Hornsea Project Four: Environmental Statement (ES)

PINS Document Reference: A2.9
APFP Regulation: 5(2)(a)

Volume A2, Chapter 9: Marine Archaeology

Prepared	Maritime Archaeology. July 2021
Checked	GoBe Consultants Ltd. August 2021
Accepted	David King, Orsted. August 2021
Approved	Julian Carolan, Orsted. September 2021

Doc. no. A2.9
Version B

Table of Contents

List of Tables

List of Figures

Annexes

Annex	Heading
A5.9.1	Marine Archaeology Technical Report

Glossary

Term	Definition
Archaeological Exclusion Zone	Areas where archaeological receptors are present and should be avoided during project works.
Commitment	A term used interchangeably with mitigation and enhancement measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, Preliminary Environmental Information Report (PEIR) or ES). Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are acceptable.
Cumulative impact	Impacts that result from changes caused by other past, present or reasonably foreseeable actions together with Hornsea Four.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Export cable corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Four array area to the Creyke Beck National Grid substation, within which the export cables will be located.
Marine Heritage Receptors	Physical resources such as shipwrecks, aviation remains, archaeological sites, archaeological finds and material including pre-historic deposits as well as archival documents and oral accounts recognised as of historical/ archaeological or cultural significance.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Maximum Design Scenario (MDS)	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.
Mitigation	A term used interchangeably with Commitment(s) by Hornsea Four. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, PEIR, or ES).
Model Clauses	Guidance issued by The Crown Estate; Model Clauses for Archaeological Written Schemes of Investigation: Offshore Renewables Projects.
Offshore	Seaward of Mean High Water Springs (MHWS)
Orsted Hornsea Project Four Ltd	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Outline Marine Written Scheme of Investigation (WSI)	Project specific document forming the agreement between the Applicant, the appointed archaeologists, contractors and the relevant stakeholders seaward of Mean High Water Springs (MHWS). The document sets out the

Term	Definition
	methods to mitigate the effects on all the known and potential archaeological receptors within the Hornsea Four offshore Order Limits.
Outline Onshore Written Scheme of Investigation (WSI)	Project specific document forming the agreement between the Applicant, the appointed archaeologists, contractors and the relevant stakeholders landward of MHWS. The document sets out the methods to mitigate the effects on all the known and potential archaeological receptors within the Hornsea Four onshore Order Limits.

Acronyms

Acronym	Definition
AEZ	Archaeological Exclusion Zone
AfL	Agreement for Lease
CEA	Cumulative Effect Assessment
CIfA	Charted Institute for Archaeologists
CITiZAN	Coastal and Intertidal Zone Archaeological Network
CPT	Cone Penetration Test
DCO	Development Consent Order
dML	Deemed Marine Licence
DMRB	Design Manual for Roads and Bridges
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
ES	Environmental Statement
GBS	Gravity Base Structure
HE	Historic England
HSC	Historic Seascape Characterisation
HVAC	High Voltage Alternating Current
JUV	Jack Up Vessel
LSE	Likely Significant Effect
MAG	Magnetometer
MBES	Multi-beam Echo Sounder
MDS	Maximum Design Scenario
MFP	Minimum Facilities Platform
MHWS	Mean High Water Springs
MPS	Marine Policy Statement
NPS	National Policy Statement
NRHE	National Record of the Historic Environment
NSIP	Nationally Significant Infrastructure Project
NSPP	North Sea Palaeolandscapes Project
OSS	Offshore Substation
OWF	Offshore Wind Farm
PAD	Protocol for Archaeological Discoveries
PEIR	Preliminary Environmental Information Report

Acronym	Definition
PINS	Planning Inspectorate
REC	Regional Environmental Characterisation
ROV	Remotely Operated Vehicles
SBP	Sub-Bottom Profiler
SSS	Side Scan Sonar
UHRS	Ultra-High Resolution Seismic
UKHO	United Kingdom Hydrographic Office
UXO	Unexploded Ordnance
WSI	Written Scheme of Investigation
WTG	Wind Turbine Generator

Units

Unit	Definition
m	Metres
km	Kilometres
nT	Nanotesla (magnetic induction)

9.1 Introduction

9.1.1.1 Orsted Hornsea Project Four Limited (hereafter 'the Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm, (hereafter 'Hornsea Four') which will be located approximately 69 km from the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume A1, Chapter 1: Introduction** for further details on the former Hornsea Zone). Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network (please see **Volume A1, Chapter 4: Project Description** for full details on the Project Design).

9.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

9.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the array area taken forward at the point of DCO application. Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

9.1.1.4 This chapter of the ES presents the results of the EIA for the potential impacts of the Hornsea Four on marine archaeology. Specifically, this chapter considers the potential impact of Hornsea Four seaward of Mean High Water Springs (MHWS) during its construction, operation and maintenance, and decommissioning phases. The offshore and onshore archaeological assessments overlap at the intertidal zone as outlined in **Volume A5, Annex 9.1: Marine Archaeology Technical Report** and **Volume A3, Chapter 5: Historic Environment**, respectively.

9.1.1.5 This chapter summarises the information contained within **Volume A5, Annex 9.1: Marine Archaeology Technical Report**, incorporating a geophysical data review (Appendix C of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**) and a paleogeographic review of geophysical survey data (Appendix D of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**).

9.2 Purpose

9.2.1.1 The primary purpose of this ES is to support the DCO application for Hornsea Four under the Planning Act 2008 (the 2008 Act).

9.2.1.2 The ES has been finalised following completion of the pre-application consultation (see **B1.1: Consultation Report** and **Table 9.3**) and the ES will accompany the application to the Planning Inspectorate (PINS) for Development Consent.

9.2.1.3 This ES chapter:

- Summarises the existing environmental baseline established from desk studies, and consultation;
- Presents the potential environmental effects on marine archaeology arising from Hornsea Four, based on the information gathered and the analysis and assessments undertaken;
- Identifies any assumptions and limitations encountered in compiling the environmental information; and
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental effects identified in the EIA process.

9.3 Planning and Policy Context

9.3.1.1 Planning policy on offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to marine archaeology, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; DECC 2011a) and the NPS for Renewable Energy Infrastructure (EN-3, DECC 2011b).

9.3.1.2 NPS EN-1 and NPS EN-3 include guidance on what matters are to be considered in the assessment. These are summarised in **Table 9.1** below.

Table 9.1: Summary of NPS EN-1 and EN-3 provisions relevant to marine archaeology.

Summary of NPS EN-1 and EN-3 provisions	How and where considered in 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" (Paragraph 5.8.8 of NPS EN-1).	Construction, operation and decommissioning phases of Hornsea Four have been assessed as discussed in **Section 9.11**.
"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" (Paragraph 5.8.9 of NPS-EN1).	The archaeological potential has been considered and assessed in **Volume A5, Annex 9.1: Marine Archaeology Technical Report** and summarised in **Section 9.7**.
"The applicant should ensure that the extent of the impact of the proposed development on the significance of any heritage assets	The significance and impact on the archaeological receptors of the development is discussed in **Section 9.11**.

Summary of NPS EN-1 and EN-3 provisions	How and where considered in the ES
affected can be adequately understood from the application and supporting documents" (Paragraph 5.8.10 of NPS-EN1).	
"Where the loss of the whole or a material part of a heritage asset's significance is justified, the IPC [hereafter the Secretary of State (SoS)] *should require the developer to record and advance understanding of the significance of the heritage asset before it is lost. The extent of the requirement should be proportionate to the nature and level of the asset's significance. Developers should be required to publish this evidence and deposit copies of the reports with the relevant Historic Environment Record. They should also be required to deposit the archive generated in a local museum or other public depository willing to receive it"* (Paragraph 5.8.20 of NPS-EN1).	The Outline Marine Written Scheme of Investigation (WSI) (Document **F2.4**) outlines all provisions made and standards expected for archaeological recording of marine heritage receptors. The document further outlines where archives and material will be deposited.
"Where appropriate, the SoS should impose requirements on a consent that such work is carried out in a timely manner in accordance with a written scheme of investigation that meets the requirements of this Section and has been agreed in writing with the relevant Local Authority (the Marine Management Organisation and English Heritage), and that the completion of the exercise is properly secured" (Paragraph 5.8.21 of NPS-EN1).	Commitment Co140 (**Table 9.9**) details how the Outline Marine WSI (Document **F2.4)** will be implemented.
"Where the SoS considers there to be a high probability that a development site may include as yet undiscovered heritage assets with archaeological interest, the SoS should consider requirements to ensure that appropriate procedures are in place for the identification and treatment of such assets discovered during construction" (Paragraph 5.8.22 of NPS-EN1).	The Hornsea Four Protocol for Archaeological Discoveries (PAD) is appended to the Outline Marine WSI (Document **F2.4**) and defines the procedure that will be followed if new archaeological receptors are identified during the construction, operation and maintenance or decommissioning of Hornsea Four.
"Heritage assets can be affected by Offshore Wind Farm (OWF) development in two principal ways: from the direct effect of the physical siting of the development itself and from indirect changes to the physical marine environment" (Paragraph 2.6.139 of NPS-EN3).	Potential effects have been assessed in **Section 9.11**.
"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 wind farm design" (Paragraph 2.6.141 of NPS-EN3).	The technical report and associated appendices (**Volume A5, Annex 9.1: Marine Archaeology Technical Report**) present assessments of geophysical and geotechnical data collected. The results are summarised in **Section 9.7**.
"Assessment should 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 of NPS-EN3).	Beneficial effects on potential archaeological receptors are discussed in **Section 9.7**.
"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 in EN-1" (Paragraph 2.6.143 of NPS-EN3).	The onshore and offshore archaeological resources have been cross-referenced and technical reports have been shared between archaeological contractors. The offshore and onshore archaeological assessments overlap at the intertidal zone as outlined in the

Summary of NPS EN-1 and EN-3 provisions	How and where considered in the ES
	respective technical reports (**Volume A5, Annex 9.1: Marine Archaeology Technical Report** and **Volume A6, Annex 5.1: Historic Environment Desk Based Assessment**).
"Avoidance of important heritage assets, including archaeological sites and historic wrecks, is the most effective form of protection and can be achieved through the implementation of Archaeological Exclusion Zones (AEZs) around such heritage assets which preclude development activities within their boundaries" (Paragraph 2.6.145 of NPS-EN3).	Exclusion zones have been applied to all known wrecks and contacts of high and medium significance as outlined in **Volume A5, Annex 9.1: Marine Archaeology Technical Report**. The Commitments adopted are detailed in **Table 9.9**.

9.3.1.3 NPS-EN1 and NPS EN-3 also highlight several factors relating to the determination of an application and in relation to mitigation. These are summarised in **Table 9.2** below.

Table 9.2: Summary of NPS-EN1 and NPS-EN3 policy on decision making relevant to marine archaeology.

Summary of NPS-EN1 and NPS EN-3 provisions	How and where considered in the ES
"In considering applications, the SoS should seek to identify and assess the particular significance of any heritage asset that may be affected by the proposed development, including by development affecting the setting of a heritage asset, taking account of: • *evidence provided with the application;* • *any designation records;* • *the Historic Environment Record, and similar sources of information;* • *the heritage assets themselves;* • *the outcome of consultations with interested parties; and* • *where appropriate and when the need to understand the significance of the heritage asset demands it, expert advice"* (Paragraph 5.8.11 of NPS-EN1).	**Volume A5, Annex 9.1: Marine Archaeology Technical Report** presents assessments of documentary records, geophysical and geotechnical data collected. The results are summarised in **Section 9.7**. Potential impacts have been assessed in **Section 9.11**.
"In considering the impact of a proposed development on any heritage assets, the SoS should take into account the particular nature of the significance of the heritage assets and the value that they hold for this and future generations. This understanding should be used to avoid or minimise conflict between conservation of that significance and proposals for development" (Paragraph 5.8.12 of NPS-EN1).	The significance of archaeological receptors and the potential impacts of the development on such receptors is discussed in **Section 9.11**.
"The SoS should take into account the desirability of sustaining and, where appropriate, enhancing the significance of heritage assets, the contribution of their settings and the positive contribution, they can make to sustainable communities and economic vitality" (Paragraph 5.8.13 of NPS-EN1).	The significance of submerged landscapes in the Southern North Sea will be enhanced by increased understanding of the resource and dissemination of the results as per commitment Co167 (**Table 9.9**).
"There should be a presumption in favour of the conservation of designated heritage assets and the more significant the	All identified archaeological receptors will be preserved *in situ* by utilising AEZs, as detailed in

Summary of NPS-EN1 and NPS EN-3 provisions	How and where considered in the ES
designated heritage asset, the greater the presumption in favour of its conservation should be. Once lost heritage assets cannot be replaced and their loss has a cultural, environmental, economic and social impact" (Paragraph 5.8.14 of NPS-EN1).	**Volume A5, Annex 9.1: Marine Archaeology Technical Report**.
"Any harmful impact on the significance of a designated heritage asset should be weighed against the public benefit of development, recognising that the greater the harm to the significance of the heritage asset the greater the justification will be needed for any loss" (Paragraph 5.8.15 of NPS-EN1).	All identified archaeological receptors will be preserved *in situ* by utilising AEZs, as detailed in **Volume A5, Annex 9.1: Marine Archaeology Technical Report**. If preservation *in situ* is not possible, mitigation through further investigation and/or removal of receptors in accordance with **F2.4 Outline Marine WSI** will be undertaken.
"When considering proposals, the SoS should take into account the relative significance of the element affected and its contribution to the significance of the World Heritage Site or Conservation Area as a whole" (Paragraph 5.8.16 of NPS-EN1).	All effects on marine archaeology of the development have been assessed or scoped out, as stated in **Section 9.8**. The development is not located within a World Heritage Site or Conservation Area.
"Where loss of significance of any heritage asset is justified on the merits of the new development, the SoS should consider imposing a condition on the consent or requiring the applicant to enter into an obligation that will prevent the loss occurring until it is reasonably certain that the relevant part of the development is to proceed" (Paragraph 5.8.17 of NPS-EN1).	The Applicant's Commitments, as outlined in **Table 9.9** will ensure that no loss of archaeological receptors will occur. Ongoing consultation with the statutory adviser, Historic England, as outlined in **Table 9.3**, will ensure that the commitments are adhered to and that any unavoidable impacts, should they arise, are properly considered and mitigated to the fullest practical extent through the mechanism of the agreed versions of the Marine WSI.
"When considering applications for development affecting the setting of a designated heritage asset, the SoS should treat favourably applications that preserve those elements of the setting that make a positive contribution to or better reveal the significance of, the asset" (Paragraph 5.8.18 of NPS-EN1).	The significance of archaeological receptors in the Southern North Sea, including shipwrecks and submerged landscapes, will be enhanced by increased understanding of the resource and dissemination of the results as per commitment Co167 in **Table 9.9**. **Volume A5, Annex 9.1: Marine Archaeology Technical Report** and its associated appendices present assessments of documentary records, geophysical and geotechnical data collected. The results are summarised in **Section 9.7**. Potential impacts have been assessed in **Section 9.11**.
"The Planning Inspectorate (PINS) will need to be satisfied that the foundations will not have an unacceptable adverse effect on marine heritage assets" (Paragraph 2.6.32 of NPS-EN3).	All effects on marine archaeology of the development have been assessed or scoped out as stated in **Section 9.8**.

Summary of NPS-EN1 and NPS EN-3 provisions	How and where considered in the ES
"Consultation with relevant statutory consultees Historic England should be undertaken by the applicants at an early stage of the Development" (Paragraph 2.6.140 of NPS-EN3).	Consultation with Historic England has been undertaken as detailed in **Table 9.3**.
"PINS should be satisfied that OWFs and associated infrastructure have been designed sensitively taking into account known heritage assets and their status (for example designated features)" (Paragraph 2.6.144 of NPS-EN3).	Designated features and their sensitivity have been assessed in **Volume A5, Annex 9.1: Marine Archaeology Technical Report**, **F2.4 Outline Marine WSI**, and are summarised in **Table 9.7**.
"Where requested by applicants, PINS should consider granting consents that allow for micro-siting to be undertaken within a specified tolerance. This allows changes to be made to the precise location of infrastructure during the construction phase so that account can be taken of unforeseen circumstances such as the discovery of marine archaeological remains" (Paragraph 2.6.146 of NPS-EN3).	The Hornsea Four PAD for unexpected archaeological discoveries (appended to **F2.4 Outline WSI** describes the procedure that should be followed if archaeological receptors are found during construction, operation and maintenance or decommission.

9.3.1.4 The UK Marine Policy Statement (MPS; HM Government 2011) is also relevant to marine archaeology matters. Specifically, the Marine Policy Statement, in paragraph 2.6.6.3, states that heritage assets in the marine environment *"should be conserved through marine planning in a manner appropriate and proportionate to their significance"*, adding that, *"opportunities should be taken to contribute to our knowledge and understanding of our past by capturing evidence from the historic environment and making this publicly available, particularly if a heritage asset is to be lost"*.

9.3.1.5 With reference to non-designated heritage assets the MPS states, in paragraph 2.6.6.5, that the "Many heritage assets with archaeological interest in these areas are not currently designated as scheduled monuments or protected wreck sites but are demonstrably of equivalent significance. The absence of designation…does not necessarily indicate lower significance and the marine plan authority should consider them subject to the same policy principles as designated heritage assets…based on information and advice from the relevant regulator and advisors".

9.3.1.6 When considering possible damage to or destruction of heritage assets by development proposals, the MPS states in paragraph 2.6.6.9 that *"the marine plan authority should identify and require suitable mitigating actions to record and advance understanding of the significance of the heritage asset before it is lost"*.

9.4 Consultation

9.4.1.1 Consultation is a key part of the DCO application process. Consultation regarding marine archaeology has been conducted through Evidence Plan Technical Panel meetings, the EIA scoping process (Orsted 2018) and formal consultation on the Preliminary Environmental Information Report (PEIR) under section 42 of the 2008 Act. An overview of the project consultation process is presented within **Volume A1, Chapter 6: Consultation**.

9.4.1.2 The key issues raised during consultation specific to marine archaeology are outlined below in Table 9.3, together with how these issues have been considered in the production of this ES.

Table 9.3: Consultation responses.

Consultee	Date, Document, Forum	Issues raised	Response to Issue and where addressed in the ES
Historic England	12 November 2018 Scoping Opinion	Section 6.7 [of the Scoping Report] references the recorded wrecks within the development area, it does not consider the potential represented by the casualties and recorded losses within the National Record of the Historic Environment (NRHE) for both shipwreck and aircraft losses.	NRHE shipwreck and aircraft losses are considered in Section 9.7.1.
Historic England	12 November 2018 Scoping Opinion	Historic England are unable to provide advice on the suitability of the mitigation measures, until a full assessment of the area has been completed inclusive of desk-based resources and site specific geophysical and geotechnical data, and the location of sites of archaeological interest are known.	The existing marine archaeological baseline is presented in Section 9.7.1.
Historic England	12 November 2018 Scoping Opinion	There is no detail presented within Chapter 8 'Cumulative Effects' with regards to the topics proposed for inclusion within the offshore cumulative effects assessment. In particular, Historic England require further detail to be included with regards to the cumulative impact of the project on palaeoenvironmental deposits across the area.	The marine archaeology Cumulative Effects Assessment (CEA) is presented in Section 9.12.
PINS	23 November 2018 Scoping Opinion	The Scoping Report does not provide specific detail with respect to [embedded mitigation: primary, secondary and tertiary] measures but they are acknowledged to constitute recognised methods of control for the impacts described. The Planning Inspectorate is content that if the above measures are adequately secured (with reference to implementation) and presented in sufficient detail then they may be relied upon as means to demonstrate an absence of significant effect in the ES. The Applicant should make effort to agree the detail in relation to these measures with relevant consultation bodies.	Embedded mitigation (referred to as Commitments) are detailed in Section 9.8.2 alongside how these measures are secured. The full Commitments Register is provided in Volume A4, Annex 5.2.
Historic England	18 December 2018, Marine Archaeology Evidence Plan Technical Panel Meeting.	The overall approach to the evidence plan process and proportionality were presented to Historic England, including details of planned surveys and assessment methodology. While no issues were raised regarding proposed methods, the use of proportionality was not a concept that Historic England had accepted or endorsed on other projects. It was agreed that it was necessary to provide additional detail on proportionality in	Further detail provided in Section 9.8. It is important to note that in subsequent meetings, Historic England deemed the proportionate approach acceptable

Consultee	Date, Document, Forum	Issues raised	Response to Issue and where addressed in the ES
		subsequent technical panel meetings (see below). Historic England were unable to commit to the approval of the overall proportional approach until further details and clarity could be provided later in the process.	(OFF-ARCH-2.2).
Historic England	06 June 2019, Marine Archaeology Evidence Plan Technical Panel Meeting.	Further detail regarding the archaeological programme of works, including timings, as well as how proportionality is being applied in practical terms, was presented. Agreed that the use of the Commitments Register would be expanded with additional commitments to ensure that any further concerns that Historic England may have are clearly dealt with and documented in any subsequent DCO and deemed Marine Licence (dML) conditions. It was also agreed that regular update meetings between the Applicant and Historic England would be held on a bi-monthly basis in addition to a further two workshops prior to application.	Commitments are detailed in Section 9.8.2 alongside how these measures will be secured. The full Commitments Register is provided in Volume A4, Annex 5.2.
Historic England	20 September 2019, Section 42 Response	Historic England note that the impact assessment does not include consideration of the impacts from cable repair and remediation activities and request that such consideration is given.	The wording of impact MA-O-7 in Section 9.10 has been amended to include consideration of cable repair and remediation activities (OFF-ARCH-1.2).
Historic England	20 September 2019, Section 42 Response	Historic England note that there is evidence of Mesolithic activity at Fraisthorpe Sands, which lies within the PEIR boundary. This would need to be explicitly considered within investigations of the landfall area, in order to ensure adequate mitigation. Historic England are however, pleased by the current mitigation measures set out based on the current baseline assessment and impact assessment.	Mesolithic activity is considered in Section 9.7.
Historic England	20 September 2019, Section 42 Response	Historic England suggest the following changes/ additions to the Outline Marine WSI: • A log of completed and proposed geophysical and geotechnical investigations, with detail on the date, resolution, coverage, quality assessment, confidence statement, and associated reports for each survey; • Detail on the implementation, amendments and removal of AEZs and TEZs, in particular the relevant parties from whom advice should be sought; • Detail on the timescales for the production of reports, their delivery to the archaeological curator for review, their deposition to archival institutes, and	The Outline Marine WSI (Document F2.4) has been amended to reflect comments.

Consultee	Date, Document, Forum	Issues raised	Response to Issue and where addressed in the ES
		the production of method statements prior to survey works; • Amendments to Historic England contacts; • Reference added to Historic England Geophysical guidance and geoarchaeological guidance; • Staff list should be expanded to include future staff; and • Further detail added to clarify that finds should not be cleaned or 'emptied', and associated finds should be kept together.	
Historic England	13 November 2019, Marine Archaeology Evidence Plan Technical Panel Meeting.	Through highlighting the commitments and mitigation measures that support any "scoped out" impacts, Historic England were talked through the proportionate approach and how this was presented in the PEIR documentation.	Commitments are detailed in Section 9.8.2 alongside how these measures will be secured. The full Commitments Register is provided in Volume A4, Annex 5.2.
Historic England	12 May 2020, Marine Archaeology Evidence Plan Technical Panel Meeting.	Historic England suggested further changes to the Outline Marine WSI (Document F2.4).	The Outline Marine WSI (Document F2.4) has been amended to reflect comments.
Historic England	29 January 2021, Consultation on draft DCO documents.	Historic England confirmed that they were aware of the approach adopted by Hornsea Four, but that any formal comments will be subject to the appropriate baseline assessment and the securement of mitigation measures within a draft Commitments Register.	Commitments are detailed in Section 9.8.2 alongside how these measures will be secured. The full Commitments Register is provided in Volume A4, Annex 5.2: Commitments Register.
Historic England	Regular offshore update meetings from July 2019 up until DCO Application submission	Regular catch-up meetings to keep Historic England updated on how Hornsea Four is progressing, including ongoing surveys, marine archaeology deliverables and timescales for submission.	N/A

9.4.1.3 Agreements made with consultees within the Evidence Plan process are set out in the topic specific Evidence Plan Logs which are appendices to the Hornsea Four Evidence Plan (**Volume B1, Annex 1.1: Evidence Plan**), an annex of the Hornsea Four Consultation Report (**Volume B1, Chapter 1: Consultation Report**). All agreements within the Evidence Plan Logs have unique identifier codes which have been used throughout this document to signpost to the specific agreements made (e.g. OFF-ARCH-2.1).

9.5 Study Area

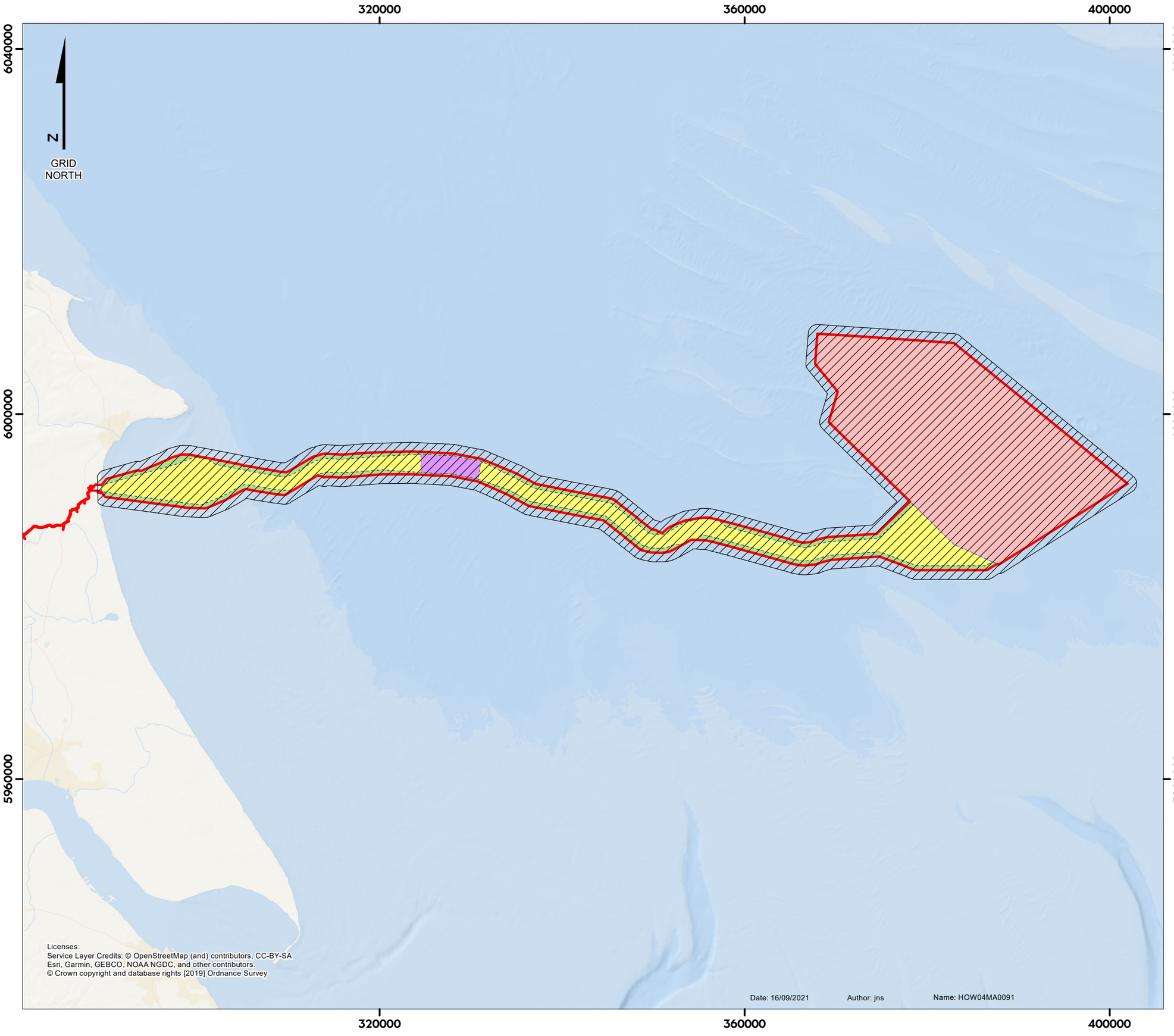
9.5.1.1 The marine archaeology study area was established to encompass the Hornsea Four Order Limits plus a 1 km buffer defining the zone where any potential effects on marine archaeology receptors may occur (**Figure 9.1**). The buffer was defined at the Scoping phase, based on professional judgement, in order to capture baseline records of marine casualties for which positioning has historically been poor.

9.5.1.2 Hornsea Four adopted a major site reduction from the AfL presented at Scoping (846 km^2) to the PEIR boundary (600 km^2), with a further reduction adopted for the ES and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A3, Annex 3.2: Selection and Refinement of Offshore Infrastructure**.

Hornsea Four

Figure 9.1

Marine Archaeology Study Area



- Marine Archaeology Study Area
- Order Limits
- Array
- HVAC Booster Station Works
- Offshore Temporary Works
- Offshore Export Cable

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 7.5 15 Kilometres

0 3.5 7 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	15/07/2019
A	Updated following PEIR consultations for DCO	16/09/2021

Archaeology Study Area
Document no: HOW04MA0091
Created by: CH
Checked by: BM
Approved by: GM

MARITIME ARCHAEOLOGY

Ørsted

9.6 Methodology to Inform Baseline

9.6.1 Desktop Study

9.6.1.1 A desktop study was undertaken to obtain information on known marine archaeological receptors. Data were acquired within the Hornsea Four marine archaeological study area and surrounding region through a detailed desktop review of existing studies and datasets. Further detail is presented within **Volume A5, Annex 9.1: Marine Archaeology Technical Report**.

9.6.1.2 The following sources of information in **Table 9.4** were consulted.

Table 9.4: Key sources of marine archaeological data.

Source	Summary	Coverage of Hornsea Four
National Record of the Historic Environment (NRHE)	Spatial and descriptive data[1]	Full coverage (seaward and landward of MHWS) of the Hornsea Four marine archaeology study area.
United Kingdom Hydrographic Office (UKHO)	Spatial data[2]	Full coverage (seaward of MHWS) of the Hornsea Four marine archaeology study area.
Humber Historic Environment Record	Spatial and descriptive[3]	The Hornsea Four marine archaeology study area landward of MHWS.
Rapid Coastal Zone Assessment: Yorkshire and Lincolnshire	Descriptive data[4]	The Hornsea Four marine archaeology study area landward of MHWS.
Yorkshire Archaeological Research Framework	Descriptive data[5]	The Hornsea Four marine archaeology study area landward of MHWS.
CITiZAN – Coastal and Intertidal Zone Archaeological Network	Descriptive data[6]	The Hornsea Four marine archaeology study area landward of MHWS.

9.6.1.3 Data for known shipwrecks, obstructions and recorded shipping losses within the marine archaeology study area were obtained from the UKHO and the NRHE. The two datasets were compared, and duplicates removed. Where discrepancies were found in the spatial data between the different sources, the coordinates provided by UKHO were used.

9.6.1.4 Known and identified features within the marine environment typically fall into two categories: wrecks and obstructions. Definitions of these terms, as used by the UKHO, are provided below:

- **Wreck:** The ruined remains of a stranded or sunken vessel or aviation remain which has been rendered useless; and
- **Obstruction:** In marine navigation, anything that hinders or prevents movement, particularly anything that endangers or prevents passage of a vessel. The term is

[1] https://archaeologydataservice.ac.uk/archives/view/398/
[2] https://www.oceanwise.eu/
[3] http://www.hull.gov.uk/resident/planning-and-building-control/humber-historic-environment-record
[4] https://archaeologydataservice.ac.uk/archives/view/yorksrcza_eh_2009
[5] https://historicengland.org.uk/images-books/publications/yorks-arch-res-framework-resource-assessment/
[6] https://www.citizan.org.uk/

usually used to refer to an isolated danger to navigation. 'Fouls' (areas safe to navigate over but which should be avoided for anchoring, taking the ground, or ground fishing) listed by the UKHO are included within this category.

9.6.1.5 Wrecks and obstructions are further classified by the UKHO as:

- LIVE: Wreck considered to exist as a result of detection through survey;
- DEAD: Not detected over repeated surveys, therefore not considered to exist in that location;
- LIFT: Wreck has been salvaged; and
- ABEY: Existence of wreck in doubt and therefore not shown on charts.

9.6.1.6 Data contained within the NRHE database and reported as fishermen's fasteners (defined as places where fishermen have snagged their fishing gear) are included in this desktop study.

9.6.2 Site Specific Surveys

9.6.2.1 To inform the EIA, site-specific surveys have been undertaken. **Table 9.5** summarises the status of all completed geophysical and geotechnical investigations as well as the associated archaeological works undertaken. Further details on survey resolution, coverage and quality control can be found in the archaeological reports listed in the table.

Table 9.5: Completed offshore investigations.

Title, year, and reference	Survey summary	Archaeological Reports
Geophysics 1A Pre-application survey Data acquired during summer 2018 and 2019.	Multi-beam Echo Sounder (MBES), Side Scan Sonar (SSS), Magnetometer (MAG), Sub-Bottom Profiler (SBP) and Ultra-High Resolution Seismic (UHRS) survey in the array area to inform the application process and characterise the Order Limits.	**Volume A5, Annex 9.1: Marine Archaeology Technical Report** - Appendices C and D.
Geophysics 1C Pre-geotechnical (1A) survey Data acquired during spring 2020.	Eighteen locations where geotechnical samples were collected were surveyed and assessed for archaeological potential.	**Volume A5, Annex 9.1: Marine Archaeology Technical Report** - Appendices C and D.
Geotechnical 1A Pre-application survey. Data acquired during summer 2020.	Intrusive ground investigations comprising seabed and down-hole testing (Cone Penetration Tests (CPTs), Vibrocores and Boreholes) to ground truth the geophysical ground model to inform the site design and characterise the Order Limits.	A staged geoarchaeological assessment following the processes detailed in Section 7 of **F2.4: Outline Marine WSI** will be submitted to Historic England once available.
Geophysics Seismic (Data acquired during summer 2021.	Seismic survey (MBES/Backscatter, SBP and UHRS) of Order Limits to inform the site design.	A staged geoarchaeological assessment following the processes detailed in Section 7 of **F2.4: Outline Marine WSI** will be

Title, year, and reference	Survey summary	Archaeological Reports
		submitted to Historic England once available.
Geophys-MBES. Data acquired during summer 2021.	Full coverage bathymetry survey of array area (MBES/Backscatter) to inform the site design.	A marine archaeological technical report following the process detailed in Sections 5.5 and 7 of **F2.4: Outline Marine WSI** will be submitted to Historic England once available.
Landfall geophysical and Geotechnical survey Data acquired in summer 2021.	Targeted landfall investigation using CPTs, boreholes and geophysical survey in order to inform the site design.	A staged geoarchaeological assessment following the processes detailed in Section 7 of **F2.4: Outline Marine WSI** will be submitted to Historic England once available.

9.6.2.2 The scope and assessment methodology for future surveys is summarised in Table 8 of **F2.4: Outline Marine WSI** and are being planned in line with the Commitments made by the Applicant**.** These Commitments are listed in **Table 9.9** with further detail provided in **Volume A4, Annex 5.2: Commitments Register**. Survey scopes and methodologies will be submitted to the Historic England Marine Planning Team for review and comment.

9.7 Baseline Environment

9.7.1 Existing baseline

9.7.1.1 A detailed description of the marine archaeology and cultural heritage within the Hornsea Four Order Limits and more widely within the marine archaeology study area is provided within **Volume A5, Annex 9.1: Marine Archaeology Technical Report**. A summary of the known and potential archaeology within the marine archaeology study area is presented below and in **Table 9.7**, with a focus on heritage assets which may be impacted by Hornsea Four.

Palaeolandscapes

9.7.1.2 The presence of Holocene landscape features and deposits within the Hornsea Four marine archaeological study area and its immediate vicinity has been demonstrated by the North Sea Palaeolandscapes Project (NSPP) (Gaffney et al. 2007) and the Humber Regional Environmental Characterisation (REC) where sampling has shown that the likelihood of survival of the remains of Mesolithic activity and settlement on the Mesolithic shoreline, or within fluvial deposits, is high (Tappin et al. 2011).

Sedimentary horizons

9.7.1.3 A palaeogeographic review of site-specific geophysical survey data (Appendix C of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**) was undertaken which identified a sedimentary sequence and deposits of archaeological potential.

9.7.1.4 The basal deposits identified include Bolders bank, Swarte bank and Yarmouth Roads, which lie on top of chalk, or pre-chalk, bedrock. In some areas, a unit of interest which underlies the Holocene deposits and overlies the basal deposit has been identified (Appendix C of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**).

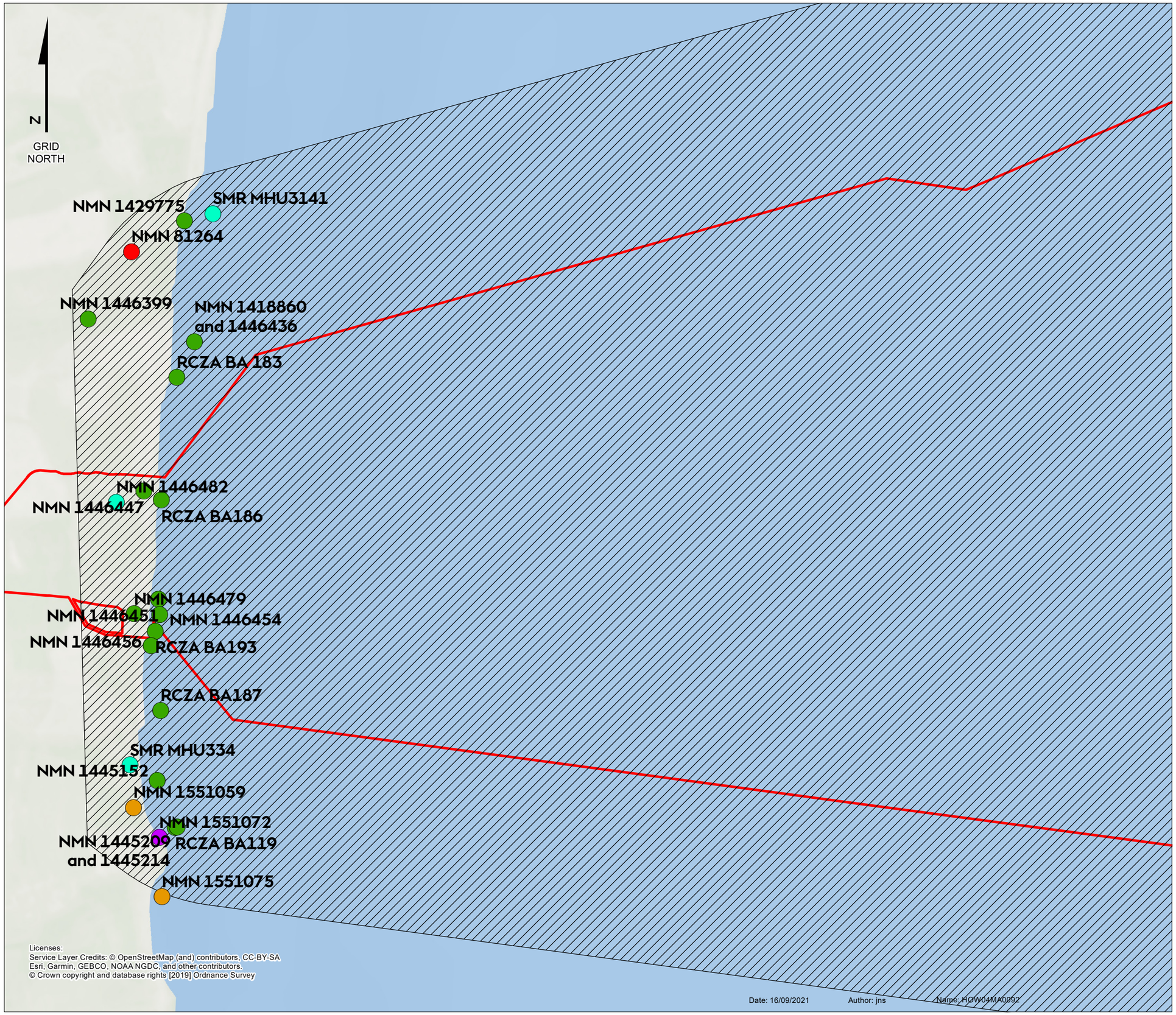
Offshore-Maritime

9.7.1.5 A broad contextual overview of human activity in the region and of the archaeological site types that may be expected to occur within the marine archaeology study area is included in **Volume A5, Annex 9.1: Marine Archaeology Technical Report**.

9.7.1.6 The offshore marine archaeological resource is presented by three main classes of material and features:

- Submerged prehistoric landscapes caused by changes to sea level and eventual stabilisation of sea level at or near to the present position. Such landscapes may contain highly significant evidence of prehistoric human occupation and/or environmental change;
- Archaeological remains of watercraft deposited when vessels sank while at sea or became abandoned in an inter-tidal context which subsequently became inundated; and
- Remains of aircraft crash sites, either coherent assemblages or scattered material, usually the result of Second World War military conflict, but also numerous passenger casualties, particularly during the peak of seaplane activity during the inter-war period. Also includes aircraft, airships and other dirigibles dating to the First World War, although these rarely survive in the archaeological record.

9.7.1.7 The assessment concludes that all time periods are represented within the marine archaeology study area, with a concentration of known sites and find spots located on land and in the intertidal zone, as illustrated on **Figure 9.2**, which outlines the potential for the preservation of similar features and deposits within the marine zone.



Hornsea Four

Figure 9.2

Archaeological sites included within the Marine Archaeology Study Area

Order Limits

Marine Archaeology Study Area

Sites included within the baseline archaeology review

- Bronze Age
- Iron Age
- Medieval
- Neolithic
- Roman
- Second World War

Information sources used in the archaeological desk-based assessment are detailed in Volume A5, Annex 9.1: Marine Archaeology Technical Report.

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:20,000

0 0.5 Kilometres

0 0.15 0.3 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	15/07/2019
A	Updated following PEIR consultations for DCO	16/09/2021

Neolithic, Bronze Age and Iron Age sites
Document no: HOW04MA0092
Created by: JNS
Checked by: CH
Approved by: GM

MARITIME ARCHAEOLOGY

Ørsted

Known Wrecks, Obstructions and Aviation Remains

9.7.1.8 Following Holocene sea level rise which led to the severing of (modern) Britain from the European landmass, the nature of the potential marine heritage encountered in the offshore zone becomes dominated by 'maritime' – ships, boats and shipborne debris as further outlined in Section 3.4 of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**.

9.7.1.9 Data for known shipwrecks, obstructions and recorded shipping losses within the marine archaeology study area were obtained from the UKHO and the NRHE as per **Table 9.4** and Section 2 of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**.

9.7.1.10 There are 18 wrecks within the Order Limits, nine of them are known and nine of them are unknown, the known wrecks are contained within both the UKHO and the NRHE datasets. There are also five obstructions contained in the UKHO data set and reports of six fishermen fasteners in the NRHE data (**Figure 9.3**). The majority of the known wrecks are dated to the twentieth century.

9.7.1.11 There are no reported or known aviation sites or remains within the marine archaeology study area as further discussed in Section 3.3 of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**, however considering the high number if unidentified seabed obstructions and geophysical anomalies identified within the Order Limits, the potential to locate aviation remains is high.

Hornsea Four

Figure 9.3

Known wrecks or obstructions within the Marine Archaeology Study Area

320000 360000 400000

6040000

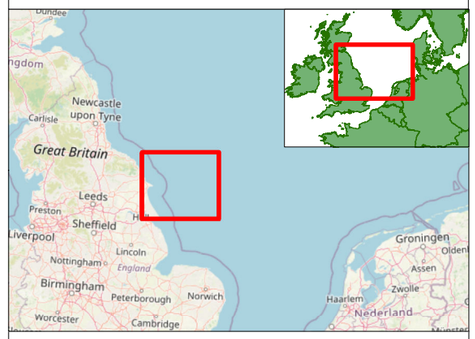
6000000

5960000

N

GRID NORTH

- Order Limits
- Marine Archaeology Study Area
- Known wrecks (UKHO)
- Obstruction, Foul ground (UKHO)
- Fishermen's fastener (NRHE)
- Known wrecks (NRHE)



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 8 16 Kilometres

0 3 6 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	15/07/2019
A	Updated following PEIR consultations for DCO	16/09/2021

Known wrecks or obstructions
Document no: HOW04MA0093
Created by: CH
Checked by: BM
Approved by: GM

MARITIME ARCHAEOLOGY

Ørsted

Date: 16/09/2021 Author: jns Name: HOW04MA0093

Geophysical data

9.7.1.12 The assessment of geophysical data as detailed in Appendix C of **Volume A5, Annex 9.1: Marine Archaeology Technical Report** identified 146 anomalies of potential anthropogenic origin within the Order Limits (low, medium and high) as detailed in **Table 9.6** and illustrated in **Figure 9.4**. One hundred and thirty-nine (139) of these are of low archaeological potential. Five medium and two high potential anomalies were identified and assigned AEZs.

9.7.1.13 There is one known vessel within the Order Limits with a UKHO record and corresponding geophysical anomaly (MSDS_HOW04_2019_ARCH_0224): the 1940 wreck of the Lapwing. A British steam-powered trawler, the Lapwing measured 35.1 x 6.1 m and was built in 1904. The vessel struck a mine on 6th June 1940 and sank with no lives lost.

9.7.1.14 A further 41 magnetic anomalies over 100 nT but with no corresponding seabed contacts have been identified within the Order Limits as shown on **Figure 9.5** and further described in Appendix C and Section 5.3 of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**.

9.7.1.15 Contacts of low archaeological potential, isolated magnetic anomalies and fishermen fastners are deemed unlikely to be of archaeological significance and have not been assigned AEZs. All contacts have been further detailed in Appendix C of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**.

Table 9.6: Anomalies of archaeological potential identified from the geophysical datasets.

Potential	Anomalies (number)
Low	139
Medium	5
High	2
High magnetic (over 100 nT)	41
Total	**187**

320000

360000

400000

6040000

N

GRID NORTH

A614

A165

Barmston

Yorkshire and the Humber

B1242

Ulrome

B1249

Skipsea

Beeford

Licenses:
Service Layer Credits: © OpenStreetMap (and) contributors, CC-BY-SA
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors.
© Crown copyright and database rights [2019] Ordnance Survey

Date: 16/09/2021 Author: jns Name: HOW04MA0094

Hornsea Four

Figure 9.4

Anomalies of archaeological potential identified in the geophysical data

Order Limits

Anomalies of archaeological potential

- High
- Medium
- Low

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 7.5 15 Kilometres

0 3 6 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	15/07/2019
A	Updated following PEIR consultations for DCO	16/09/2021

Anomalies of archaeological potential
Document no: HOW04MA0094
Created by: JNS
Checked by: CH
Approved by: GM

MARITIME ARCHAEOLOGY

Ørsted

320000

360000

400000

6040000

N

GRID NORTH

Hilderthorpe

A165

Barmston

Ulrome

Skipsea

Yorkshire and the Humber

Licenses:
Service Layer Credits: © OpenStreetMap (and) contributors, CC-BY-SA
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors.
© Crown copyright and database rights [2019] Ordnance Survey

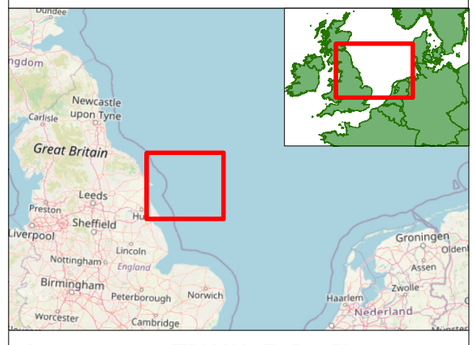
Date: 16/09/2021 Author: jns Name: HOW04MA0095

Hornsea Four

Figure 9.5

Magnetic Anomalies over 100nT

- Order Limits
- Magnetic Anomalies over 100nT



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 7.5 15 Kilometres

0 3 6 Nautical Miles

REV	REMARK	DATE
	First Issue for PEIR	15/07/2019
A	Updated following PEIR consultations for DCO	16/09/2021

Anomalies of archaeological potential
Document no: HOW04MA0095
Created by: JNS
Checked by: CH
Approved by: GM

MARITIME ARCHAEOLOGY

Ørsted

Table 9.7: Summary of existing baseline study.

Baseline assessment	Summary
Palaeolandscapes	The geoarchaeological potential within the deposits present is high and it is likely that the general area contains important prehistoric archaeological material and palaeoenvironmental evidence. Specifically, there is likelihood of surviving remains of Mesolithic activity and settlement on the Mesolithic shoreline identified in the northern part of the array area.
Sedimentary horizons	The sedimentary sequence assessment identified the following deposits of archaeological potential within the Hornsea Four marine archaeology study area: • Holocene deposits; • Botney cut; • Eem Formation; and • Yarmouth Roads. Figures detailing areas of concentration of the deposits outlined can be found in Appendix D of **Volume A5, Annex 9.1: Marine Archaeology Technical Report.**
Offshore-Maritime	The offshore marine archaeological resource may include submerged pre-historic landscapes, archaeological remains of watercraft, as well as structural remains, such as fish traps, abandoned quays, hards or defensive structures. Potential maritime receptors from all time periods can be expected within the Order Limits and the marine archaeology study area.
Known Wrecks and Obstructions	Within the Order Limits there are 18 known wrecks with 13 classed as LIVE, with five foul and seabed obstructions and six fishermen's fasteners. There are no reported or known aviation sites or remains within the marine archaeology study area. The majority of the known wrecks are dated to the twentieth century.
Geophysical data	Within the Order Limits, the following contacts of archaeological potential have been identified from the geophysical data assessment: • 139 anomalies of low potential; • 41 magnetic anomalies over 100 nT but with no corresponding seabed contact; • Five anomalies of medium potential; and • Two anomalies of high potential.

9.7.1.16 The current baseline description above provides an accurate reflection of the current state of the existing environment. The earliest possible date for the start of construction is 2026, with an expected operational life of 35 years, and therefore there exists the potential for the baseline to evolve between the time of assessment and point of impact. Changes to the baseline in relation to marine archaeology usually occur over an extended period of time (considered in **Section 9.7.3**). The current baseline described above gives an accurate portrayal of the existing environment based on the most recent available data, and the baseline at the point of impact is expected to be broadly similar to this in most respects.

9.7.2 Historic Seascape Characterisation

9.7.2.1 Changes to the character of sea surface and the perception of the historic seascape as a direct result of the construction, operation, maintenance and decommissioning of Hornsea Four may result from the addition of new infrastructure such as foundations and turbines as well as ongoing activity from installation and maintenance vessels. The existing seascape of the Hornsea Four marine archaeology study area is an open sea with limited

marine traffic, utilised mainly for fishing, transport and navigation, where the installation of large structures may alter the perception of the historic seascape.

9.7.2.2 The Historic Seascape Characterisation (HSC) assessment constitutes one element of the EIA and draws on Historic Seascape Characterisation: England's Historic Seascape: HSC Method Consolidation (Tapper & Johns 2008); and England's Historic Seascape: Demonstrating the Method (Merritt & Dellino-Musgrave 2009).

9.7.2.3 **Volume A5, Annex 9.1: Marine Archaeology Technical Report** does not contain an assessment of the historic seascape and therefore the results have been included below. It should be noted that changes to the visible elements of the shore and the sea surface have been assessed further in **Chapter 10: Seascape, Landscape and Visual Resources** and therefore this section only considers the specifically historic aspects of HSC.

9.7.2.4 The marine environment presents some characteristic differences in comparison with the land for historic character assessment. HSC considers the multi-dimensional aspects of the marine environment which is broken down by four levels: sub-sea floor, sea floor, water column and sea surface. The character of these multiple layers is subject to assessment due to the dynamic nature of the marine environment.

9.7.2.5 The sub-sea floor and sea floor have been assessed for archaeological potential in **Volume A5, Annex 9.1: Marine Archaeology Technical Report**, incorporating a geophysical data review (Appendix C of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**) and a paleogeographic review of geophysical survey data (Appendix D of **Volume A5, Annex 9.1: Marine Archaeology Technical Report**).

9.7.2.6 For the historic seascape, the marine archaeological study area plus an additional 45 km buffer has been applied to define the radius of maximum extent of significant visual effect, as recommended in the Visual Representation of Wind Farms: Guidance (Scottish Natural Heritage 2017) for turbines with a total height above 150 m.

9.7.2.7 The intertidal and marine zones are ever-changing due to physical processes such as currents, tidal range and sediment mobility. Considering this dynamism and the multi-dimension defined by HSC, people create complex spatial relationships within and across all marine levels, reflected within sites of cultural activity and their material imprints as detailed in **Volume A5, Annex 9.1: Marine Archaeology Technical Report**.

9.7.2.8 The marine topography of the Hornsea Four marine archaeology study area is characterised by a mixture of fine and coarse sediments of mud, silt and sand, as detailed in **Chapter 1: Marine Geology, Oceanography and Physical Processes**. The wider region is also valued for its fishing grounds.

9.7.2.9 Further anthropogenic studies have the potential to contribute to our understanding of how people have used and perceived the landscape/seascape in a variety of dynamic ways in the past.

9.7.2.10 Historic Seascape Characterisation in nearby areas has been undertaken by the University of Durham on behalf of English Heritage (Aldred 2013a; 2013b; and 2013c). The HSC East Yorkshire to Norfolk Project Area 2 covers Hornsea Four and extends to the median line

between the UK and the Netherlands. The study identifies the area as holding the following Broad Historic Character Types:

- Fishing;
- Shipping and energy industry;
- Cultural topography; and
- Tele- and transport communications.

9.7.2.11 The HSC considers the added effect of Hornsea Four within the multiple-dimensions of the marine environment (sub-sea floor, sea floor, water column and sea surface) in combination with the existing activity within the Broad Historic Character Types.

9.7.2.12 Activities on the sea surface and the water column are dominated by modern and current navigational routes in combination with historic shipping routes, further discussed in **Volume A5, Annex 9.1: Marine Archaeology Technical Report**. Fishing activities represent multiple time periods, also discussed in detail in **Volume A5, Annex 9.1: Marine Archaeology Technical Report**. The sea surface also comprises offshore infrastructure such as renewables, gas, oil, navigational markers and ocean survey equipment. It is therefore unlikely that Hornsea Four will further alter the perception of the Historic Seascape within the sea surface and water column.

9.7.2.13 Activities on the seafloor and within the sub-sea floor include fishing (where the historic aspect is covered in **Volume A5, Annex 9.1: Marine Archaeology Technical Report**), the energy industry (oil, gas, renewables) construction including foundations, cables, pipelines and anchor activities and telecommunication cables. The historic characterisation of the seafloor and sub-sea floor also considers the cultural topography which includes pre-historic deposits and artefacts as well as shipwrecks and aviation remains from multiple periods. The impact on identified archaeological receptors is discussed in **Section 9.11**. It is therefore unlikely that Hornsea Four will further alter the perception of the Historic Seascape within the sea floor and sub-sea floor.

9.7.2.14 The value and perception of the above Broad Historic Character Types include the increased attention of the wider general public of modern aquaculture and the benefits and disadvantages of renewable energy, sub-sea communication cables and marine global trading. People's perception of the sea and its value also include the biodiversity, the archaeological potential and fishing and transport heritage.

9.7.2.15 It has been established that HSC is value-neutral and was developed to be a positive force in informing change as well as recognising that landscape and seascape are both a product of that inevitable change. Developments should therefore respect and retain cultural distinctiveness and legibility wherever possible (English Heritage 2008).

9.7.2.16 Considering the perception of the above outlined Broad Historic Character Types (as well as people's perception of the sea and its value, no significant change (Likely Significant Effect (LSE) in EIA terms, as discussed in the Hornsea Four Proportionate Approach to EIA and set out in Section 5.5 of **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**) in the multiple-dimensions of the marine environment as a result of Hornsea Four in isolation or cumulatively with neighbouring developments as per the long list of cumulative projects (**Volume A4, Annex 5.3: Offshore Cumulative Effects**) is identified.

9.7.2.17 In addition, there are no national or regional seascape designations within the Hornsea Four seascape and visual resource study areas.

9.7.2.18 Therefore, it is considered that the impact on the historic seascapes by the introduction of wind farm infrastructure does not warrant further methodological development or mitigation.

9.7.3 Evolution of the Baseline

9.7.3.1 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 require that "an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge" is included within the ES (EIA Regulations, Schedule 4, Paragraph 3). From the point of assessment, over the course of the development and operational lifetime of Hornsea Four (operational lifetime anticipated to be 35 years), long-term trends mean that the condition of the baseline environment is expected to evolve. This section provides a qualitative description of the evolution of the baseline environment, on the assumption that Hornsea Four is not constructed, using available information and scientific knowledge of marine archaeology.

9.7.3.2 Archaeological receptors within the marine environment are identified by a combination of baseline assessment of the relevant study area and analysis of geophysical and/or geotechnical data for archaeological potential. On the assumption that Hornsea Four is not constructed, the current understanding of the baseline will remain the same as described in **Section 9.7.1**. Natural sediment movements might uncover and/or cover the identified receptors; covering receptors is likely to protect them from impacts, whereas uncovering them may expose them to natural and chemical degradation. There is potential for the scientific knowledge of marine archaeology to develop over this timescale. This, alongside other studies of data held and collected in the area ahead of other marine developments, or undertaken as part of future research projects, could enhance understanding of the baseline and identified receptors.

9.7.4 Data Limitations

9.7.4.1 The key data limitations with the baseline data and their ability to materially influence the outcome of the EIA are the absence of full coverage geophysical survey data at the time of DCO application (in line with the Hornsea Four proportionate approach to EIA (see **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**) and the ongoing geoarchaeological programme.

9.7.4.2 The proportionate approach, as discussed with Historic England and outlined in Section **9.4**, **9.8** and **9.10** may contribute to a perceived increased risk to potential maritime archaeological receptors as parts of the seabed within the Order Limits have not been assessed for archaeological potential at the time of DCO application. Unknown marine archaeological receptors might therefore be located during the pre-construction, construction, operation and maintenance or decommissioning phases. This data limitation will be minimised by future and ongoing seabed surveys, as well as by the marine archaeology commitments detailed in **Table 9.9** which include the development of a Marine WSI (Co140) in accordance with **F2.4: Outline Marine WSI**, which will include

methodologies to be undertaken if unknown or unexpected marine archaeological receptors are located. As such, there is no increased risk from Hornsea Four, in comparison to the typical seabed survey approach taken by other offshore wind farms in development.

9.8 Project Basis for Assessment

9.8.1 Impact register and impacts not considered in detail in this ES

9.8.1.1 Upon consideration of the baseline environment, the project description outlined in **Volume A1, Chapter 4: Project Description**, the Hornsea Four Commitments detailed within **Volume A4, Annex 5.2: Commitments Register**, and in response to formal consultation on the PEIR, a number of impacts are "not considered in detail in the ES". All impacts assessed within the PEIR for marine archaeology have been further considered in the ES, with no impacts falling into the category "not considered in detail in the ES". **Table 9.8** details impacts that were agreed to be scoped out during the Scoping phase. Further detail is provided in **Volume A4, Annex 5.1: Impacts and Effects Register**.

9.8.1.2 In line with the Proportionate Approach to EIA, several potential impacts on marine archaeology receptors that would traditionally have been "scoped in" as part of similar projects have been "scoped out" from this assessment, on the condition that Historic England will be consulted on the delivery of proposed mitigations strategies. This approach has been agreed by PINS and Historic England as per **Section 9.4** following submission of the Hornsea Four Scoping Report (Orsted 2018).

9.8.1.3 The justification for "scoping out" the potential impacts listed in **Table 9.8** is based on the outcomes from similar projects within the former Hornsea Zone, as well as other offshore wind farms located further afield, where location-specific impacts on marine archaeology have been successfully mitigated through the application of best-practice mitigation, which now form Commitments as detailed in **Table 9.9**.

9.8.1.4 The Hornsea Four Proportionate Approach to EIA has been presented to, and clarified for, Historic England (during the meetings held on 18 December 2018, 6 June 2019 and 13 November 2019 - see **Table 9.3**); Hornsea Four has ensured that the Commitments outlined in **Table 9.9** and **Volume A4, Annex 5.2: Commitments Register** are secured through the draft DCO and associated DML(s) to minimise impacts of Hornsea Four on known and unknown archaeological receptors.

9.8.1.5 These principles form the embedded mitigation Commitments, summarised in **Section 9.8.2**, that are essential to the proportionate "scoping out" of these potential impacts.

Table 9.8: Impacts scoped out of assessment and justification.

Project activity and impact	Likely significance of effect	Approach to assessment	Justification
Construction: Disturbance, removal, intrusion, compression and/or penetration of sediments containing archaeological receptors (material or contexts) leading to total or partial loss in Hornsea Four array area and offshore Export Cable Corridor (ECC) from construction activities (MA-C-1).	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.7.1). The implementation of Commitments Co46, Co140, Co166 and Co167 (Table 9.9) will result in a negligible impact on marine archaeology receptors. Previous assessments for Hornsea Project One, Hornsea Project Two and Hornsea Three have shown that this will have no likely significant effect with application of best-practice mitigation.
Construction: Intrusion of piling foundations disturbing or destroying archaeological receptors in Hornsea Four array area and offshore ECC from construction activities (MA-C-2).	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.7.2). Commitments Co46, Co140, Co166 and Co167 (Table 9.9) will result in a negligible impact during piling operations, primarily by ensuring identification of marine archaeology receptors and avoidance. Previous assessments for Hornsea Project One, Hornsea Project Two and Hornsea Three have shown that this will have no likely significant effect with application of best-practice mitigation.
Construction: Compression of stratigraphic contexts containing archaeological material from combined weight of foundation, transition piece, tower, and wind turbines in Hornsea Four array area and offshore ECC from construction activities (MA-C-3).	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.7.3). The implementation of Commitments Co46, Co140, Co166 and Co167 (Table 9.9) will result in a negligible impact from compression effects. Previous assessments for Hornsea Project One, Hornsea Project Two and Hornsea Three have shown that this will have no likely significant effect with application of best-practice mitigation.

Project activity and impact	Likely significance of effect	Approach to assessment	Justification
Construction: Disturbance of sediment containing potential archaeological receptors (material and contexts) during cable laying operations (MA-C-6).	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.7.4). The implementation of Commitments Co46, Co140, Co166 and Co167 (Table 9.9) will result in a negligible impact resulting from cable laying operations, primarily through the identification and avoidance of marine archaeology receptors. Previous assessments for Hornsea Project One, Hornsea Project Two and Hornsea Three have shown that this will have no likely significant effect with application of best-practice mitigation.
Decommissioning: Draw-down of sediment into voids left by removed foundations leading to loss of sediment and penetration and compression effects of jack-up barges and anchoring of decommissioning vessels leading to total or partial loss of archaeological receptors (material or contexts) (MA-D-10).	No likely significant effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.7.7). The implementation of Commitments Co46, Co140, Co166, Co167 and Co181 (Table 9.9) will result in a negligible impact on marine archaeology receptors. Previous assessments for Hornsea Project One, Hornsea Project Two and Hornsea Three have shown that this will have no likely significant effect with application of best-practice mitigation.

Notes:
Grey – Potential impact is scoped out at EIA Scoping and both PINS and Hornsea Four agree.

9.8.1.6 Please note that the term "scoped out" relates to the LSE in EIA terms and not "scoped out" of the EIA process per se. All impacts "scoped out" of LSE are assessed for magnitude, sensitivity of the receiving receptor and conclude an EIA significance in **Volume A4, Annex 5.1: Impacts Register**. This approach is aligned with Hornsea Four's Proportionate Approach to EIA (see **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**).

9.8.2 Commitments

9.8.2.1 Hornsea Four has adopted commitments (primary design principles inherent as part of Hornsea Four, installation techniques and engineering designs/modifications) as part of their pre-application phase, to eliminate and/or reduce the LSE arising from of a number of impacts. These are outlined in **Volume A4, Annex 5.2 Commitments Register**. Further commitments (adoption of best practice guidance), referred to as tertiary commitments

in Table 9.9 below, are embedded as an inherent aspect of the EIA process. Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are reduced to environmentally acceptable levels.

9.8.2.2 The commitments adopted by Hornsea Four in relation to marine archaeology are presented in Table 9.9.

Table 9.9: Relevant marine archaeology commitments.

Commitment ID	Measure Proposed	How the measure will be secured
Co46	Primary: All intrusive construction activities will be routed and microsited to avoid any identified archaeological receptors pre-construction, with buffers as detailed in the Marine Written Scheme of Investigation (WSI).	DCO Schedule 11, Part 2 - Condition 13(2) and 13(3) and; DCO Schedule 12, Part 2 - Condition 13(2) and 13(3) (Marine Written Scheme of Archaeological Investigation)
Co140	Tertiary: A Marine Written Scheme of Archaeological Investigation (WSI) will be developed in accordance with the Outline Marine WSI. The Marine WSI will include the requirement for Archaeological Exclusion Zones (AEZs) to be established to protect any known / identified /unexpected marine archaeological receptors and the implementation of a Protocol for Archaeological Discoveries (PAD) in accordance with 'Protocol for Archaeological Discoveries: Offshore Renewables Projects' (The Crown Estate 2014).	DCO Schedule 11, Part 2 - Condition 13(2) and 13(3) and; DCO Schedule 12, Part 2 - Condition 13(2) and 13(3) (Marine Written Scheme of Archaeological Investigation)
Co166	Secondary: An offshore geophysical survey (including an Unexploded Ordnance (UXO) survey) will be undertaken prior to construction and will be subject to a full archaeological review in consultation with Historic England.	DCO Schedule 11, Part 2 - Condition 13(2) and 13(3) and; DCO Schedule 12, Part 2 - Condition 13(2) and 13(3) (Marine Written Scheme of Archaeological Investigation)
Co167	Secondary: An offshore geotechnical survey will be undertaken prior to construction, including a staged geoarchaeological assessment and analysis of geotechnical data inclusive of publication, in consultation with Historic England.	DCO Schedule 11, Part 2 - Condition 13(2) and 13(3) and; DCO Schedule 12, Part 2 - Condition 13(2) and 13(3) (Marine Written Scheme of Archaeological Investigation)
Co181	Tertiary: An Offshore Decommissioning Plan will be developed prior to decommissioning.	DCO Schedule 11, Part 1(6) and; DCO Schedule 12, Part 1(6) (General Provisions)
Co201	Primary: Gravity Base Structure (GBS) foundations (WTG type) will be utilised at a maximum of 110 of the 180 WTG foundation locations. The location of GBS foundations, if used for WTG, will be confirmed through a construction method statement which will include details of foundation installation methodology.	DCO Schedule 11, Part 2 - Condition 13(1(c) (Construction Method Statement)

9.9 Maximum Design Scenario

9.9.1.1 This section describes the Maximum Design Scenario (MDS) parameters on which the marine archaeology assessment has been based. These are the parameters which are judged to give rise to the maximum levels of effect for the assessment undertaken, as set out in **Volume A1, Chapter 4: Project Description**. Should Hornsea Four be constructed to different parameters within the design envelope, then impacts would not be any greater than those set out in this ES using the MDS presented in **Table 9.10**.

Table 9.10: Maximum design scenario for impacts on marine archaeology.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
Operation			
Scour, penetration, draw down and compression effects caused by (a) the presence of Wind Turbine Generator (WTG) and substation foundations, and (b) the exposure and replacement of cables or the use of cable protection measures (such as remedial cable burial), impacting archaeological receptors and exposing such material to natural, chemical or biological processes and causing or accelerating loss of the same (MA-O-7).	Primary: Co46 Co201 Secondary: Co166 Co167 Tertiary: Co140	**Array Area** *WTG Foundations* - 110 Gravity Base Structures (GBS) (WTG-type) foundations with associated scour protection, total seabed permanent area 504,540 m^2; and - 70 suction caisson jacket (WTG type) foundations with associated scour protection, total seabed permanent area 296,881 m^2. *Offshore Platforms* - Up to six small Offshore Substations (OSS) on GBS (Box-type) foundations with association scour protection, and up to three large OSS on GBS (large OSS) foundations with associated scour protection, total seabed permanent area 371,250 m^2; and - One offshore accommodation platform on a GBS (Box type) foundations, total seabed permanent area 30,625 m^2. *Array and Interconnector Cable Protection* - 32 cable crossings (including interconnector cables); - 204,000 m^2 cable/pipe crossings: pre- and post-lay rock berm area; and - 221,000 m^3 cable/pipe crossings: pre- and post-lay rock berm volume. *Array Cable Activities* - Remedial burial of array cables (42 km total length reburied, 100 m width) = 4,200,000 m^2; - Array cable repairs (up to 10 array cable repairs) = 363,736 m^2; and - Cable protection replacement (25% of cable protection replaced) = 156,000 m^2. *Interconnector Cable Activities* - Remedial burial of interconnector cables (7 km total length reburied, 100 m width) = 700,000 m^2; - Interconnector cable repairs (up to three interconnector cable repairs) = 20,028 m^2; and - Cable protection replacement (25% of cable protection replaced) = 23,500 m^2. **Offshore ECC** *High Voltage Alternating Current (HVAC) Booster Stations* - Up to three HVAC booster stations on GBS (Box-type) foundations with associated scour	Design scenario representing the maximum spatial extent of disturbance to archaeological receptors in relation to scour, penetration, draw down and compression effects. It is important to note that three HVDC converter substations in the array area are mutually exclusive with three HVAC booster stations along the ECC in a single transmission system. As secured by **C1.1 Draft DCO including Draft DML**, a maximum of ten OSS and platforms will be constructed within the Hornsea Four Order Limits, however in order to assess the MDS for both the array and the ECC, the presence of the maximum numbers of OSS and platforms in each area has been considered (ten and three, respectively). As a

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
		protection, total seabed permanent area 91,875 m^2. *Offshore Export Cable Protection* - 54 cable crossings; - 344,000 m^2 cable/pipe crossings: pre- and post-lay rock berm area; and - 372,000 m^3 cable/pipe crossings: pre- and post-lay rock berm volume. *Offshore Export Cable Activities* - Remedial burial of export cables (14 km total length reburied, 100m width) = 1,400,000 m^2; - Export cable repairs (up to 23 export cable repairs) = 153,548 m^2; and - Cable protection replacement (25% of cable protection replaced) = 198,000 m^2.	result, the outcome of the assessment is therefore inherently precautionary.
Penetration and compression effects on seabed caused by corrective and preventative operation and maintenance activities (via jack-up vessels or divers) leading to total or partial loss of archaeological receptors (material or contexts) (MA-O-8)	Primary: Co46 Secondary: Co166 Co167 Tertiary: Co140	**WTG O&M activities requiring Jack Up Vessels (JUVs)** - Component replacement (1260 events, 300 m^2 disturbances per jack-up event) = 378,000 m^2; - Access ladder replacement (1260 events, 300 m^2 disturbances per jack-up event) = 378,000 m^2; - Foundation anode replacement (1260 events, 300 m^2 disturbances per jack-up event) = 378,000 m^2; and - J-Tube repair/ replacement (360 events, 300 m^2 disturbances per jack-up event) = 108,000 m^2. **Offshore Platform O&M activities requiring JUV or anchoring** Offshore substation component replacement (20 events, 300 m^2 disturbances per jack-up event) = 6,000 m^2; Access ladder replacement (300 events, 300 m^2 disturbances per jack-up event) = 90,000 m^2; Foundation anode replacement (70 events, 300 m^2 disturbances per jack-up event) = 21,000 m^2; and J-Tube repair/ replacement (20 events, 300 m^2 disturbances per jack-up event) = 6,000 m^2. **Cable O&M activities requiring JUV or anchoring** - Array cable repairs (10 events, 300 m^2 disturbance per jack-up event) = 3,000 m^2; - Export cable repairs (23 events, 300 m^2 disturbance per jack-up event) = 6,900 m^2; and	Design scenario representing the maximum spatial extent of disturbance to archaeological receptors in relation to penetration and compression effects.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
		- Interconnector cable repairs (3 events, 300 m^2 disturbance per jack-up event) = 900 m^2.	
Decommissioning			
Draw-down of sediment into voids left by removed foundations or cables leading to loss of sediment, destabilising archaeological sites and contexts, and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same (MA-D-9).	Primary: Co46 Co201 Secondary: Co166 Co167 Tertiary: Co140 Co181	**WTGs and Offshore Platforms** - All structures above the seabed or ground level will be completely removed. The decommissioning sequence will generally be the reverse of the construction sequence; and - Total disturbance as a result of the removal of all structures is assumed to be the same as during installation as set out in MA-O-7. **Cable removal activities** - Although it is expected that most array and export cables will be left in situ, it has been assumed that all cables will be removed during decommissioning, though any cable protection installed will be left in situ); and - Total disturbance as a result of the removal of all cables is assumed to be the same as during installation as set out in MA-O-7.	Design scenario representing the maximum spatial extent of disturbance to archaeological receptors in relation to draw-down effects. The removal of cables and rock protection is considered the MDS, however the necessity to remove cables and rock protection will be reviewed at the time of decommissioning.

9.10 Assessment Methodology

9.10.1.1 The assessment methodology for marine archaeology is consistent with that presented in **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**. The marine archaeology methodology has been presented to and discussed with Historic England via the Evidence Plan process (during the Technical Panel meeting on 13 November 2019) (OFF-ARCH-2.2).

9.10.1.2 Historic England's remaining concerns regarding the proportionate approach to EIA have been discussed (during the Technical Panel meetings held on 18 December 2018, 06 June 2019 and 13 November 2019) and have been addressed through the expanded use of **Volume A4, Annex 5.2: Commitments Register** to encompass a full schedule of archaeological works within the geophysical and geotechnical survey programme (see Commitments 140, 166 and 167 as outlined in **Table 9.9**).

9.10.2 Impact assessment criteria

9.10.2.1 In July 2019, Highways England issued an update to the Design Manual for Roads and Bridges (DMRB) significance matrix (see **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**). Impacts formerly assessed within the category medium sensitivity and minor magnitude, as Minor (Not Significant), under the new guidance are now within the significance range of Slight or Moderate and therefore require professional judgement. Following a review of impacts, it was considered that the changes do not alter the overall significance of the impacts assessed at Scoping and in the PEIR (see **Volume A4, Annex 5.1: Impacts Register**). Therefore, impacts assessed as not significant at PEIR have not been considered in detail within this ES chapter, unless there has been a material change to Hornsea Four, baseline characterisation, or the assessment methodology that necessitates re-assessment. For marine archaeology, all impacts assessed within the PEIR have been further considered in the ES, with no impacts falling into the category "not considered in detail in the ES".

9.10.2.2 The criteria for determining the significance of effects is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the impacts. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts. The terms used to define sensitivity and magnitude are based on those used in the DMRB methodology, which is described in further detail in **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**, and further augmented with the terms of reference set out by the Department for Culture, Media and Sport (2013) for defining importance of the historic environment.

Table 9.11: Definition of terms relating to receptor sensitivity.

Sensitivity	Definition used in this chapter
Very High	Very high importance and rarity, international scale and very limited potential for substitution. Unique in terms of period, rarity, level of documentation, group value vulnerability, diversity and/or archaeological potential.
High	High importance and rarity, national scale and limited potential for substitution. Very rare in terms of period, rarity, level of documentation, group value, condition, vulnerability, diversity and / or archaeological potential.
Medium	High or medium importance and rarity, regional scale, limited potential for substitution. Regionally rare in terms period, rarity, level of documentation, group value, condition, vulnerability, diversity and / or archaeological potential.
Low	Low importance and rarity, local scale. Low or no appreciable value in terms of period, rarity, level of documentation, group value, condition, vulnerability, diversity and / or archaeological potential.

The criteria for defining magnitude in this chapter are outlined in Table 9.12 below.

Table 9.12: Definition of terms relating to magnitude of an impact.

Magnitude of impact	Definition used in this chapter
Major	Substantial or complete change of archaeological sites, resulting in significant alteration, inhibiting interpretation of characteristics, sub-features or components (Adverse).
	Substantial or complete change to environment or context of archaeological materials or features, resulting in significant alteration of archaeological site, feature or materials (Adverse).
	Large-scale enhanced understanding of the archaeological resource inversely proportional to the scale of adverse effect, e.g. benefit through large area geophysical/geotechnical survey data released to public domain (Beneficial).
Moderate	Moderate changes to archaeological sites, resulting in clear alteration, inhibiting interpretation of several key characteristics, sub-features or components (Adverse).
	Moderate changes to archaeological materials, resulting in clear alteration, inhibiting interpretation of several key characteristics, sub-features or components (Adverse).
	Moderate change to environment or context of archaeological materials or features, resulting in clear alteration of archaeological site, feature or materials (Adverse).
	Benefit to, or addition of, key characteristics, features or elements; e.g. site specific survey and investigation leading to an enhancement of disseminated knowledge; for example, diver/ Remotely Operated Vehicle (ROV) ground-truthing of anomalies, published results (Beneficial).
Minor	Minor changes to archaeological sites, resulting in clear alteration, inhibiting interpretation of several key characteristics, sub-features or components (Adverse).
	Minor changes to archaeological materials, resulting in clear alteration, inhibiting interpretation of several key characteristics, sub-features or components (Adverse).
	Minor change to environment or context of archaeological materials or features, resulting in clear alteration of archaeological site, feature or materials (Adverse).
	Minor benefit to, or addition of, one or more key characteristics, features or elements through enhanced knowledge and understanding of receptors not disseminated or made publicly available (Beneficial).

Magnitude of impact	Definition used in this chapter
Negligible	Changes that are indistinguishable from natural variation, do not change archaeological sites or materials, and do not affect key characteristics, sub-features, or components or their environment or context.

9.10.2.3 The significance of the effect upon marine archaeology is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The method employed for this assessment is presented in **Table 9.12**. Where a range of significance of effect is presented in **Table 9.13**, the final assessment for each effect is based upon expert judgement.

9.10.2.4 For the purposes of this assessment, any effects with a significance level of minor or less have been concluded to be not significant in terms of the EIA Regulations.

Table 9.13: Matrix used for the assessment of the significance of the effect.

		Magnitude of impact (degree of change)			
		Negligible	*Minor*	*Moderate*	*Major*
Environmental value (sensitivity)	*Low*	Neutral or Slight (Not Significant)	Neutral or Slight (Not Significant)	Slight (Not Significant)	Slight (Not Significant) or Moderate (Significant)
	Medium	Neutral or Slight (Not Significant)	Slight (Not Significant) or Moderate (Significant)	Moderate or Large (Significant)	Moderate or Large (Significant)
	High	Slight (Not Significant)	Slight (Not Significant) or Moderate (Significant)	Moderate or Large (Significant)	Large or Very Large (Significant)
	Very High	Slight (Not Significant)	Moderate or Large (Significant)	Large or Very Large (Significant)	Very Large (Significant)

9.11 Impact Assessment

9.11.1 Construction

9.11.1.1 The impacts of the offshore construction of Hornsea Four have been considered on marine archaeology receptors (**Volume A4, Annex 5.1: Impacts Register**). All environmental impacts arising from the construction of Hornsea Four have been scoped out from further assessment as detailed in **Table 9.8** and **Volume A4, Annex 5.1: Impacts Register**.

9.11.2 Operation and Maintenance

9.11.2.1 The impacts of the offshore operation and maintenance of Hornsea Four have been assessed on marine archaeology receptors (**Volume A4, Annex 5.1: Impacts Register**). The environmental impacts arising from the operation and maintenance of Hornsea Four are listed in **Table 9.10** along with the MDS against which each operation and maintenance phase impact has been assessed.

Scour, penetration, draw down and compression effects caused by (a) the presence of WTG and substation foundations, and (b) the exposure and replacement of array, interconnector and export cables or the use of cable protection measures (such as remedial cable burial), impacting archaeological receptors and exposing such material to natural, chemical or biological processes and causing or accelerating loss of the same (MA-O-7).

Magnitude of impact

9.11.2.2 Table 9.10 outlines the MDS for impacts on marine archaeology during the operation and maintenance phase. Impacts are assumed to be limited to the immediate area around the foundations and cables.

9.11.2.3 Impacts on archaeological receptors during the operation and maintenance phase can occur if deposits of archaeological potential are buried close to the seafloor and are directly, or by sedimentary changes, affected by the works.

9.11.2.4 Impact on shipwrecks, obstructions and aviation material will be local, adverse, irreversible and result in a permanent change to the receptor.

9.11.2.5 If a direct impact or exposure of archaeological material to natural, chemical or biological processes occurs, it will generally be adverse and irreversible and result in a permanent change to the receptor.

9.11.2.6 The embedded commitments, as described in Section 9.8.2 and Table 9.9 for the avoidance and monitoring of archaeological receptors (informed by geotechnical and geophysical data, as outlined in the Outline Marine WSI (Document F2.4), and the project specific PAD) will ensure that such receptors are entirely avoided. If avoidance is not possible, further mitigation will be undertaken as per the commitments and the methodologies detailed in the Outline Marine WSI (Document F2.4). Therefore, the magnitude of impact is assessed as **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (Table 9.13) and is therefore not considered further in this assessment.

9.11.2.7 If any archaeological receptors are subject to increased sedimentation as a result of the operation and maintenance phase, they may benefit from the conditions which provide a higher level of preservation *in situ*.

Future monitoring

9.11.2.8 Monitoring measures related to marine archaeology are included in the Outline Marine WSI (Document F2.4). A detailed Marine WSI will be developed prior to commencement of the relevant licensed activities.

Penetration and compression effects on seabed caused by corrective and preventative operation and maintenance activities (via jack-up vessels or divers) leading to total or partial loss of archaeological receptors (material or contexts) (MA-O-8).

Magnitude of impact

9.11.2.9 Table 9.10 outlines the MDS for impacts on marine archaeology during the operational and maintenance phase. Impacts are assumed to be limited to the immediate area around the foundations or cable repair and reburial areas where contact with the seabed occurs as a result of the usage of JUVs.

9.11.2.10 The vessels involved in the operation and maintenance of Hornsea Four may cause disturbance of archaeological contexts or material that may potentially be present within the seabed footprint through the impact of their spud-cans during operations.

9.11.2.11 Impact on shipwrecks, obstructions, aviation remains will be local, adverse, irreversible and result in a permanent change to the receptor.

9.11.2.12 If a direct impact or exposure of archaeological material to natural, chemical or biological processes occurs, it will generally be adverse and irreversible and result in a permanent change to the receptor.

9.11.2.13 The embedded commitments, as described in Section 9.8.2 and Table 9.9 for the avoidance of archaeological receptors (informed by geotechnical and geophysical data, the Outline Marine WSI (Document F2.4) and the project specific PAD) will ensure that such receptors are entirely avoided. Therefore, the magnitude of impact is assessed as **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (Table 9.13) and is not considered further in this assessment.

9.11.2.14 If any archaeological receptors are subject to increased sedimentation as a result of the operation and maintenance phase, they may benefit from such conditions which provide a higher level of preservation *in situ*.

Future monitoring

9.11.2.15 Monitoring measures related to marine archaeology are included in the Outline Marine WSI (Document F2.4).

9.11.3 Decommissioning

Draw-down of sediment into voids left by removed turbine foundations or cables leading to loss of sediment, destabilising archaeological sites and contexts, and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same (MA-D-9).

Magnitude of impact

9.11.3.1 Table 9.10 outlines the MDS for impacts on marine archaeology during the decommissioning phase. Impacts are assumed to be limited to the immediate area around the foundations and cables when cut and removed and if contact with the seabed happens as a result of anchoring and the usage of jack-up legs.

9.11.3.2 Impact on archaeological receptors during the decommissioning phase can occur if deposits of archaeological potential are buried close to the seafloor and are directly or by sediment movements affected by the removal works including vessel anchoring and jack-up legs coming in direct contact with the seafloor.

9.11.3.3 Impact on shipwrecks, obstructions or aviation material will be local, adverse, irreversible and result in a permanent change to the receptor.

9.11.3.4 If a direct impact or exposure of archaeological material to natural, chemical or biological processes occurs, it will generally be adverse and irreversible and result in a permanent change to the receptor.

9.11.3.5 The embedded commitments, as described in Section 9.8.2 and Table 9.9 for the avoidance of archaeological receptors (informed by geotechnical and geophysical data, the Outline Marine WSI (Document F2.4) and the project specific PAD) will ensure that such receptors are entirely avoided. Therefore, the magnitude of impact is assessed as **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (Table 9.13) and is not considered further in this assessment.

9.11.3.6 If any archaeological receptors are subject to increased sedimentation as a result of the decommissioning phase, they may benefit from such conditions which provide a higher level of preservation *in situ*.

Future monitoring

9.11.3.7 Monitoring measures related to marine archaeology are included in the Outline Marine WSI (Document F2.4). A detailed Marine WSI will be developed prior to commencement of the relevant licensed activities.

9.12 Cumulative Effect Assessment (CEA)

9.12.1.1 Cumulative effects can be defined as effects upon a single receptor from Hornsea Four when considered alongside other proposed and reasonably foreseeable projects and developments. This includes all projects that result in a comparative effect that is not

intrinsically considered as part of the existing environment and is not limited to offshore wind projects.

9.12.1.2 A screening process has identified a number of reasonably foreseeable projects and developments which may act cumulatively with Hornsea Four. The full list of such projects that have been identified in relation to the offshore environment are set out in **Volume A4, Annex 5.3: Offshore Cumulative Effects** and are presented in a series of maps within **Volume A4, Annex 5.4: Location of Offshore Cumulative Schemes**.

9.12.1.3 In assessing the potential cumulative impacts for Hornsea Four, it is important to bear in mind that some projects, predominantly those 'proposed' or identified in development plans, may not actually be taken forward, or fully built out as described within their MDS. There is therefore a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals. For example, those projects under construction are likely to contribute to cumulative impacts (providing effect or spatial pathways exist), whereas those proposals not yet approved are less likely to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors.

9.12.1.4 With this in mind, all projects and plans considered alongside Hornsea Four have been allocated into 'tiers' reflecting their current stage within the planning and development process. This allows the cumulative impact assessment to present several future development scenarios, each with a differing potential for being ultimately built out. This approach also allows appropriate weight to be given to each scenario (tier) when considering the potential cumulative impact. The proposed tier structure is intended to ensure that there is a clear understanding of the level of confidence in the cumulative assessments provided in the Hornsea Four ES. An explanation of each tier is included in **Table 9.14**.

Table 9.14: Description of tiers of other developments considered for CEA (adapted from PINS Advice Note 17).

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

9.12.1.5 The plans and projects selected as relevant to the CEA of impacts to marine archaeology are based on an initial screening exercise undertaken on a long list (see **Volume A4, Annex 5.3: Offshore Cumulative Effects**). A consideration of effect-receptor pathways, data confidence and temporal and spatial scales has been given to select projects for a topic-

specific short-list. For the majority of potential effects for marine archaeology, planned projects were screened into the assessment based on case to case basis to represent the marine archaeology resources within the southern North Sea.

9.12.1.6 The specific projects scoped into the CEA for marine archaeology, as well as the tiers into which they have been allocated, are presented in **Table 9.15** below. The operational projects included within the table are included due to their completion/ commissioning subsequent to the data collection process for Hornsea Four and as such are not included within the baseline characterisation. Note that this table only includes the projects screened into the assessment for marine archaeology based on the criteria outlined above. For the full list of projects considered, including those screened out, please see **Volume A4, Annex 5.3: Offshore Cumulative Effects**.

Table 9.15: Project screened into the marine archaeology cumulative assessment.

Tier	Project/plan	Details/ relevant dates	Distance to Hornsea Four Array	Distance to Hornsea Four ECC	Distance to Hornsea Four HVAC Booster Area	Reason for inclusion in CEA
1	Bridlington A Disposal site	Operational	>50 km	2.69 km	28.59 km	Distance from Hornsea Four with potential cumulative effects on sediment movement and disturbance.
1	Viking Link Interconnector	Consented Construction expected 2020-2023	1.98 km	4.04 km	42.23 km	Distance from Hornsea Four with potential cumulative effects on sediment movement and disturbance.
1	Dogger Bank Wind Farm A Export Cables	Consented Construction expected 2021-2024	28.88 km	0.00 km	9.16 km	Spatial overlap with Hornsea Four with potential cumulative effects on sediment movement and disturbance.
1	Dogger Bank Farm B Export Cables	Consented Construction expected 2021-2024	28.88 km	0.00 km	9.16 km	Spatial overlap with Hornsea Four with potential cumulative effects on sediment movement and disturbance.
1	Hornsea Project Two Wind Farm Export Cables	Consented Construction expected 2020-2021	9.30 km	13.67 km	>50 km	Distance from Hornsea Four with potential cumulative effects on sediment movement and disturbance.
1	Tolmount Area Development	Consented Construction	35.36 km	1.46 km	3.98 km	Distance from Hornsea Four with potential

Tier	Project/plan	Details/ relevant dates	Distance to Hornsea Four Array	Distance to Hornsea Four ECC	Distance to Hornsea Four HVAC Booster Area	Reason for inclusion in CEA
		expected 2020				cumulative effects on sediment movement and disturbance.
1	Dana Petroleum Platypus Pipeline	Construction expected 2021-2022	17.01 km	0.00 km	20.56 km	Spatial overlap with Hornsea Four with potential cumulative effects on sediment movement and disturbance.
3	Scotland England Green Link 2 (SEGL2)	Not consented: It is expected that construction activities will commence in 2025 with operations commencing in 2030.	53.53 km	0.15 km	16.12 km	Distance from Hornsea Four with potential cumulative effects on sediment movement and disturbance.
3	Endurance Carbon Capture and Storage Area	Construction expected in 2023	0.00 km	2.15 km	18.78 km	Spatial overlap with Hornsea Four with potential cumulative effects on sediment movement and disturbance.

9.12.1.7 Certain impacts assessed for the project alone are not considered in the cumulative assessment due to:

- The highly localised nature of the impacts (i.e. they occur entirely within the Hornsea Four Order Limits only);
- Management measures in place for Hornsea Four will also be in place on other projects reducing their risk of occurring; and/or
- Where the potential significance of the impact from Hornsea Four alone has been assessed as negligible.

9.12.1.8 The impacts that are considered in the CEA are as follows:

- Cumulative sediment disturbance from Hornsea Four, alongside offshore wind farms' export cables, the Viking interconnectors, Tolmount Area Development, Bridlington disposal site, Dana Petroleum Platypus pipeline, the Scotland England Green Link 2 (SEGL2) and Endurance Carbon Capture and Storage Area may result in the loss of sediment, destabilising archaeological sites and contexts, including

palaeoenvironmental information and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same;
- Cumulative sediment disturbance from Hornsea Four, alongside offshore wind farms' export cables, the Viking interconnector and Bridlington disposal site, may damage or result in loss or destabilising of maritime and aviation archaeological sites and materials; and
- Cumulative deposition of sediments from Hornsea Four alongside offshore wind farms' export cables, the Viking interconnector and Bridlington disposal site, resulting in a potential effect on heritage receptors.

9.12.1.9 The cumulative MDS described in **Table 9.16** have been selected as those having the potential to result in the greatest cumulative effect on an identified receptor group. The cumulative impacts presented and assessed in this section have been selected from the details provided in **Volume A1, Chapter 4: Project Description** (summarised for marine archaeology in **Table 9.15**) as well as the information available on other projects and plans in order to inform a cumulative maximum design scenario. Effects of greater adverse significance compared to those assessed here are not predicted to arise should any other development scenario, based on details within the project design envelope, be taken forward in the final design scheme.

Table 9.16: Cumulative MDS for marine archaeology.

Project Phase	Potential Impact	Maximum Design Scenario	Justification
Construction	Cumulative sediment changes may result in the loss or accumulation of sediment, thereby altering or destabilising archaeological sites and contexts, including palaeoenvironmental information and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same.	MDS for Hornsea Four plus the cumulative full development of the following projects: **Tier 1:** - Open Disposal site (Bridlington A); - Consented interconnector (Viking Link); - Consented wind farm Export Cables (Dogger Bank and Hornsea Two Offshore Wind Farms); - Consented Tolmount Area Development; and - Dana Petroleum Platypus pipeline. **Tier 2:** - No Tier 2 projects identified. **Tier 3:** - Endurance Carbon Capture and Storage Area; and - Scotland England Green Link 2 (SEGL2).	Maximum additive sediment disturbance is calculated within a representative 50 km buffer of Hornsea Four as this area can be considered to represent the marine archaeology within the Southern North Sea. Impact on archaeological receptors for other offshore developments have been gathered from the respective ES chapters, where available.
Operation	Cumulative sediment changes may result in the loss or accumulation of sediment, thereby altering or	MDS for Hornsea Four plus the cumulative full development of the following projects: **Tier 1:** - Open Disposal site (Bridlington A); - Consented interconnector (Viking Link); - Consented wind farm Export Cables	Maximum additive sediment disturbance is calculated within a representative 50 km buffer of Hornsea Four as this area can be

Project Phase	Potential Impact	Maximum Design Scenario	Justification
	destabilising archaeological sites and contexts, including palaeoenvironmental information and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same.	(Dogger Bank and Hornsea Two Offshore Wind Farms); - Consented Tolmount Area Development; and - Dana Petroleum Platypus pipeline. **Tier 2:** - No Tier 2 projects identified. **Tier 3:** - Endurance Carbon Capture and Storage Area; and - Scotland England Green Link 2 (SEGL2).	considered to represent the marine archaeology within the southern North Sea. Impact on archaeological receptors for other offshore developments have been gathered from the respective ES chapters, where available.

9.12.1.10 A description of the significance of cumulative effects upon marine archaeology arising from each identified impact is given below. The cumulative effects assessment has been based on information available in ESs where available and it is noted that the project parameters quoted within ESs are often refined during the determination period and in the post-consent phase. The assessment presented here is therefore considered to be conservative, with the level of impacts expected to be reduced compared to those presented here.

9.12.1.11 The active Bridlington A (HU015) disposal site located 28.59 km from the Hornsea Four HVAC Booster Station Search Area is used for the disposal of dredged maintenance material from the port of Bridlington. The maximum quantity authorised for disposal annually is 30,000 tonnes. Material deposited at HU015 is generally a mixture of fine sands and silts, which be expected to move by both wave and tidal current (Cefas 2009).

9.12.1.12 The Viking Link interconnector will, when installed, require minor maintenance and repair with no impact scour or displacement of sediments expected. The project has undertaken its independent EIA where the impact on marine archaeology and cultural heritage has been mitigated and assessed as not significant (Viking Link 2017).

9.12.1.13 Dogger Bank A and B export cables, when installed, may require regular planned and unplanned maintenance. The data generated by the project has been assessed for archaeological potential as well as impact on known receptors in the Dogger Bank EIA; it was concluded that significant impacts will not occur (Forewind 2013).

9.12.1.14 Hornsea Project Two export cable when installed may require regular planned and unplanned maintenance with up to 0.8 km^2 of seabed disturbance. The data generated by the project has been assessed for archaeological potential as well as impact on known archaeological receptors in the Hornsea Project Two EIA. It was concluded the impact on archaeological receptors will be of minor adverse significance (Smart Wind 2015).

9.12.1.15 The Tolmount Area Development is mainly a gas field, with some condensate, located in the Southern North Sea and within the Hornsea Four Marine Archaeology Study Area. The seabed preparation and installation of the wells, a Minimum Facilities Platform (MFP) and

pipeline will include temporary localised and direct disturbance from anchors. Direct and localised long-term sediment compression and displacement at the MFP piles and along the gas pipeline (Premier Oil 2017).

9.12.1.16 The Dana Petroleum Platypus pipeline in the southern North Sea is a subsea pipeline to the Cleeton Wellhead Platform. Exported fluids (gas, condensate and water) will be comingled with fluids from other fields on the Cleeton Platform and then exported to shore. The installations will include a pipeline, umbilical and wells. A marine archaeological impact assessment has not been included in the ES; however, it was recognised that no known sites of archaeological significance are located within the immediate vicinity of the Platypus pipeline (Dana Petroleum 2018).

9.12.1.17 The Tier 3 Endurance Carbon Capture and Storage Project is expected to construct pipelines, up to 30 wells, and several platform structures, planned to commence in early 2023 with operations commencing in 2026. There will be no construction overlap with Hornsea Four, however Endurance operation and maintenance activities will overlap with the Hornsea Four construction phase (Letter from NGV to Orsted dated 20 November 2020, [confidential]).

9.12.1.18 The SEGL2 project is a proposal to install a sub-sea high-voltage direct current (HVDC) cable from Sandford Bay, Peterhead, to Drax in England. Survey works commenced in 2021 with planning applications to be submitted in early 2022. The expected construction start is planned for 2025 and the cable will be operational by 2030. The development has a spatial overlap with Hornsea Four and is it expected that some construction and operation and maintenance activities will overlap.

Tier 1 significance assessment

9.12.1.19 **Construction phase** Cumulative sediment changes may result in the loss or accumulation of sediment, thereby altering or destabilising archaeological sites and contexts, including paleoenvironmental information and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same.

9.12.1.20 The cumulative impacts during the construction phase of Hornsea Four and the outlined Tier 1 projects is therefore predicted to be of local spatial extent, long term duration, continuous and limited reversibility. Any impact will affect the receptor directly. Based on the commitment to avoid archaeological receptors, the magnitude of impact is considered to be indistinguishable to natural variation meaning **negligible**.

9.12.1.21 **Operational and maintenance phase:** Cumulative sediment changes may result in the loss or accumulation of sediment, thereby altering or destabilising archaeological sites and contexts, including paleoenvironmental information and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same.

9.12.1.22 The cumulative impacts of the operation and maintenance phase of Hornsea Four and the outlined Tier 1 projects is therefore predicted to be of local spatial extent, long term duration, continuous and limited reversibility. Any impact will affect the receptor directly. Based on the commitment to avoid archaeological receptors, the magnitude of impact is considered to be indistinguishable to natural variation meaning **negligible**.

Tier 3 significance assessment

9.12.1.23 **Construction phase** Cumulative sediment changes may result in the loss or accumulation of sediment, thereby altering or destabilising archaeological sites and contexts, including paleoenvironmental information and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same.

9.12.1.24 The cumulative impacts during the construction phase of Hornsea Four and the outlined Tier 3 projects (Endurance Carbon Capture and Storage Project and SEGL2) is predicted to be of local spatial extent, long term duration, continuous and limited reversibility. Any impact will affect the receptor directly. There is currently limited detail on the Endurance Carbon Capture and Storage Project and the SEGL2 and therefore it is not possible to make a detailed assessment of the significance of cumulative effect on marine archaeological receptors.

9.12.1.25 However, given the low number of additional structures planned and the substantial commitments (**Table 9.9**) in place to mitigate effect on marine archaeological receptors, it is not anticipated that any effects if qualified would result in a significant change for any marine archaeological receptors.

9.12.1.26 **Operational and maintenance phase:** Cumulative sediment changes may result in the loss or accumulation of sediment, thereby altering or destabilising archaeological sites and contexts, including paleoenvironmental information and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same.

9.12.1.27 The cumulative impacts of the operation and maintenance phase of Hornsea Four and the outlined Tier 3 projects (Endurance Carbon Capture and Storage Project and SEGL2) is therefore predicted to be of local spatial extent, long term duration, continuous and limited reversibility. Any impact will affect the receptor directly. There is currently limited detail on the Endurance Carbon Capture and Storage Project and SEGL2 and therefore it is not possible to make a detailed assessment of the significance of cumulative effect on marine archaeological receptors.

9.12.1.28 However, given the low number of additional structures planned and the substantial commitments (**Table 9.9**) in place to mitigate effect on marine archaeological receptors, it is not anticipated that any effects if qualified would result in a significant change for any marine archaeological receptors.

9.13 Transboundary Effects

9.13.1.1 Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from Hornsea Four alone, or cumulatively with other projects in the wider area. A transboundary screening exercise has been undertaken (**Volume 4, Annex 5.7: Transboundary Screening Report**) which concluded that there is no potential for significant transboundary effects in relation to marine archaeology to occur as a result of the construction, operation or decommissioning of Hornsea Four.

9.14 Inter-Related Effects

9.14.1.1 Inter-related effects consider impacts from the construction, operation or decommissioning of Hornsea Four on the same receptor (or group). Such inter-related effects include both:

- Project lifetime effects: i.e. those arising throughout more than one phase of the project (construction, operation, and decommissioning) to interact to potentially create a more significant effect on a receptor than if just one phase were assessed in isolation; and
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor (or group). Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.

9.14.1.2 A description of the process to identify and assess these effects is presented in Section 5.8 of **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**.

Table 9.17: Inter-related effects assessment for marine archaeology.

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
Project-lifetime effects			
Construction, Operation and, decommissioning	Scour, penetration, draw down and compression effects caused by (a) the presence of WTG substation foundations, and (b) the exposure of array and export cables or the use of cable protection measures, impacting archaeological receptors and exposing such material to natural, chemical or biological processes and causing or accelerating loss of the same.	Impacts were assessed as being of and of minor adverse significance in the O&M and decommissioning phases.	The majority of seabed disturbance including scour, penetration, draw down and compression, will occur within the construction and decommissioning phases. There is potential for some disturbance within the operational phase, however, these activities will avoid archaeological receptors. It is therefore considered that impacts in the operation phase will not contribute to inter-related effects, and that the construction and decommissioning phases are significantly temporally separate such that there will be no interaction between the two. There will therefore be no inter-related effects of greater significance compared to the impacts considered alone.
Receptor-led effects			
Inter-related effect from the combination of disturbance or direct impact from construction activities and operating vessels on known archaeological		The greatest potential for spatial and direct impact on archaeological receptors is likely to occur during contact with the seabed during construction, O&M and decommissioning phases. The individual impacts were assigned significance of negligible to minor.	

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
receptors.		It is therefore not anticipated that any inter-related effects will occur that are of any greater significance compared to the impacts considered alone.	

9.14.1.3 The assessment concludes that there are no inter-related impacts from the construction, operation or decommissioning of Hornsea Four on marine archaeology receptors.

9.15 Conclusion and Summary

9.15.1.1 This chapter has assessed the potential effects on marine archaeological receptors arising from Hornsea Four. The range of potential impacts and associated affects has been informed by relevant legislation and guidance, the scoping process and consultation with statutory advisers.

9.15.1.2 The detailed description of the marine archaeology and cultural heritage of Hornsea Four array and ECC is available within **Volume A5, Annex 9.1: Marine Archaeology Technical Report**.

9.15.1.3 This chapter summarises the results from the baseline study including the likely presence of prehistoric landscape features and deposits, known wrecks, geophysical anomalies of archaeological potential, and includes a HSC.

9.15.1.4 Included in this chapter is the relevant planning and policy context, the results from the consultation process and the outlined methodology for impact assessment on marine archaeological receptors.

9.15.1.5 Included is also an assessment of the impacts of Hornsea Four on marine archaeology as well as cumulative, transboundary and inter-related effects on marine heritage of Hornsea Four.

9.15.1.6 It is concluded that as the magnitude of impacts on marine archaeology are assessed to be negligible, the impacts are not significant.

9.15.1.7 **Table 9.18** presents a summary of the significant impacts assessed within this ES, mitigation and residual effects.

Table 9.18: Summary of potential impacts assessed for marine archaeology.

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
Operation				
Scour, penetration, draw down and compression effects caused by (a) the presence of WTG substation foundations, and (b) the exposure and replacement of cables or the use of cable protection measures (such as remedial cable burial), impacting archaeological receptors and exposing such material to natural, chemical or biological processes and causing or accelerating loss of the same. (MA-O-7)	The magnitude is Negligible therefore receptor sensitivity is not considered further in this assessment, as it will not lead to a significant effect based on the matrix used for the assessment of significance and expert judgement.	Negligible magnitude Not Significant	None proposed beyond existing Commitments.	Not significant
Penetration and compression effects on seabed caused by corrective and preventative operation and maintenance activities (via jack-up vessels or divers) leading to total or partial loss of archaeological receptors (material or contexts). (MA-O-8)	The magnitude is Negligible therefore receptor sensitivity is not considered further in this assessment, as it will not lead to a significant effect based on the matrix used for the assessment of significance and expert judgement.	Negligible magnitude Not Significant	None proposed beyond existing Commitments.	Not significant
Decommissioning				
Draw-down of sediment into voids left by removed turbine foundations or cables leading to loss of sediment, destabilising archaeological sites and contexts, and exposing such material to natural, chemical or biological processes, and causing or accelerating loss of the same. (MA-D-9)	The magnitude is Negligible therefore receptor sensitivity is not considered further in this assessment, as it will not lead to a significant effect based on the matrix used for the assessment of significance and expert judgement.	Negligible magnitude Not Significant	None proposed beyond existing Commitments.	Not significant

9.16 References

Aldred., A. (2013a). Historic Seascape Character (HSC): East Yorkshire to Norfolk. Section One: Background, Methodology and Results. [Online] Available at https://content.historicengland.org.uk/images-books/publications/hsc-east-yorkshirenorfolk/HSC_East_Yorks_to_Norfolk_Rep_Pt1.pdf/ [Accessed 22 June 2019].

Aldred. A. (2013b). Historic Seascape Character (HSC): East Yorkshire to Norfolk. Section Two: Applications Review and Case Studies. [Online] Available at https://content.historicengland.org.uk/images-books/publications/hsc-east-yorkshirenorfolk/HSC_East_Yorks_to_Norfolk_Rep_Pt2.pdf/ [Accessed 22 June 2019].

Aldred. A. (2013c). Historic Seascape Character (HSC): East Yorkshire to Norfolk. Section One: National and Regional Perspective Character Type Texts. [Online] Available at https://content.historicengland.org.uk/images-books/publications/hsc-east-yorkshirenorfolk/HSC_East_Yorks_to_Norfolk_Rep_Pt3.pdf/ [Accessed 22 June 2019].

Centre for Environment, Fisheries and Aquaculture Science (Cefas) (2009). Dredged Material Disposal Site Monitoring Around the Coast of England: Results of Sampling (2009) [Online] Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/491114/SLAB5_Report_2009-10.pdf [Accessed 26 June 2019].

Charted Institute for Archaeologists (2012). Standard and Guidance for Historic Environment Desk-based Assessment. Reading, CIfA.

DCMS (2013). Scheduled Monuments & nationally important but non-scheduled monuments. London, Department for Culture, Media and Sport.

Forewind (2013). Environmental Statement Chapter 5 Project Description. Application Reference: 6.5. [Online] Available at https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010021/EN010021-000451-6.5%20Chapter%205%20Project%20Description%20-%20Application%20Submission_DVD_F-OFC-CH-005_Issue_4.pdf [Accessed 26 June 2019].

English Heritage (2008). Conservation Principles for the Sustainable Management of the Historic Environment

Merritt & Dellino-Musgrave (2009). Historic Seascape Characterisation (HSC): Demonstrating the Method. Part 1: Implementing the Method. Final Report for English Heritage. SeaZone Solutions Ltd.

Orsted (2018). Hornsea Four Environmental Impact Assessment Scoping Report. Available at: https://hornseaprojects.co.uk/-/media/WWW/Docs/Corp/UK/Hornsea-Project-Four/Scoping-Report/Hornsea-Four-Scoping-Report-LOW-RES

Orsted (2019). Hornsea Project Four: Preliminary Environmental Information Report (PEIR) Volume 2, Chapter 10: Marine Archaeology.

Dana Petroleum (2018). Platypus Development Environmental Statement. Document number D/4229/2018. 2018.

Premier Oil (2017). Tolmount Area Development Offshore Environmental Statement. Document No AB-TO-XGL-HS-SE-SN-0001. November, 2017.

Scottish Natural Heritage (2017). Visual Representation of Wind farms: Guidance, Version 2.2 [Online] Available at https://www.nature.scot/sites/default/files/2017-07/A2203860%20-%20Visual%20representation%20of%20wind%20farms%20-%20Guidance%20-%20Feb%202017.pdf [Accessed 22 June 2019].

Smart Wind (2015). Hornsea Offshore Wind Farm Project Two – Environmental Statement Volume 2 – Offshore Chapter 9 – Marine Archaeology and Ordnance. [Online] Available at https://infrastructure.planninginspectorate.gov.uk/wp content/ipc/uploads/projects/EN010053/EN010053-000336 7.2.09%20Marine%20Archaeology%20and%20Ordnance.pdf [Accessed 26 June 2019].

Tapper, B. and Johns, C. (2008). England's Historic Seascapes. Historic Seascape Characterisation (HSC). National HSC Method Statement. Final Report. Cornwall, Historic Environment Service, Cornwall County Council on behalf of English Heritage.

The Crown Estate (2010). Model Clauses for Archaeological Written Schemes of Investigation, Offshore Renewables Projects. Salisbury, Wessex Archaeology.

The Crown Estate (2014). Protocol for Archaeological Discoveries: Offshore Renewables Projects. Salisbury, Wessex Archaeology.

Viking Link (2017). Bridging Document End to End Environmental Assessment. Document VKL-07-30-J800-086. [Online] Available at http://viking-link.com/media/1167/vkl-07-30-j800-086_viking-link-end-to-end-environmental-assessment.pdf [Accessed 26 June 2019].