investigation. MACHU originated as a three-year project involving seven countries sponsored by the European Union's Culture 2000 programme. The project ran from September 2006 to August 2009 although the web resources remain. This collaborative working is also represented through joint ventures such as the 2017 excavations of the *Rooswijk*, a former Dutch East India Company ship wrecked on the Goodwin Sands in 1740, by the Dutch Cultural Heritage Agency and Historic England.

253. These examples highlight the potential for developments to cumulatively affect larger-scale archaeological features such as palaeolandscapes and the North Sea maritime and aviation resource, and to affect the setting of heritage assets and historic landscapes/seascapes which may extend across these international boundaries as outlined for cumulative impacts in section 17.8.1 above. The potential for integrated research and management, however, also represents a positive transboundary impact of offshore wind farm development across all sectors of the North Sea.

254. For example, in the Netherlands, the spatial planning of the North Sea has been laid down in the 'National Waterplan' which includes the *Policy Document on the North Sea 2016-2021* (The Dutch Ministry of Infrastructure and the Environment and The Dutch Ministry of Economic Affairs 2015). New wind farms can only be constructed at sites within designated wind farm zones and are subject to EIA. Rijkswaterstaat (the executive agency of the Ministry of Infrastructure and Environment) fulfils the role of competent authority with regard to archaeological heritage management and the Cultural Heritage Agency (RCE: Rijksdienst voor het Cultureel Erfgoed) acts as a consultant for Rijkswaterstaat. In order to support the EIA and permitting processes, the Cultural Heritage Agency of the Netherlands has commissioned the production of a policy advice map for the North Sea's submerged archaeological landscapes which will comprise landscape zoning for the North Sea accompanied by (geo-archaeological) research guidelines for each zone.

255. Alongside data produced through UK offshore wind farm development, and that of the Netherlands, Belgium and Germany, for example, data sharing across national

boundaries has the potential to result in a significant beneficial transboundary impact. The positive effect of this, however, is dependent on the completion of studies to professional archaeological standards, and upon the publication of results, and raw data where appropriate, so that the benefit can be realised by those engaged in marine archaeological research (and the offshore wind industry) for both commercial and non-commercial purposes.

17.10 Inter-relationships

256. Inter-relationships between offshore archaeology and Marine Physical Processes (Chapter 8) have been discussed as part of the impact assessment above. This has demonstrated that no significant impacts are expected for any single archaeological receptor as a result of the construction, operation or decommissioning of the Norfolk Boreas project. As such, there is no potential for the accumulation of residual impacts on a single archaeological receptor.

17.11 Interactions

257. 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 but, for clarity, the areas of interaction between impacts are presented in Table 17.22, along with an indication as to whether the interaction may give rise to synergistic impacts.

Table 17.22 Interaction between impacts

Construction	1 Direct impact to known heritage assets	2 Direct impact to potential heritage assets	3 Indirect impact to heritage assets from changes to physical processes	4 Impacts to the setting of heritage assets and historic seascape character	5 Impacts to site preservation conditions from drilling fluid breakout
1 Direct impact to known heritage assets	-	No	No	No	No
2 Direct impact to potential heritage assets	No	-	Yes	Yes	Yes
3 Indirect impact to heritage assets from changes to physical processes	No	Yes	-	Yes	No
4 Impacts to the setting of heritage assets and historic seascape character	No	Yes	Yes	-	No
5 Impacts to site preservation conditions from drilling fluid breakout	No	Yes	No	No	-
Operation	1 Direct impact to known heritage assets	2 Direct impact to potential heritage assets	3 Indirect impact to heritage assets from changes to physical processes	4 Impacts to the setting of heritage assets and historic seascape character	5 Impacts to site preservation conditions from heat loss from installed cables
1 Direct impact to known heritage assets	-	No	No	No	No
2 Direct impact to potential heritage assets	No	-	Yes	Yes	No
3 Indirect impact to heritage assets from changes to physical processes	No	Yes	-	Yes	No
4 Impacts to the setting of heritage assets and historic seascape character	No	Yes	Yes	-	No
5 Impacts to site preservation conditions from heat loss from installed cables	No	No	No	No	-
Decommissioning					
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.					

17.12 Summary

258. A summary of the impact assessment for offshore and intertidal archaeology is presented in Table 17.23. In accordance with the methodology for assessment presented in section 17.4.1 this table should only be used in conjunction with the additional narrative explanations provided in section 17.7.

Table 17.23 Potential Impacts Identified for Offshore and Intertidal Archaeology

Potential Impact	Receptor	Value/Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Direct impact to known heritage assets	Wrecks and Anomalies (A1)	High	High	**Major adverse**	50m AEZs	**No impact**
	A3 wrecks	High	High	**Major adverse**	50m AEZs/Avoid location	**No impact**
	Additional anomalies (A2)	High	High	**Major adverse**	Avoid location	**No impact**
	Intertidal assets	Low	No impact	**No impact**	None	**No impact**
Direct impact to potential heritage assets	In-situ prehistoric, maritime or aviation sites	High	High	**Major adverse**	Further assessment	**Minor adverse**
	In-situ intertidal sites	High	Negligible	**Minor adverse**	Further (geoarchaeological) assessment	**Minor adverse**
	Isolated finds associated with early prehistoric activity	High	Low	**Moderate adverse**	Protocol to be established	**Minor adverse**
	Isolated finds	Medium	Low	**Minor adverse**	Protocol to be established	**Minor adverse**
Indirect impact to heritage assets from changes to physical processes	Known and potential heritage assets	Low to High	Negligible	**Negligible to Minor**	None	**Negligible to Minor adverse/ beneficial**
Impacts to the setting of heritage assets and historic seascape character	Temporary changes to setting and historic seascape character from construction activities are not considered to result in harm to the significance of heritage assets within the study area.					
Impacts to site preservation conditions from drilling fluid breakout	Intertidal assets	Low	Negligible / No impact	**Negligible**	None	**Negligible**
Operation						
Direct impact to known heritage assets	As for construction					**No impact**

Potential Impact	Receptor	Value/Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Direct impact to potential heritage assets	In-situ prehistoric, maritime or aviation sites	High	High	**Major adverse**	Further assessment	**Minor adverse**
Indirect impact to heritage assets from changes to physical processes	Known and potential heritage assets	Low to High	Negligible	**No impact to Negligible**	None	**No impact to Negligible**
Impacts to the setting of heritage assets and historic seascape character	Changes to setting and historic seascape character during operation are not considered to result in harm to the significance of heritage assets within the study area.					
Impacts to site preservation conditions from heat loss from installed cables	Known and potential heritage assets	Low to High	No impact	**No impact**	None	**No impact**
Decommissioning						
Direct impact to known heritage assets	As for construction					**No impact**
Direct impact to potential heritage assets	In-situ prehistoric, maritime or aviation sites	High	High	**Major adverse**	Further assessment	**Minor adverse**
Indirect impact to heritage assets from changes to physical processes	As for construction (or less)					**Negligible to Minor adverse/ beneficial**
Impacts to the setting of heritage assets and historic seascape character	Temporary changes to setting and historic seascape character from decommissioning activities are not considered to result in harm to the significance of heritage assets within the study area.					
Cumulative						
Direct impact to known heritage assets	In-situ prehistoric, maritime or aviation sites	Low to High	High	**Major adverse**	Avoidance	**No impact**
Direct impact to potential heritage assets	In-situ prehistoric, maritime or aviation sites	Medium to High	High	**Major adverse**	Further assessment/reporting protocol	**Minor adverse (plus positive benefit from accumulation of**

Potential Impact	Receptor	Value/Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
						data)
Indirect impact to heritage assets from changes to physical processes	Known and potential heritage assets	Low to High	Negligible	**No impact**	None	**No impact**
Impacts to the setting of heritage assets and historic seascape character	Cumulative impacts to the setting of heritage assets and historic seascape character will occur. Whether this is considered adverse/beneficial depends upon individual perceptions of a seascape associated with offshore renewables as a negative or positive change.					
Transboundary						
Direct impact to known heritage assets	Wrecks or aircraft of non-British origin	High	High	**Major adverse**	Avoidance	**No impact**
Direct impact to potential heritage assets	Wrecks or aircraft of non-British origin	High	High	**Major adverse**	Further assessment/ reporting protocol/ consideration of legal status in country of origin	**Minor adverse**
	Prehistoric, maritime and aviation archaeological resource (across national boundaries)	Medium to High	High	**Major adverse**	Further assessment/ reporting protocol	**Minor adverse (plus positive benefit from accumulation of data)**
Indirect impact to heritage assets from changes to physical processes	Tidal ellipses show that all movement is in a north south direction so will not cross the international boundary and transboundary impacts will not occur.					

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