



Hornsea Project Four: Preliminary Environmental Information Report (PEIR)

Volume 2, Chapter 10 : Marine Archaeology

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Annexes

Annex	Heading
10.1	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. Commitments are Embedded Mitigation Measures. Commitments are either Primary (Design) or Tertiary (Inherent) and embedded within the assessment at the relevant point in the EIA (e.g. at Scoping or PEIR). The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSE's), in EIA terms
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.
Hornsea Four	The proposed Hornsea Project Four offshore wind farm project; the term covers all elements within the DCO (i.e. both the offshore and onshore components).
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 or PEIR).
Model Clauses	Guidance issued by The Crown Estate; Model Clauses for Archaeological Written Schemes of Investigation: Offshore Renewables Projects.
Ørsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Development Consent Order (DCO).
Written Scheme of Investigation (WSI)	Project specific document forming the agreement between the client, the appointed archaeologists, contractors and the relevant stakeholders. The document sets out methods to mitigate the effects on all the known and potential archaeological receptors within the development area.

Acronyms

Acronym	Definition
AAP	Area of Archaeological Potential
AEZ	Archaeological Exclusion Zone
CEA	Cumulative Effect Assessment
CIfA	Chartered Institute for Archaeologists
CPT	Cone Penetration Test
DCO	Development Consent Order
dML	Deemed Marine Licence
DMRB	Design Manual for Roads and Bridges
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIA Report	Environmental Impact Assessment Report (note that the new EIA Directive refers to an EIA Report and not an Environmental Statement)
HE	Historic England
HSC	Historic Seascape Characterisation
MAG	Magnetometry Data
MBES	Multi-beam Echo Sounder
MDS	Maximum Design Scenario
MHWS	Mean High Water Springs
NPS	National Policy Statement
NRHE	National Record of the Historic Environment
NSIP	Nationally Significant Infrastructure Project
OSS	Offshore Sub-station
PAD	Protocol for Archaeological Discoveries
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
SBP	Sub-bottom Profiler
SoS	Secretary of State
SSS	Side Scan Sonar
UKHO	United Kingdom Hydrographic Office
UXO	Unexploded Ordnance
WSI	Written Scheme of Investigation
WTG	Wind Turbine Generator
WWII	Second World War

Units

Unit	Definition
nT	Nanotesla (magnetic induction)

10.1 Introduction

- 10.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents the results of the Environmental Impact Assessment (EIA) to date for the potential impacts of the Hornsea Project Four offshore wind farm (hereafter 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 5, Annex 5.10: Marine Archaeology Technical Report](#) and [Volume 3, Chapter 5: Historic Environment](#).
- 10.1.1.2 Ørsted Hornsea Project Four Limited (the Applicant) is proposing to develop Hornsea Four which will be located approximately 65 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 1, 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 1, Chapter 4: Project Description](#) for full details on the Project Design).
- 10.1.1.3 This chapter summarises information contained within technical reports which are included in the consolidated Marine Archaeology PEIR Technical Report ([Volume 5, Annex 5.10.1: Marine Archaeology Technical Report](#)), incorporating a geophysical data review ([Appendix C of Volume 5, Annex 5.10.1: Marine Archaeology Technical Report](#)) and a paleogeographic review of geophysical survey data ([Appendix D of Volume 5, Annex 5.10.1: Marine Archaeology Technical Report](#)).

10.2 Purpose

- 10.2.1.1 This PEIR presents the preliminary environmental information for Hornsea Four and sets out the findings of the EIA to date to support the pre-Development Consent Order (DCO) application consultation activities required under the Planning Act 2008.
- 10.2.1.2 The feedback from this consultation will be used to inform the final project design and the associated EIA (which will be reported in an Environmental Statement (ES)) that will accompany the DCO application to the Planning Inspectorate (PINS).
- 10.2.1.3 This PEIR chapter:
- Presents 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 to date;
 - 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.

10.3 Planning and Policy Context

10.3.1.1 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).

10.3.1.2 NPS EN-1 and NPS EN-3 include guidance on what matters are to be considered in the assessment. These are summarised in [Table 10.1](#) below.

Table 10.1: 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 PEIR
<p><i>"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).</i></p>	<p>Construction, operation and decommissioning phases of Hornsea Four have been assessed as discussed in Section 10.11.</p>
<p><i>"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).</i></p>	<p>The archaeological potential has been assessed in the technical report (Volume 5, Annex 5.10: Marine Archaeology Technical Report) and summarised in Section 10.7.</p>
<p><i>"The applicant should ensure that the extent of the impact of the proposed development on the significance of any heritage assets affected can be adequately understood from the application and supporting documents" (Paragraph 5.8.10 of NPS-EN1).</i></p>	<p>The significance and impact on the archaeological receptors of the development is discussed in Section 10.11.</p>
<p><i>"Where the loss of the whole or a material part of a heritage asset's significance is justified, the IPC 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).</i></p>	<p>The Outline Marine WSI (Document number F2.4) outlines all provisions made and standards expected for archaeological recording of marine heritage receptors. The document further outlines where archives and material should be deposited.</p>
<p><i>"Where appropriate, the IPC 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).</i></p>	<p>Commitment Co140 and Co141 (Table 10.9) outline how the Outline Marine WSI (Document F2.4) is implemented.</p>

Summary of NPS EN-1 and EN-3 provisions	How and where considered in the PEIR
<p><i>"Where the IPC considers there to be a high probability that a development site may include as yet undiscovered heritage assets with archaeological interest, the IPC should consider requirements to ensure that appropriate procedures are in place for the identification and treatment of such assets discovered during construction"</i> (Paragraph 5.8.22 of NPS-EN1).</p>	<p>The project-specific Protocol for Archaeological Discoveries appended to the Outline Marine WSI (Document number F2.4) defines the procedure that should be followed if new archaeological receptors are identified during construction, operation and maintenance or decommissioning.</p>
<p><i>"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"</i> (Paragraph 2.6.139 of NPS-EN3).</p>	<p>Potential effects have been assessed in Section 10.11.</p>
<p><i>"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"</i> (Paragraph 2.6.141 of NPS-EN3).</p>	<p>The technical report and included appendices (Volume 5, Annex 5.10: Marine Archaeology Technical Report) present assessments of geophysical and geotechnical data collected to date. The results are summarised in Section 10.7.</p>
<p><i>"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"</i> (Paragraph 2.6.142 of NPS-EN3).</p>	<p>Beneficial effects on potential archaeological receptors are discussed in Section 10.7.</p>
<p><i>"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"</i> (Paragraph 2.6.143 of NPS-EN3).</p>	<p>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 respective technical reports (Volume 5, Annex 5.10: Marine Archaeology Technical Report and Volume 6, Annex 5.1: Historic Environment Desk Based Assessment).</p>
<p><i>"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 AEZ around such heritage assets which preclude development activities within their boundaries"</i> (Paragraph 2.6.145 of NPS-EN3).</p>	<p>Exclusion zones have been applied to all known wrecks and contacts of high and medium significance as outlined in the technical report Volume 5, Annex 5.10: Marine Archaeology Technical Report. The commitments adopted are detailed in Table 10.9.</p>

10.3.1.3 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 10.2](#) below.

Table 10.2: Summary of EPS-EN1 and EPS-EN3 policy on decision making relevant to marine archaeology.

Summary of NPS-EN1 and NPS EN-3 provisions	How and where considered in the PEIR
<p><i>"In considering applications, the IPC 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:</i></p> <ul style="list-style-type: none"> • <i>evidence provided with the application;</i> • <i>any designation records;</i> • <i>the Historic Environment Record, and similar sources of information;</i> • <i>the heritage assets themselves;</i> • <i>the outcome of consultations with interested parties; and</i> • <i>where appropriate and when the need to understand the significance of the heritage asset demands it, expert advice"</i> (Paragraph 5.8.11 of NPS-EN1). 	<p>The technical report and included appendices (Volume 5, Annex 5.10: Marine Archaeology Technical Report) present assessments of documentary records, geophysical and geotechnical data collected to date. The results are summarised in Section 10.7.</p> <p>Potential impacts have been assessed in Section 10.11.</p>
<p><i>"In considering the impact of a proposed development on any heritage assets, the IPC 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"</i> (Paragraph 5.8.12 of NPS-EN1).</p>	<p>The significance of archaeological receptors and the potential impacts of the development on such receptors is discussed in Section 10.11.</p>
<p><i>"The IPC 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"</i> (Paragraph 5.8.13 of NPS-EN1).</p>	<p>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 10.9.</p>
<p><i>"There should be a presumption in favour of the conservation of designated heritage assets and the more significant the 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"</i> (Paragraph 5.8.14 of NPS-EN1).</p>	<p>All identified archaeological receptors will be preserved <i>in situ</i> by utilising Archaeological Exclusion Zones, as detailed in Volume 5, Annex 5.10: Marine Archaeology Technical Report.</p>
<p><i>"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"</i> (Paragraph 5.8.15 of NPS-EN1).</p>	<p>All identified archaeological receptors will be preserved <i>in situ</i> by utilising Archaeological Exclusion Zones, as detailed in Volume 5, Annex 5.10: Marine Archaeology Technical Report.</p>
<p><i>"When considering proposals, the IPC should take into account the relative significance of the element affected and its contribution to the significance of the World Heritage Site</i></p>	<p>All effects on marine archaeology of the development have been assessed or scoped out, as stated in Section 10.8. The development is not</p>

Summary of NPS-EN1 and NPS EN-3 provisions	How and where considered in the PEIR
<p>or Conservation Area as a whole” (Paragraph 5.8.16 of NPS-EN1).</p> <p>“Where loss of significance of any heritage asset is justified on the merits of the new development, the IPC 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).</p>	<p>located within a World Heritage Site or Conservation Area.</p> <p>The applicant’s commitments, as outlined in Table 10.9 will ensure that no loss of archaeological receptors will occur. Ongoing consultation with the statutory adviser, Historic England, as outlined in Table 10.3, 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.</p>
<p>“When considering applications for development affecting the setting of a designated heritage asset, the IPC 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).</p>	<p>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 10.9.</p> <p>The technical report and included appendices (Volume 5, Annex 5.10: Marine Archaeology Technical Report) presents assessments of documentary records, geophysical and geotechnical data collected to date. The results are summarised in Section 10.7.</p> <p>Potential impacts have been assessed in Section 10.11.</p>
<p>“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).</p>	<p>All effects on marine archaeology of the development have been assessed or scoped out as stated in Section 10.8.</p>
<p>“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).</p>	<p>Consultation with Historic England has been undertaken as detailed in Table 10.3.</p>
<p>“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).</p>	<p>Designated features and their sensitivity have been assessed in the technical report (Volume 5, Annex 5.10: Marine Archaeology Technical Report), the Outline Marine WSI (Document number F2.4), and are summarised in Table 10.7.</p>
<p>“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).</p>	<p>The project specific protocol for unexpected archaeological discoveries appended to the outline WSI (Document number F2.4) outlines the procedure that should be followed if archaeological receptors are found during construction, operation and maintenance or decommission.</p>

- 10.3.1.4 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”*.
- 10.3.1.5 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”*.
- 10.3.1.6 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”*.

10.4 Consultation

- 10.4.1.1 Consultation is a key part of the DCO pre-application process. Consultation regarding marine archaeology has been conducted through the Evidence Plan process via Technical Panel meetings, and scoping (Ørsted, 2018). An overview of the project consultation process is presented within [Volume 1, Chapter 6: Consultation](#).
- 10.4.1.2 Details of the key issues raised during consultation specific to marine archaeology is outlined below in [Table 10.3](#), together with how these issues have been considered in the production of this PEIR.
- 10.4.1.3 A formal scoping opinion was sought from PINS following submission of the scoping report (Ørsted, 2018). Ongoing consultation post-scoping has been important in the evolution of Hornsea Four and the parameters for assessment. The issues raised by the Secretary of State (SoS) and other consultees relating to marine archaeology are also presented below in [Table 10.3](#), along with a description of how Hornsea Four has considered those issues and addressed the comments received.

Table 10.3: Consultation responses.

Consultee	Date, Document, Forum	Issues raised	Response to Issue and where addressed in the PEIR
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 10.7.1 .
Historic England	12 November 2018 Scoping Opinion	We 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 10.7.1 .
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, we require further detail to be included with regards to the cumulative impact of the project on palaeoenvironmental deposits across the area.	The marine archaeology CEA is presented in Section 10.12 .
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 10.8.2 alongside how these measures will be secured. The full Commitments Register is provided in Volume 4, 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 subsequent technical panel meetings (see below). Historic England were unable to commit to the approval	Further detail provided in Section 10.8 .

Consultee	Date, Document, Forum	Issues raised	Response to Issue and where addressed in the PEIR
		of the overall proportional approach until further details and clarity could be provided later in the process.	
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 10.8.2 alongside how these measures will be secured. The full Commitments Register is provided in Volume 4, Annex 5.2 .

10.4.1.4 As identified in [Volume 1, Chapter 3: Site Selection and Consideration of Alternatives](#) and [Volume 1, Chapter 4: Project Description](#), the Hornsea Four design envelope has been refined significantly and is anticipated to be further refined for the DCO submission. This process is reliant upon stakeholder consultation feedback.

10.4.1.5 Design amendments to landfall are of relevance to this chapter. The Hornsea Four PEIR boundary currently comprises two landfall options (shown in [Volume 1, Chapter 4: Project Description, Figure 4.13](#)), which have been assessed in the respective PEIR receptor chapters. A decision on the preferred landfall (A3 or A4) will be made post-PEIR and the Project Description and assessments updated for the ES and DCO for the preferred 40,000 m² compound within the landfall location.

10.4.1.6 This process will be based on the results of the PEIR assessments, in addition to stakeholder feedback and suggestions.

10.5 Study area

10.5.1.1 The marine archaeology study area was established to encompass the Hornsea Four PEIR boundary plus a 1 km buffer defining the zone where any potential effects on marine archaeology receptors may occur. 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.

10.5.1.2 The Hornsea Four Agreement for Lease (AfL) area was 848 km² at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate EIA, the project is currently giving due consideration to the size and location (within the existing AfL area) of the final project that will be taken forward to consent application (DCO). 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. The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the AfL taken forward at the point of PEIR (see [Figure 10.1](#)). The evolution of the AfL is detailed in [Volume 1, Chapter 3: Site Selection and Consideration of Alternatives](#) and [Volume 4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure](#).

- 10.5.1.3 The final developable area taken forward to consent may differ from that presented in [Figure 10.1](#) due to the results of the EIA, technical considerations and stakeholder feedback.

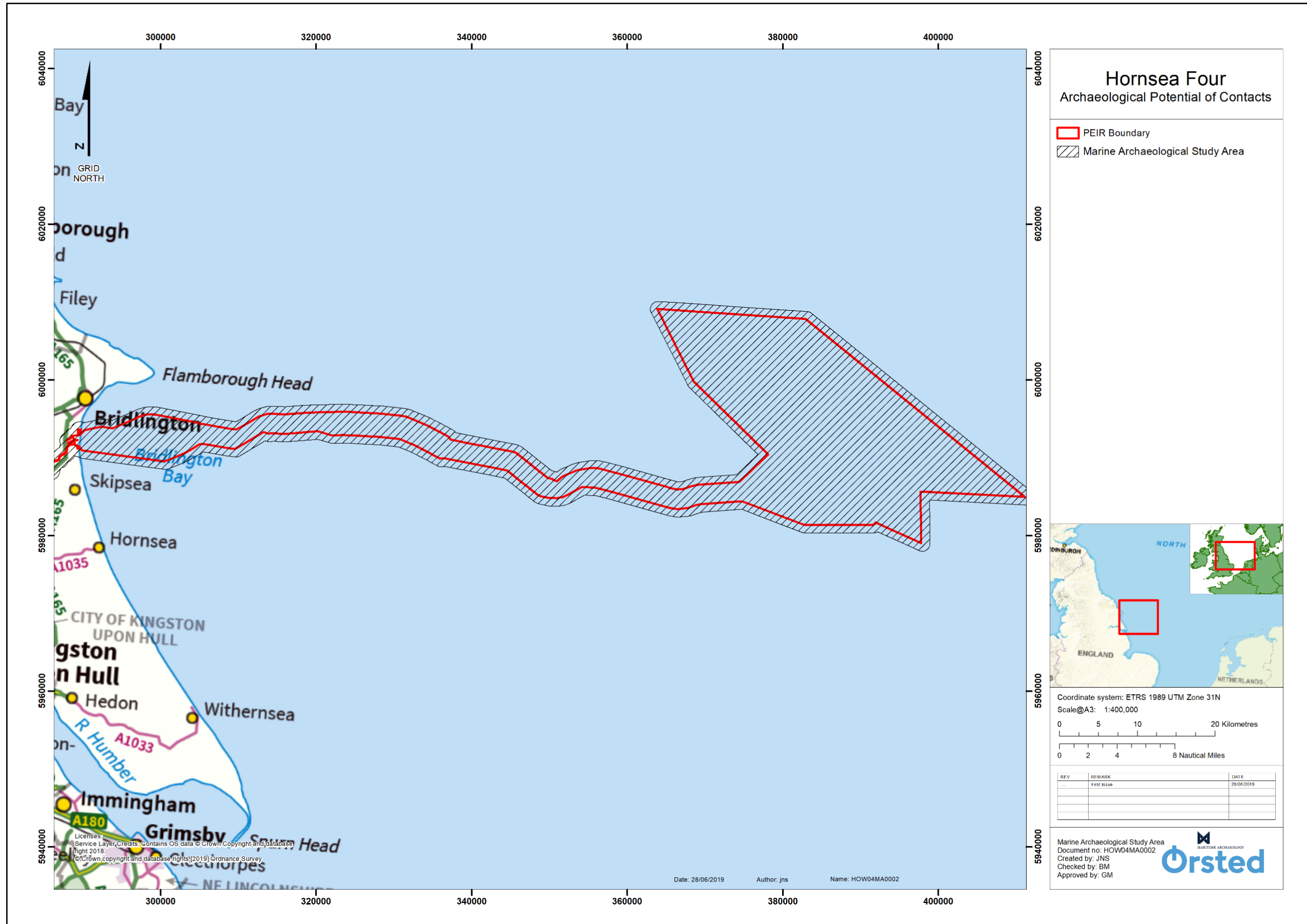


Figure 10.1: Hornsea Four marine archaeology study area (not to scale).

10.6 Methodology to inform baseline

10.6.1 Desktop Study

10.6.1.1 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 5, Annex 10.1: Marine Archaeology Technical Report**.

10.6.1.2 The following sources of information in **Table 10.4** were consulted.

Table 10.4: 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 of the Hornsea Four marine archaeology study area.
United Kingdom Hydrographic Office (UKHO)	Spatial data ²	Full coverage of the Hornsea Four marine archaeology study area.
Humber Historic Environment Record	Spatial and descriptive ³	Full coverage of the Hornsea Four marine archaeology study area.
Rapid Coastal Zone Assessment: Yorkshire and Lincolnshire	Descriptive data ⁴	Full coverage of the Hornsea Four marine archaeology study area.
Yorkshire Archaeological Research Framework	Descriptive data ⁵	Full coverage of the Hornsea Four marine archaeology study area.
CITIZAN – Coastal and Intertidal Zone Archaeological Network	Descriptive data ⁶	Full coverage of the Hornsea Four marine archaeology study area.

10.6.2 Site Specific Surveys

10.6.2.1 To inform the EIA, site-specific surveys have been undertaken. The scope and assessment methodology of future surveys are being planned in line with Commitments made by the Applicant. These Commitments are listed in **Table 10.5** below with further detail on these Commitments provided in **Table 10.9**. These survey scopes and methodologies will be submitted to the Historic England Marine Planning Team for review and comment. A summary of completed and planned surveys is outlined in **Table 10.5** and further detail on these surveys is presented within **Volume 5, Annex 10.1: Marine Archaeology Technical Report**.

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.citizen.org.uk/>

Table 10.5: Summary of site-specific survey data.

Title, year and reference	Summary	Coverage of Hornsea Four
<p>Geophysics 1A Pre-application survey Data acquired during summer 2018 and 2019</p>	<p>Survey works to inform the application process and characterize the PEIR area. Line spacing is generally wide and the survey is not full coverage. Sensors: Multibeam Echosounder (MBES), Side Scan Sonar (SSS), Magnetometer (MAG), Sub-bottom Profiler (SBP), in the array area also Ultra-high Resolution Seismic (UHRS).</p>	<p>Limited coverage of the Hornsea Four array area and export cable corridor (ECC).</p>
<p>Geophysics MBES Pre-development survey Planned for summer 2020</p>	<p>Full coverage MBES survey (low resolution, i.e. not for target picking).</p>	<p>Array and export cable areas.</p>
<p>Geophysics 1B Pre-development survey Planned for summer 2021 (Co166, Table 10.9)</p>	<p>Survey works to inform design and development. (Insonifies seabed contacts >0.5m.) Sensors: MBES, SSS, MAG, SBP, (UHRS).</p>	<p>Targeted areas in array and export cable areas.</p>
<p>Geophysics 1C Pre-Geotech surveys Takes place prior to each of the geotechnical campaigns. So far pre-GT1A-ECR area completed in 2018, pre-GT1A-Array area planned for spring 2020 (Co167, Table 10.9)</p>	<p>Survey works to mitigate risk of UXO at geotechnical locations. (Insonifies seabed contacts > 0.3m.) Sensors: MBES, SSS, MAG, SBP.</p>	<p>Each position where geotechnical samples will be obtained.</p>
<p>Geophysics 2A Pre-construction survey Timing depends on construction date (Co166, Table 10.9)</p>	<p>High-resolution survey suitable for the detection of UXO. (Insonifies seabed contacts > 0.3 m.) The survey will inform the final route planning, UXO clearance works and final archaeological mitigation. Sensors: MBES, SSS, MAG, SBP.</p>	<p>Full coverage within installation corridors/areas.</p>
<p>Geophysics 2B UXO campaign Timing depends on construction date (Co166, Table 10.9)</p>	<p>Inspection of potential UXO targets and demolition of confirmed UXO. ROV works.</p>	<p>Inspection on positions flagged for potential UXO within all installation corridors/areas.</p>
<p>Geotechnical 1A Pre-development planning Planned for spring 2020 (Co167, Table 10.9)</p>	<p>On and offshore, deep and shallow sampling and testing (boreholes/Vibrocores and Cone Penetration Tests (CPTs)) collected to support consenting and engineering requirements and the potential for deposits of geoarchaeological interest.</p>	<p>Array site and export cable route (coverage and location awaiting confirmation).</p>
<p>Geotechnical 1B Pre-development planning Planned for spring 2021 (Co167, Table 10.9)</p>	<p>On and offshore, deep and shallow sampling and testing collected to derive design values for soil properties on specific designated areas and /or locations (including OSS and RCS).</p>	<p>Array and export cable (coverage and location awaiting confirmation).</p>

10.7 Baseline environment

10.7.1 Existing baseline

10.7.1.1 A detailed description of the marine archaeology and cultural heritage of Hornsea Four array and ECC is available within [Volume 5, Annex 10.1: Marine Archaeology Technical Report](#). A summary of the known and potential archaeology within the development area is presented below and in [Table 10.7](#), with a focus on heritage assets which may be impacted by the development.

Palaeolandscapes

10.7.1.2 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: 43ff) and the Humber Regional Environmental Characterisation 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 (REC) (Tappin et al. 2011).

Sedimentary horizons

10.7.1.3 A Palaeogeographic Review of Geophysical Survey Data ([Appendix C of Volume 5, Annex 10.1: Marine Archaeology Technical Report](#)) was undertaken which identified a sedimentary sequence and deposits of archaeological potential.

10.7.1.4 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 5, Annex 10.1: Marine Archaeology Technical Report](#)).

Offshore-Maritime

10.7.1.5 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 5, Annex 10.1: Marine Archaeology Technical Report](#).

10.7.1.6 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 (WWII) 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 (WWI), although these rarely survive in the archaeological record.

- 10.7.1.7 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 10.2](#), which outlines the potential for the preservation of similar features and deposits within the marine zone.

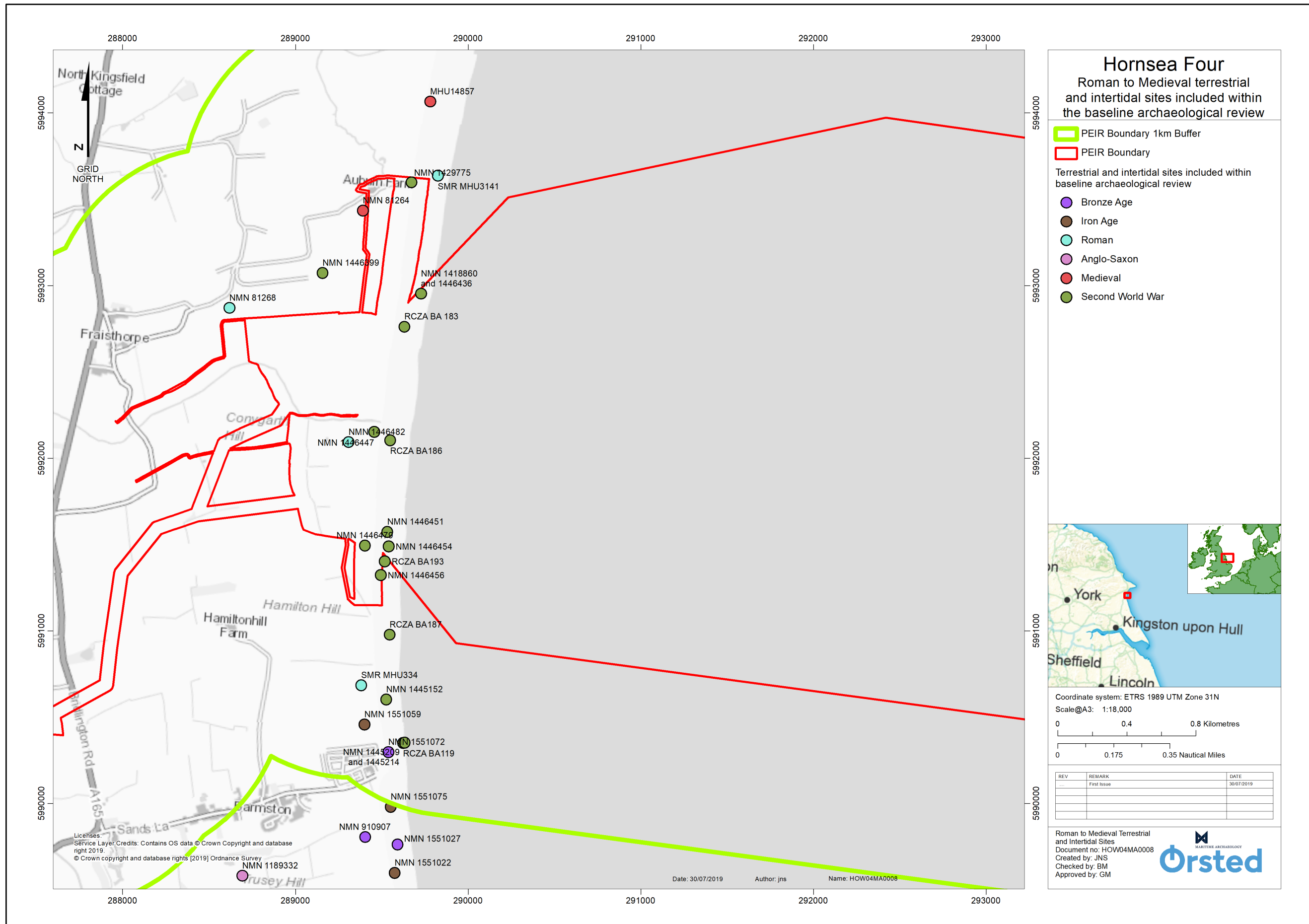


Figure 10.2: Archaeological sites and finds included in the baseline review (not to scale).

Known Wrecks and Obstructions

- 10.7.1.8 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.
- 10.7.1.9 Data for known shipwrecks and recorded shipping losses within the marine archaeology study area were obtained from the UKHO and the NRHE.
- 10.7.1.10 There are 18 known wrecks within the PEIR boundary with 13 classed as LIVE (wreck considered to exist as a result of detection through survey). Further there are also seven foul and seabed obstructions within the PEIR boundary as shown on [Figure 10.3](#). The majority of the known wrecks are dated to the 20th century.

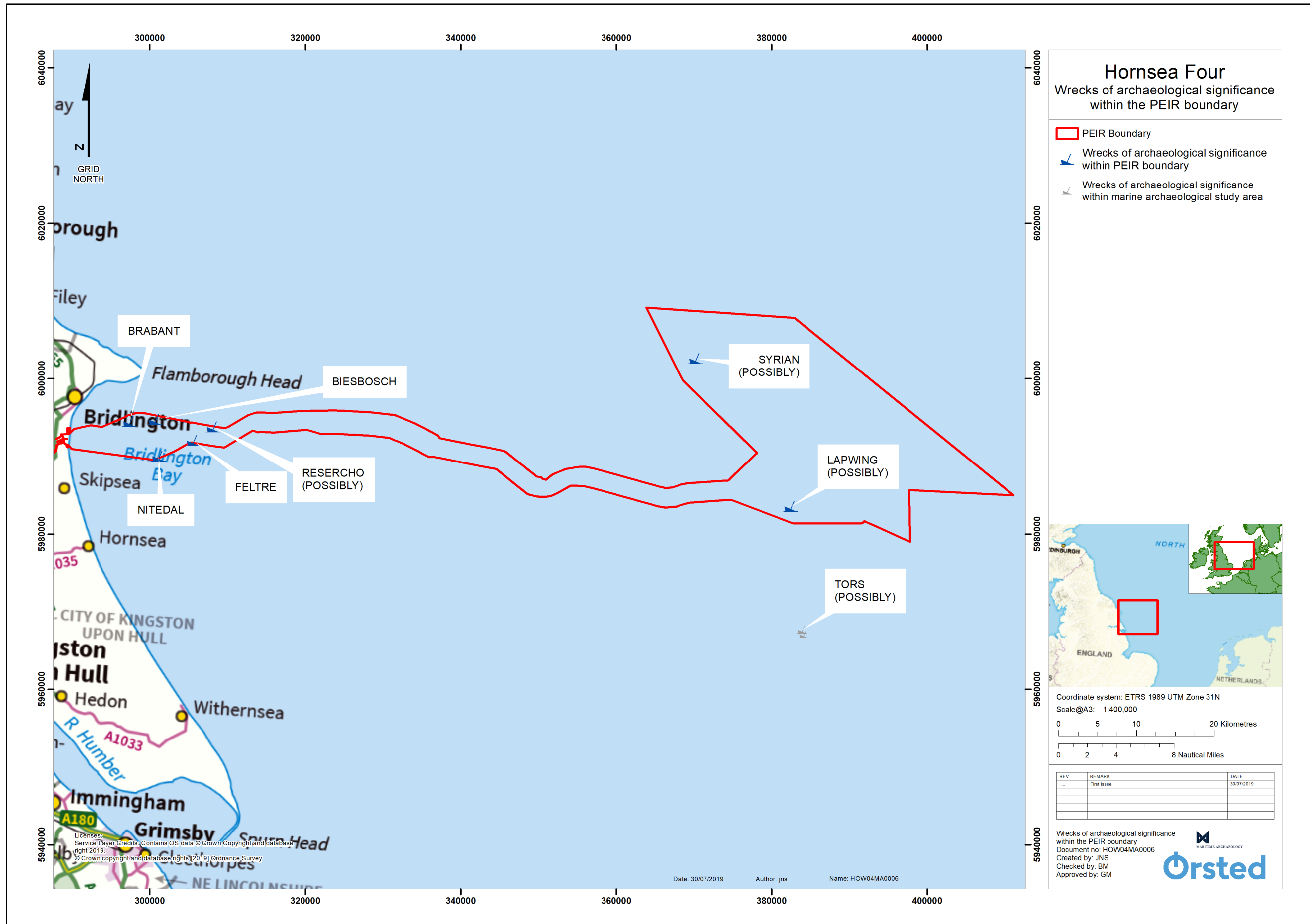


Figure 10.3: Known wrecks and obstructions within the PEIR boundary (not to scale).

Geophysical data

- 10.7.1.11 The geophysical data assessment identified 129 contacts of archaeological potential within the PEIR boundary. 'Low potential' features have been characterized as a mixture of isolated discrete anomalies or seabed contacts with associated magnetic anomalies. Three medium and two high potential anomalies were identified ([Figure 10.4](#)). A further 24 magnetic anomalies over 100 nT have been identified within the PEIR boundary but with no corresponding seabed contacts as summarised in [Table 10.6](#) and detailed in [Appendix C](#) of [Volume 5, Annex 10.1: Marine Archaeology Technical Report](#).

Table 10.6: Archaeological contacts identified from the geophysical datasets.

Potential	Archaeological contacts
Magnetic anomalies	24
Low	123
Medium	3
High	2
Total	129

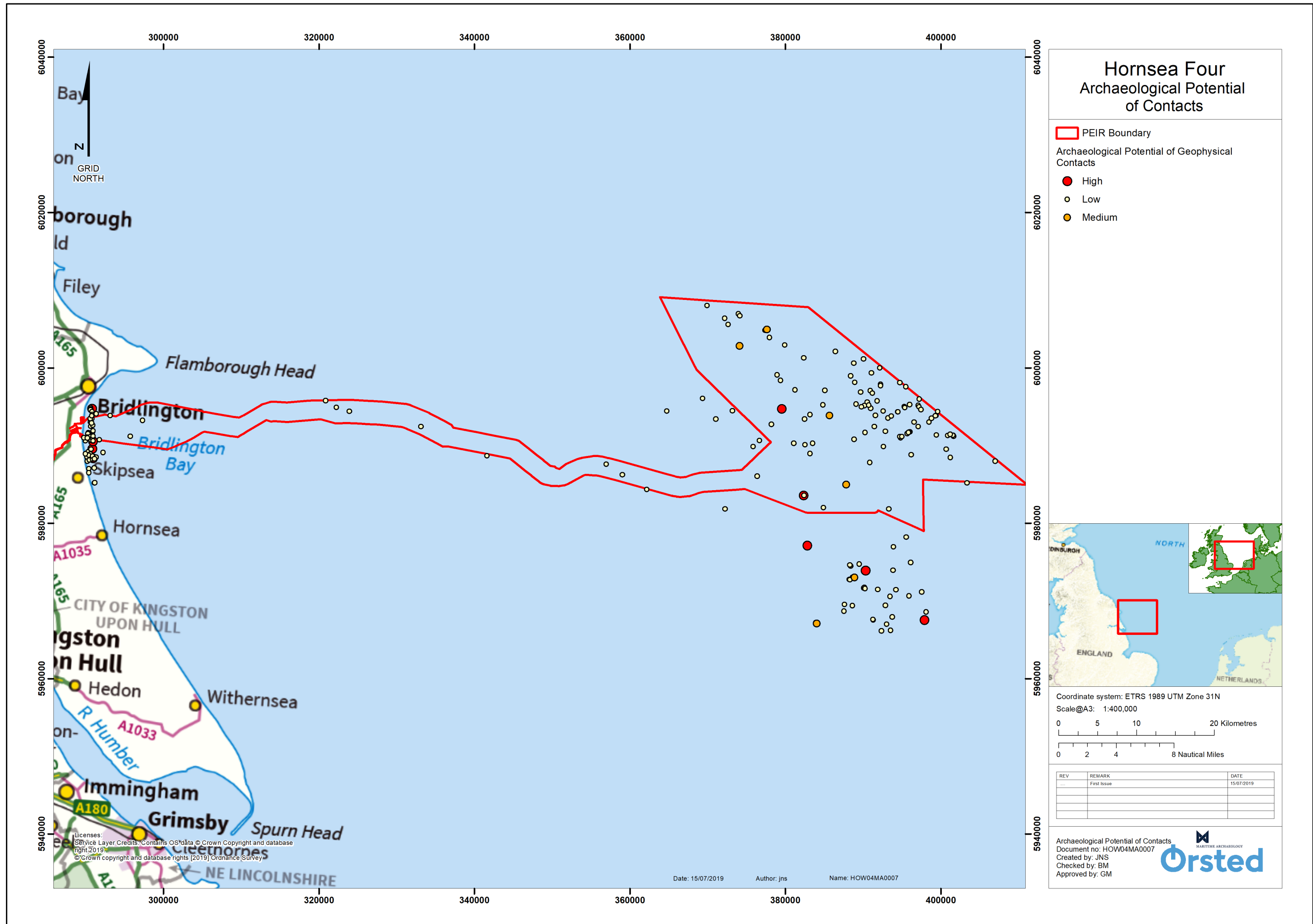


Figure 10.4: Contacts of archaeological potential identified in the geophysical data (not to scale).

Table 10.7: 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: <ul style="list-style-type: none"> • Holocene deposits; • Botney cut; • Eem Formation; and • Yarmouth Roads. <p>Figures detailing areas of concentration of the deposits outlined can be found in Appendix D of Volume 5, Annex 10.1: Marine Archaeology Technical Report.</p>
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 PEIR boundary and the marine archaeology study area.
Known Wrecks and Obstructions	Within the PEIR boundary there are 18 known wrecks with 13 classed as LIVE. In addition, there are seven fouls and seabed obstructions. The majority of the known wrecks are dated to the 20th century.
Geophysical data	Within the PEIR boundary, the following contacts of archaeological potential have been identified from the geophysical data assessment: <ul style="list-style-type: none"> • 129 features of low potential; • 24 magnetic anomalies over 100 nT but with no seabed contact; • Two features of medium potential; and • Three features of high potential.

10.7.2 Historic Seascape Characterisation

10.7.2.1 Changes to the character of sea surface and the perception of the historical seascape as a direct result of the development during construction, operation, maintenance and decommissioning phases 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 historical seascape.

10.7.2.2 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).

- 10.7.2.3 **Volume 5, Annex 10.1: Marine Archaeology Technical Report** does not contain an assessment of the historical 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 11: Seascape, Landscape and Visual Resources** and therefore this section only considers the specifically historical aspects of HSC.
- 10.7.2.4 The marine environment presents some characteristic differences in comparison with the land for historic character assessment. HSC considers the multi-dimensions 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.
- 10.7.2.5 The sub-sea floor and sea floor have also been assessed for archaeological potential in **Volume 5, Annex 10.1: Marine Archaeology Technical Report**, incorporating a geophysical data review (**Appendix C** of **Volume 5, Annex 10.1: Marine Archaeology Technical Report**) and a paleogeographic review of geophysical survey data (**Appendix D** of **Volume 5, Annex 10.1: Marine Archaeology Technical Report**).
- 10.7.2.6 For the historic seascape, the PEIR 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.
- 10.7.2.7 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 5, Annex 10.1: Marine Archaeology Technical Report**.
- 10.7.2.8 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 2: Benthic and Intertidal Ecology**. The wider region is also valued for its fishing grounds.
- 10.7.2.9 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.
- 10.7.2.10 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.

- 10.7.2.11 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 fish farming, 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.
- 10.7.2.12 Based on the information outlined above, no significant change (Likely Significant Effect (LSE) in EIA terms, as discussed in the proportionate approach to EIA and set out in [Section 5.5 of Volume 1, Chapter 5: Environmental Impact Assessment Methodology](#)) in the historic seascape character type of the area will be effected by the proposed development when considering Hornsea Four in isolation or cumulatively with neighbouring developments as per the long list of cumulative projects ([Volume 4, Annex 5.3: Offshore Cumulative Effects](#)). As such, no further modelling is recommended to be undertaken.
- 10.7.2.13 In addition, there are no national or regional seascape designations within the Hornsea Four seascape and visual resource study areas.
- 10.7.2.14 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.

10.7.3 Predicted future baseline

- 10.7.3.1 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 requires 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.
- 10.7.3.2 In the event that Hornsea Four does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section.
- 10.7.3.3 The future baseline scenario has been defined using the most recent data sources available as outlined in [Section 10.6](#). The current baseline is expected to remain largely unchanged with the exception of added, removed or altered geophysical anomalies with varying degrees of archaeological potential identified following the archaeological assessment of further geophysical surveys, as well as an increased understanding of the sedimentary horizons following the archaeological view of further geotechnical survey data.
- 10.7.3.4 Some of the newly identified anomalies are likely to be identified as archaeological receptors, which will require the application of appropriate mitigation, as set out in the Outline Marine WSI (Document number [F2.4](#)).

10.7.4 Data Limitations

- 10.7.4.1 The key data limitations with the baseline data and their ability to materially influence the outcome of the EIA are the current absence of full coverage geophysical survey data and the ongoing geoarchaeological programme prior to application.
- 10.7.4.2 It is expected that the data limitation will be minimised by the future and ongoing surveys as outlined in [Table 10.5](#), as well as by the marine archaeology commitments detailed in [Table 10.9](#).

10.8 Project basis for assessment

10.8.1 Impact register and impacts “scoped out”

- 10.8.1.1 Based on the baseline environment, the project description outlined in [Volume 1, Chapter 4: Project Description](#) and [Volume 4, Annex 5.2: Commitments Register](#), a number of impacts are “scoped out” of the PEIR assessment for marine archaeology. These impacts are outlined, together with a justification for scoping them out, in [Table 10.8](#). Further details are provided in [Volume 4, Annex 5.1: Impacts and Effects Register](#).
- 10.8.1.2 Please note that the term “scoped out” relates to the Likely Significant Effect (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 the Impacts Register (see [Volume 4, Annex 5.1](#)). This approach is aligned with Hornsea Four’s Proportionate approach to EIA (see [Volume 1, Chapter 5: EIA Methodology](#)).
- 10.8.1.3 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, an approach that has been provisionally agreed by PINS following submission of the Hornsea Four Scoping Report (Ørsted, 2018).
- 10.8.1.4 The justification for “scoping out” the potential impacts listed in [Table 10.8](#) 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 10.9](#).
- 10.8.1.5 The proportional approach to the impact assessment has been presented and clarified for Historic England (during the meetings held on 18th December 2018 and 6th June 2019, see [Table 10.3](#)); Hornsea Four has ensured that the commitments outlined in [Table 10.9](#) will be delivered through the mechanism of the resulting DCO and associated dML(s) to avoid impact of the development on known and unknown archaeological receptors, as clearly stated in the [Volume 4, Annex 5.2: Commitments Register](#).

10.8.1.6 These principles form the embedded mitigation Commitments, summarised in [Section 10.8.2](#), that are essential to the proportionate “scoping out” of these potential impacts.

Table 10.8: 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 ECC from construction activities (MA-C-1).	No likely significant effect	Scoped Out	The implementation of Commitments Co46, Co140, Co141, Co166 and Co167 (Table 10.9) will result in negligible impact on marine archaeology receptors.
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	Commitments Co46, Co140, Co141, Co166 and Co167 (Table 10.9) will result in negligible impact during piling operations, primarily by ensuring identification of marine archaeology receptors and avoidance.
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	The implementation of Commitments Co46, Co140, Co141, Co166 and Co167 (Table 10.9) will result in 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.
Construction: Disturbance of sediment containing potential archaeological receptors (material and contexts) during inter-array cable laying operations and export cable laying operations (MA-C-6).	No likely significant effect	Scoped Out	The implementation of Commitments Co46, Co140, Co141, Co166 and Co167 (Table 10.9) will result in negligible impact resulting from cable laying operations, primarily through the identification and avoidance of marine archaeology receptors.

Project activity and impact	Likely significance of effect	Approach to assessment	Justification
Decommissioning: Draw-down of sediment into voids left by removed turbine 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	The implementation of Commitments Co46, Co140, Co141, Co166 and Co167 (Table 10.9) 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 and both PINS and Hornsea Four agree.

10.8.2 Commitments

- 10.8.2.1 Hornsea Four has made several commitments (primary design principles inherent as part of the project, installation techniques and engineering designs/modifications) as part of their pre-application phase, to avoid a number of impacts or reduce impacts as far as possible. Further Commitments (adoption of best practice guidance) are also embedded as an inherent aspect of the EIA process.
- 10.8.2.2 Full details of the Commitments and how these are to be secured are included within the Commitments Register ([Volume 4, Annex 5.2](#)). The Commitments adopted by Hornsea Four in relation to marine archaeology are presented in [Table 10.9](#).

Table 10.9: Relevant marine archaeology commitments.

Commitment ID	Measure Proposed	How the measure will be secured
Co46	Primary: The offshore export cable corridor and the array will be routed 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 12(2) and; DCO Schedule 12, Part 2 - Condition 12(2) (Marine Written Scheme of Archaeological Investigation)
Co140	Primary: Archaeological exclusion zones (AEZs) will be established in the Marine WSI in accordance with the Outline Marine WSI (document reference F2.4), to protect any known / identified marine archaeological receptors.	DCO Schedule 11, Part 2 - Condition 12(2) and; DCO Schedule 12, Part 2 - Condition 12(2) (Marine Written Scheme of Archaeological Investigation)
Co141	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 implementation of a protocol for Archaeological Discoveries in accordance with 'Protocol for Archaeological Discoveries: Offshore Renewables Projects' (The Crown Estate, 2014).	DCO Schedule 11, Part 2 - Condition 12(2) and; DCO Schedule 12, Part 2 - Condition 12(2) (Marine Written Scheme of Archaeological Investigation)
Co166	Secondary: An offshore geophysical survey (including a 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 12(2) and; DCO Schedule 12, Part 2 - Condition 12(2) (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 12(2) and; DCO Schedule 12, Part 2 - Condition 12(2) (Marine Written Scheme of Archaeological Investigation)

10.9 Maximum Design Scenario

10.9.1.1 The MDSs identified in [Table 10.10](#) have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the details provided in [Volume 1, Chapter 4: Project Description](#). Effects of greater adverse significance are not predicted to arise should any other development scenario, compared to that assessed here and based on details within the project Design Envelope (e.g. different turbine layout), be taken forward in the final design scheme.

Table 10.10: Maximum design scenario for impacts on marine archaeology.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
<i>Operation</i>			
<p>Scour, penetration, draw down and compression effects caused by (a) the presence of WTG substation foundations, and (b) the exposure of inter-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 (MA-O-7) .</p>	<p>Primary: Co46 Co140</p> <p>Secondary: Co166 Co167</p> <p>Tertiary: Co141</p>	<p>Array Area:</p> <ul style="list-style-type: none"> • 180 WTGs on suction bucket jacket foundations (WTG type), total seabed permanent area 795,216 m² • Up to six offshore transformer substations and three converter substations on gravity-base foundations (box type and large OSS type), total seabed permanent area 371,250 m² • One offshore accommodation platform on a gravity base foundation (box type), total seabed permanent area 30,625 m² <p>Array Cables:</p> <p><i>Cable protection</i></p> <ul style="list-style-type: none"> • 624,000 m² cable protection • 40 cable/pipeline crossings (including interconnector cables) with 255,000 m² of pre- and post-lay cable/pipelines crossing rock berms <p><i>Remedial cable burial</i></p> <ul style="list-style-type: none"> • 2,000 m length of cable per replacement • 10 m wide disturbance corridor per disturbance event • 42 km replacement over 35 year lifetime <p><i>Cable repairs</i></p> <ul style="list-style-type: none"> • 20,000 m² temporary seabed disturbance per repair event • 10 repair events over lifetime • 200,000 m² total seabed disturbance over lifetime (10 x 20,000) <p>Interconnector cables:</p> <p><i>Cable protection</i></p> <ul style="list-style-type: none"> • 94,000 m² cable protection <p><i>Remedial cable burial</i></p> <ul style="list-style-type: none"> • 2,000 m length of cable per replacement • 10 m wide disturbance corridor per disturbance event • 7 km replacement of 35 year lifetime 	<p>Design scenario representing the maximum potential for interaction with archaeological receptors.</p>

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
		<p><i>Cable repairs</i></p> <ul style="list-style-type: none"> • 20,000 m² temporary disturbance per repair event • 5 repair events over lifetime • 100,000 m² disturbance over lifetime (5 x 20,000) <p>Offshore ECC:</p> <ul style="list-style-type: none"> • Up to three HVAC booster stations, total seabed permanent area 91,875 m² <p>Export Cables:</p> <p><i>Cable protection</i></p> <ul style="list-style-type: none"> • 792,000 m² cable protection • 10 cable/pipeline crossings with 268,999 m² of pre- and post-lay cable/pipelines crossing rock berms <p><i>Remedial cable burial</i></p> <ul style="list-style-type: none"> • 2,000 m length of cable per replacement • 10 m disturbance corridor • 14 km replacement over lifetime <p><i>Cable repairs</i></p> <ul style="list-style-type: none"> • 20,000 m² per repair event • 35 repair events over lifetime • 700,000 m² disturbance over lifetime (35 x 20,000) 	
<p>Penetration and compression effects on seabed caused by corrective and preventative operation and maintenance activities (via jack-up vessels) leading to total or partial loss of archaeological receptors (material or contexts) (MA-O-8)</p>	<p>Primary: Co46 Co140</p> <p>Secondary: Co166 Co167</p> <p>Tertiary: Co141</p>	<p>WTGs:</p> <ul style="list-style-type: none"> • 1,260 component replacement events over lifetime (jack-up), 300 m² disturbance per event • 1,260 access ladder replacements (jack-up), 300 m² disturbance per event • 1,260 anode replacements (jack-up), 300 m² disturbance per event • 360 J-tube repair/replacements (jack-up), 170 m² disturbance per event <p>Offshore platforms and accommodation platforms:</p> <ul style="list-style-type: none"> • 20 component replacement events over lifetime (jack-up), 300 m² disturbance per event • 70 access ladder replacements (jack-up), 300 m² disturbance per event • 70 anode replacements (jack-up), 300 m² disturbance per event • 20 J-tube repair/replacements (jack-up), 300 m² disturbance per event 	<p>Design scenario representing the maximum potential for interaction with archaeological receptors.</p>

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
<i>Decommissioning</i>			
<p>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).</p>	<p>Primary: Co46 Co140</p> <p>Secondary: Co166 Co167</p> <p>Tertiary: Co141</p>	<p>WTGs, offshore substations and accommodation platform:</p> <ul style="list-style-type: none"> • 180 WTGs on suction bucket jacket foundations (WTG type), total seabed area 795,216 m² • Up to six offshore transformer substations and three converter substations on gravity-base foundations (box type and large OSS type), total seabed area 371,250 m² • One offshore accommodation platform on a gravity base foundation (box type), total seabed area 30,625 m² <p>Cables:</p> <ul style="list-style-type: none"> • Total disturbance from removal of all cables = 102.6 km² • 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. <p>Vessel jack-ups and anchor placements:</p> <ul style="list-style-type: none"> • 170 m² per jack up operation • 2 jack up operations per WTG/platform (380 in array area total) • 100 m² per anchor (8 anchors per vessel) • 2 anchor vessels operations per structure 	<p>Design scenario representing the maximum potential for interaction with archaeological receptors.</p>

10.10 Assessment methodology

10.10.1.1 The assessment methodology for marine archaeology is consistent with that presented in Annex C of the Scoping Report and is detailed below. The marine archaeology methodology has been presented to and agreed with Historic England via the Evidence Plan process (during the Technical Panel meeting on 18.12.18). No issues were raised with the proposed methods which form a standard approach to offshore marine archaeological assessment (see [Table 10.3](#)).

10.10.1.2 Historic England's remaining concerns regarding the proportionate approach to EIA have been discussed (during the Technical Panel meeting on 06.06.19) and have been addressed through the expanded use of [Volume 4, Annex 5.2: Commitments Register](#) to encompass a full schedule of archaeological works within the geophysical and geotechnical survey programme (see [Table 10.3](#)).

10.10.2 Impact assessment criteria

10.10.2.1 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 1, 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 10.11: 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 10.12](#) below.

Table 10.12: 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/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).
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.

10.10.2.2 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 10.12](#). Where a range of significance of effect is presented in [Table 10.13](#), the final assessment for each effect is based upon expert judgement.

10.10.2.3 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 10.13: Matrix used for the assessment of the significance of the effect.

		Magnitude of Impact/Degree of Change			
		Negligible	Minor	Moderate	Major
Value, Importance, Sensitivity	Low	Not Significant	Not Significant or Minor (Not Significant)	Minor (Not Significant)	Minor (Not Significant) or Moderate (Significant)
	Medium	Not Significant	Minor (Not Significant)	Moderate (Significant)	Moderate (Significant) or Major (Significant)
	High	Not Significant	Minor (Not Significant) or Moderate (Significant)	Moderate (Significant) or Major (Significant)	Major (Significant) or Substantial (Significant)
	Very High	Not Significant	Moderate (Significant) or Major (Significant)	Major (Significant) or Substantial (Significant)	Substantial (Significant)

10.11 Impact assessment

10.11.1 Construction

10.11.1.1 The impacts of the offshore construction of Hornsea Four have been considered on marine archaeology receptors ([Volume 4, 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 10.8](#) and [Volume 4, Annex 5.1: Impacts Register](#).

10.11.2 Operation and Maintenance

10.11.2.1 The impacts of the offshore operation and maintenance of Hornsea Four have been assessed on marine archaeology receptors ([Volume 4, Annex 5.1: Impacts Register](#)). The environmental impacts arising from the operation and maintenance of Hornsea Four are listed in [Table 10.10](#) 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 WTC substation foundations, and (b) the exposure of inter-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 (MA-O-7).

Magnitude of impact

- 10.11.2.2 Impact on archaeological receptors during the operational 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.
- 10.11.2.3 Impact on shipwrecks, obstructions and aviation material will be local, adverse, irreversible and result in a permanent change to the receptor.
- 10.11.2.4 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.
- 10.11.2.5 **Table 10.10** outlines the maximum design scenario for impacts on marine archaeology during the operational and maintenance phase. Impacts are assumed to be limited to the immediate area around the foundations, inter-array and export cables.
- 10.11.2.6 The embedded commitments, as described in **Section 10.8.2** and **Table 10.9** for the avoidance of archaeological receptors (informed by geotechnical and geophysical data, the Outline Marine WSI (Document number **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 (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment. .
- 10.11.2.7 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

- 10.11.2.8 Monitoring measures related to marine archaeology are included in the Outline Marine WSI (Document number **F2.4**). A detailed Marine WSI will be developed prior to commencement of marine construction. No further recommendations are presented.

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

Magnitude of impact

- 10.11.2.9 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 or the anchors required to secure the vessels during operations.
- 10.11.2.10 Impact on shipwrecks, obstructions, aviation remains will be local, adverse, irreversible and result in a permanent change to the receptor.
- 10.11.2.11 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.
- 10.11.2.12 **Table 10.10** outlines the maximum design scenario for impacts on Marine Archaeology during the operational and maintenance phase. Impacts are assumed to be limited to the immediate area around the foundations and or cable repair and reburial areas where contact with the seabed occurs as a result of anchoring, the usage of jack-up legs or additional cable protection.
- 10.11.2.13 The embedded commitments, as described in **Section 10.8.2** and **Table 10.9** for the avoidance of archaeological receptors (informed by geotechnical and geophysical data, the Outline Marine WSI (Document number **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 (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment. .
- 10.11.2.14 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

- 10.11.2.15 Monitoring measures related to marine archaeology are included in the Outline Marine WSI (Document number **F2.4**). No further recommendations are presented.

10.11.3 Decommissioning

Draw-down of sediment into voids left by removed turbine foundations 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

- 10.11.3.1 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.
- 10.11.3.2 Impact on shipwrecks, obstructions or aviation material will be local, adverse, irreversible and result in a permanent change to the receptor.
- 10.11.3.3 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.
- 10.11.3.4 **Table 10.10** outlines the maximum design scenario for impacts on marine archaeology during the decommissioning phase. Impacts are assumed to be limited to the immediate area around the foundations when cut and removed and if contact with the seabed happens as a result of anchoring and the usage of jack-up legs.
- 10.11.3.5 The embedded commitments, as described in **Section 10.8.2** and **Table 10.9** for the avoidance of archaeological receptors (informed by geotechnical and geophysical data, the Outline Marine WSI (Document number **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 (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.
- 10.11.3.6 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

- 10.11.3.7 Monitoring measures related to marine archaeology are included in the Outline Marine WSI (Document number **F2.4**). A detailed Marine WSI will be developed prior to commencement of marine construction. No further recommendations are presented.

10.12 Cumulative effect assessment (CEA)

- 10.12.1.1 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.
- 10.12.1.2 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 4, Annex 5.3: Offshore Cumulative Effects](#) and are presented in a series of maps within [Volume 4, Annex 5.4: Location of Offshore Cumulative Schemes](#).
- 10.12.1.3 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.
- 10.12.1.4 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 PEIR. An explanation of each tier is included in [Table 10.14](#).

Table 10.14: 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.

10.12.1.5 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 4, 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.

10.12.1.6 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 10.15](#) 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 4, Annex 5.3: Offshore Cumulative Effects](#).

Table 10.15: 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	27.75 km	2.10 km	Distance from Hornsea Four with potential cumulative effects on sediment movement and disturbance.
1	Viking Link Interconnector	Consented Construction expected 2020-2023	0.00 km	0.00 km	40.66 km	Distance from Hornsea Four with potential cumulative effects on sediment movement and disturbance.
1	Dogger Bank Creyke Beck Wind Farm A Export Cables	Consented Construction expected 2021-2024	25.13 km	0.00 km	8.46 km	Distance from Hornsea Four with potential cumulative effects on sediment movement and disturbance.
1	Dogger Bank Creyke Wind Farm Beck B Export Cables	Consented Construction expected 2021-2024	25.13 km	0.00 km	8.46 km	Distance from Hornsea Four with potential cumulative effects on sediment movement and disturbance.

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	Hornsea Project Two Wind Farm Export Cables	Consented Construction expected 2020-2021	0.00 km	8.51 km	>50 km	Distance from Hornsea Four with potential cumulative effects on sediment movement and disturbance.

10.12.1.7 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 boundary 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.

10.12.1.8 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 and Bridlington disposal site 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 interconnectors 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 interconnectors and Bridlington disposal site, resulting in a potential effect on heritage receptors.

10.12.1.9 The cumulative MDS described in [Table 10.16](#) 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 1, Chapter 4: Project Description](#) (summarised for marine archaeology in [Table 10.15](#)) 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 10.16: 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.	<p>Maximum design scenario for Hornsea Four plus the cumulative full development of the following projects:</p> <p>Tier 1:</p> <ul style="list-style-type: none"> - Open Disposal site (Bridlington A) - Consented interconnector (Viking Link); and - Consented wind farm Export Cables (Dogger Bank and Hornsea Two Offshore Wind Farms). <p>Tier 2:</p> <ul style="list-style-type: none"> - No Tier 2 projects identified. <p>Tier 3:</p> <ul style="list-style-type: none"> - No Tier 3 projects identified. 	<p>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.</p> <p>Impact on archaeological receptors for other offshore developments have been gathered from the respective ES chapters, where available.</p>
Operation	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.	<p>Maximum design scenario for Hornsea Four plus the cumulative full development of the following projects:</p> <p>Tier 1:</p> <ul style="list-style-type: none"> - Open Disposal site (Bridlington A) - Consented interconnector (Viking Link); and - Consented wind farm Export Cables (Dogger Bank and Hornsea Two Offshore Wind Farms). <p>Tier 2:</p> <ul style="list-style-type: none"> - No Tier 2 projects identified. <p>Tier 3:</p> <ul style="list-style-type: none"> - No Tier 3 projects identified. 	<p>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.</p> <p>Impact on archaeological receptors for other offshore developments have been gathered from the respective ES chapters, where available.</p>

10.12.1.10 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 Environmental Statements 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.

10.12.2 Construction phase

10.12.2.1 All impacts of the construction phase on marine archaeological receptors have been scoped out as detailed in [Table 10.8](#).

10.12.3 Operation and Maintenance Phase

10.12.3.1 There is potential for cumulative impact as a result of operation and maintenance activities associated with Hornsea Four as detailed in [Table 10.10](#) and other projects as outlined in [Table 10.15](#). For the purposes of this PEIR, this additive impact has been assessed within 50 km which is considered to be representative of the marine archaeological resource within the southern North Sea area. The projects identified for this tier are:

- Bridlington A Disposal site;
- Viking Link Interconnector;
- Dogger Bank Creyke Beck Wind Farm A Export Cable;
- Dogger Bank Creyke Wind Farm Beck B Export Cable; and
- Hornsea Project Two Wind Farm Export Cable.

10.12.3.2 The active Bridlington A (HU015) disposal site located 2.10 km from the Hornsea Four HVAC Booster 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).

10.12.3.3 The active Bridlington A (HU015) disposal site and Hornsea Four operation and maintenance phase will overlap assuming the continues use of the Bridlington site. The cumulative impact is predicted to be of local spatial extent, long term duration, continuous and limited reversibility and any impact will affect the receptor directly. The magnitude of impact is considered to be **negligible**.

10.12.3.4 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).

10.12.3.5 The Viking link interconnector and Hornsea Four operational phases overlap and the cumulative impact therefore is predicted to be of local spatial extent, long term duration, continuous and limited reversibility and any impact will affect the receptor directly. The magnitude of impact is considered to be **negligible**.

- 10.12.3.6 Dogger Bank Creyke Beck Wind Farm 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 Creyke Beck EIA; it was concluded that significant impacts will not occur (Forewind, 2013).
- 10.12.3.7 The Dogger Bank Creyke Beck Wind Farm A and B export cables and Hornsea Four operation and maintenance phases overlap. The cumulative impact therefore is predicted to be of local spatial extent, long term duration, continuous and limited reversibility and any impact will affect the receptor directly. The magnitude of impact is considered to be **negligible**.
- 10.12.3.8 Hornsea Project Two export cable when installed may require regular planned and unplanned maintenance with up to 0.8 km² 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).
- 10.12.3.9 Hornsea Project Two export cable and Hornsea Four operation and maintenance phases overlap. The cumulative impact therefore is predicted to be of local spatial extent, long term duration, continuous and limited reversibility and any impact will affect the receptor directly. The magnitude of impact is considered to be **negligible**.

Tier 1 significance assessment

- 10.12.3.10 Prehistoric archaeological receptors such as finds and deposits of archaeological potential as well as known wrecks, obstructions and aviation remains will not recover from direct impacts. This will result in a permanent change to the receptor if present.
- 10.12.3.11 The embedded mitigation strategies by the listed projects, plans and activities should follow standard industry practice in consultation with the relevant curators and aim to avoid impacts on all marine archaeological receptors (sites and deposits) during the operations and maintenance phase and therefore the maximum sensitivity of receptors in the area is **low** and the magnitude has been assessed as **negligible**. Therefore, the significance of effect from the loss of, or damage to, archaeological receptors from Hornsea Four cumulatively with the above listed project is **minor adverse**, which is not significant in EIA terms.

10.13 Transboundary effects

- 10.13.1.1 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 was undertaken at Scoping (Annex K of the Scoping Report), which identified that there

was no potential for significant transboundary effects to occur in relation to marine archaeology.

10.14 Inter-related effects

10.14.1.1 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.

10.14.1.2 A description of the process to identify and assess these effects is presented in [Section 5.8](#) of [Volume 1, Chapter 5: Environmental Impact Assessment Methodology](#).

Table 10.17: Inter-related effects assessment for marine archaeology.

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
<i>Project-lifetime effects</i>			
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 inter-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	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.

Project phase(s)	Nature of inter-related effect	Assessment alone	Inter-related effects assessment
	accelerating loss of the same.		
<i>Receptor-led effects</i>			
Inter-related effect from the combination of disturbance or direct impact from construction activities and operating vessels on known archaeological receptors.		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. It is therefore not anticipated that any inter-related effects will occur that are of any greater significance compared to the impacts considered alone.	

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

10.15 Conclusion and summary

10.15.1.1 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.

10.15.1.2 The detailed description of the marine archaeology and cultural heritage of Hornsea Four array and ECC is available within [Volume 5, Annex 10.1: Marine Archaeology Technical Report](#).

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

10.15.1.4 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.

10.15.1.5 Included is also an assessment of the cumulative, transboundary and inter-related effects on Marine heritage of Hornsea Four.

10.15.1.6 It is concluded that as the magnitude of impact on marine archaeology is assessed to be negligible, the impact is not significant and the assessment of Inter-related effects does not include sensitivity and significance.

10.15.1.7 [Table 10.18](#) presents a summary of the significant impacts assessed within this PEIR, mitigation and residual effects.

Table 10.18: Summary of potential impacts assessed for marine archaeology.

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
<i>Operation</i>				
Scour, penetration, draw down and compression effects caused by (a) the presence of WTG substation foundations, and (b) the exposure of inter-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. (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) 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
<i>Decommissioning</i>				
MA-D-9 Draw-down of sediment into voids left by removed turbine foundations 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

10.16 References

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