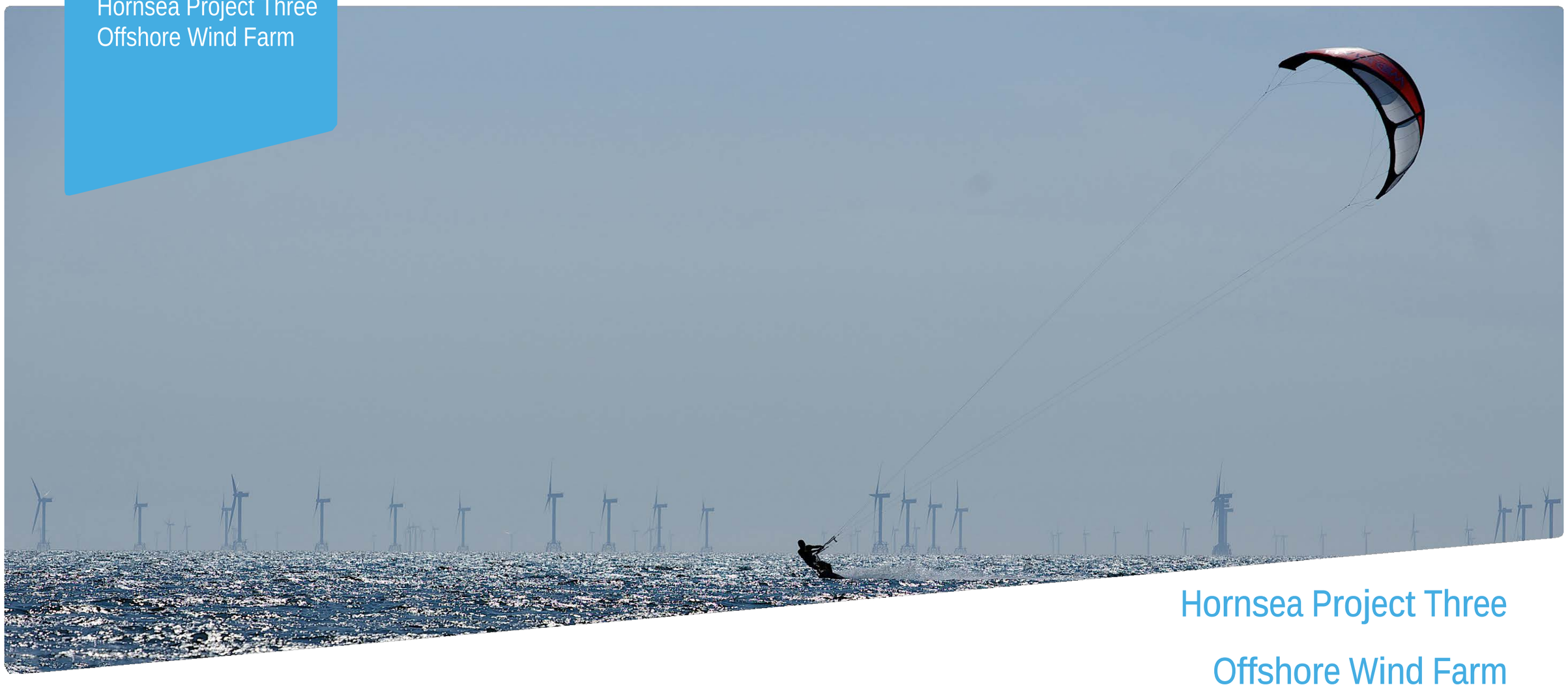
Hornsea Project Three
Offshore Wind Farm



Hornsea Project Three

Offshore Wind Farm

Environmental Statement:
Volume 2, Chapter 9 - Marine Archaeology

PINS Document Reference: A6.2.9
APFP Regulation 5(2)(a)

Date: May 2018

Hornsea 3
Offshore Wind Farm

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Environmental Impact Assessment

Environmental Statement

Volume 2

Chapter 9 – Marine Archaeology

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5 Howick Place,

London, SW1P 1WG

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Prepared by: RPS

Checked by: Jennifer Brack

Accepted by: Stuart Livesey

Approved by: Stuart Livesey

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Glossary

Term	Definition
Before Present (BP)	An archaeological dating convention– the present assumed in this report to be 1950 (i.e. based on uncalibrated radiocarbon dates).
Heritage	Historic or cultural associations.
Heritage asset	Those elements of the historic environment that hold value to this and future generations because of their historic, archaeological, architectural or artistic interest are called ”heritage assets”. A heritage asset may be any building, monument, site, place, area or landscape, or any combination of these (DECC, 2011).
Historic England	The Historic Buildings and Monuments Commission for England.
Maritime archaeology	The physical remains of boats and ships that have been wrecked, sunk or have foundered, and may also be those artefacts which rest upon the seabed as the result of being jettisoned or lost overboard (for example, anchors, cannon or fishing gear).
Prehistoric archaeology	In the British Isles the period from the earliest hominin occupation more than 780,000 years Before Present (BP) to the time of the Roman invasion of Britain in 43 AD.
Written Scheme of Investigation (WSI)	A plan detailing the protocol for any archaeological investigation to be carried out prior to the construction of Hornsea Project Three, including procedures for field survey and watching briefs, as may be required.

Acronyms

Acronym	Description
AEZ	Archaeological Exclusion Zone
BULSI	Build, use, loss, survival and investigation system
BP	Before Present
C14	Carbon 14
CEA	Cumulative Effect Assessment
DCO	Development Consent Order
DMRB	Design Manual for Roads and Bridges
EIA	Environmental Impact Assessment
GPS	Global Positioning System
KP	Kilometre Post
LAT	Lowest Astronomical Tide
MBES	Multibeam Echo Sounder
MOD	Ministry of Defence
MPS	UK Marine Policy Statement
NL	Named Location
NPS	National Policy Statement
NRHE	National Record of the Historic Environment
NSPP	North Sea Palaeolandscapes Project
NSIP	Nationally Significant Infrastructure Project
PEIR	Preliminary Environmental Information Report
REC	Humber Regional Environmental Characterisation
RNAS	Royal Naval Air Service
RCZAS	Norfolk Rapid Coastal Zone Assessment Survey
ROV	Remotely Operated Vehicle
SAM	Scheduled Ancient Monument
SBP	Sub Bottom Profiler
SSS	Sidescan Sonar

Acronym	Description
UK	United Kingdom
UKHO	United Kingdom Hydrographic Office
USBL	Ultra-Short Base Line
UXO	Unexploded Ordnance

Units

Unit	Description
m	metre
nT	Nanotesla
km	kilometre

9. Marine Archaeology

9.1 Introduction

9.1.1.1 This chapter of the Environmental Statement presents the findings of the Environmental Impact Assessment (EIA) for the potential impacts of the Hornsea Project Three offshore wind farm (hereafter referred to as Hornsea Three) on marine archaeology. Specifically, this chapter considers the potential impact of Hornsea Three seaward of Mean High Water Springs (MHWS) during its construction, operation and maintenance and decommissioning phases. Those impacts of Hornsea Three landward of MHWS are assessed in volume 3, chapter 5, Historic Environment.

9.1.1.2 This chapter summarises baseline information contained within volume 5, annex 9.1: Marine Archaeology Technical Report. The technical report provides a detailed characterisation of the marine archaeology in Hornsea Three and the surrounding area, based on existing literature sources, field surveys undertaken specifically for Hornsea Three, and includes information on submerged prehistoric archaeology, maritime archaeology and aviation archaeology.

9.2 Purpose of this chapter

9.2.1.1 The primary purpose of the Environmental Statement is to support the Development Consent Order (DCO) application for Hornsea Three under the Planning Act 2008 (the 2008 Act) and accompanies the application to the Secretary of State for Development Consent.

9.2.1.2 It is intended that the Environmental Statement will provide statutory and non-statutory consultees with sufficient information to complete the examination of Hornsea Three and will form the basis of agreement on the content of the DCO and/or Marine Licence conditions (as required).

9.2.1.3 In particular, this Environmental Statement chapter:

- Presents the existing environmental baseline established from desk studies, and consultation;
- Presents the potential environmental effects on marine archaeology arising from Hornsea Three, during construction, operation and maintenance and decommissioning based on the information gathered and the analysis and assessments;
- 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 to date in the EIA process.

9.3 Study area

9.3.1.1 For the purposes of the Hornsea Three marine archaeology EIA, two study areas have been defined as follows:

- The Hornsea Three marine archaeology study area - defined as the area which will encompass the offshore components of Hornsea Three (including the Hornsea Three array area, offshore cable corridor and temporary working areas extending some 600 m on either side, and intertidal area seaward of MHWS) as this area is considered to be directly affected by the proposed development (see Figure 9.1); and
- The regional marine archaeology study area – defined as a 20 km buffer from the Hornsea Three array area and offshore cable corridor, extended to include the Hornsea Project One and Hornsea Project Two array areas (see Figure 9.1). This regional marine archaeology study area was defined on the basis that it is considered to be a fair representation of archaeology within the wider southern North Sea, and includes the Hornsea Project One and Hornsea Project Two array areas to incorporate survey data undertaken to inform these developments. The regional marine archaeology study area is the area covered by the desktop review and therefore provides a wider context for the site-specific data, as well as the extent of the marine archaeology cumulative effect assessment (CEA).

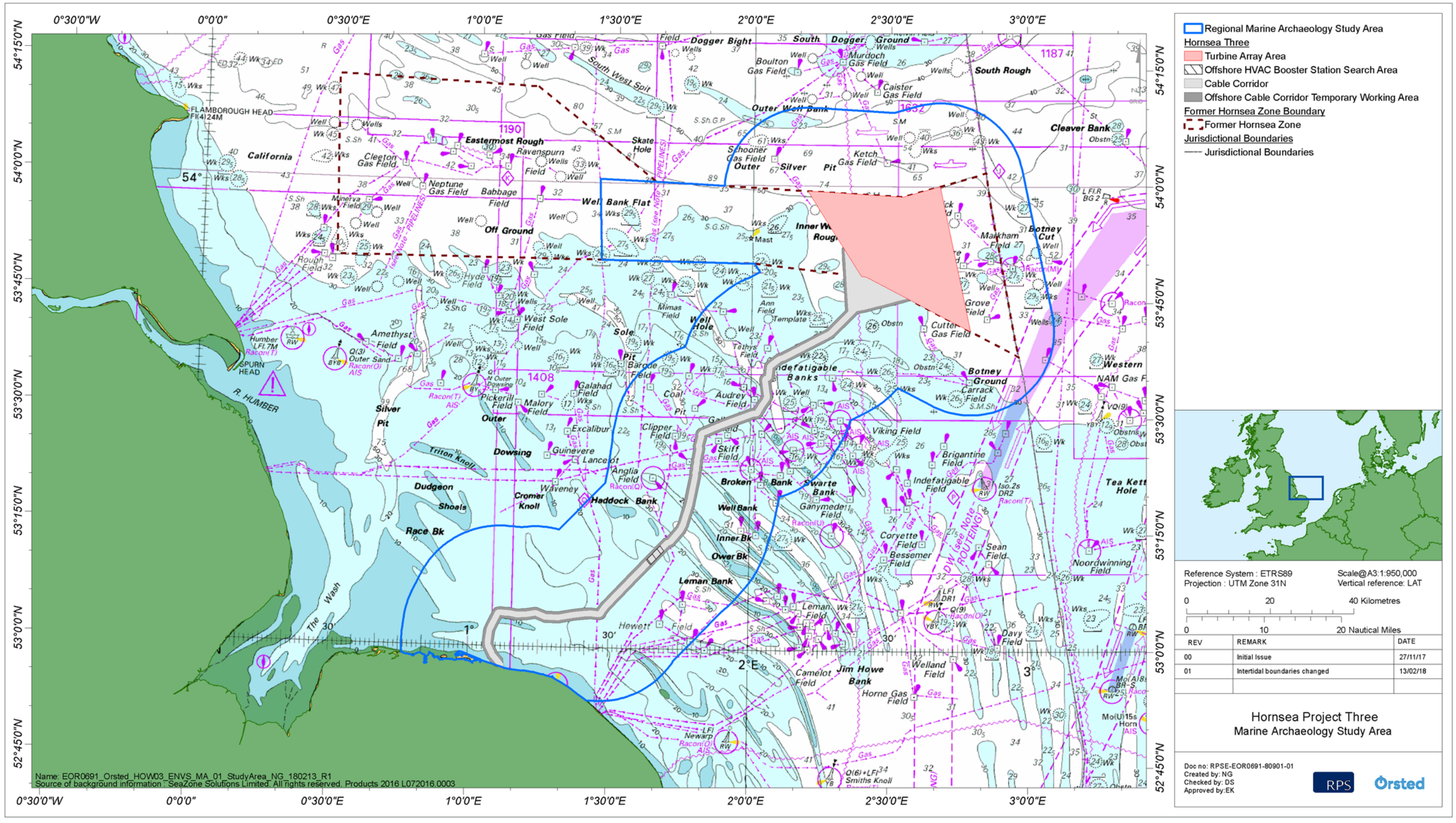

Figure 9.1: Location of Hornsea Three (the Hornsea Three marine archaeology study area), the former Hornsea Zone and the regional marine archaeology study area.

9.4 Planning policy context

9.4.1 National Policy Statements

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

9.4.1.2 NPS EN-3 includes guidance on what matters are to be considered in the assessment. These are summarised in Table 9.1 below. NPS EN-3 also highlights a number of factors relating to the determination of an application and in relation to mitigation. These are summarised in Table 9.2 below.

9.4.2 Other relevant policies

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

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

9.4.2.3 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*".

Table 9.1: Summary of NPS EN-3 provisions relevant to this chapter.

Summary of NPS EN-3 provision	How and where considered in the Environmental Statement
Consultation with all relevant statutory consultees is to be carried out at an early stage (paragraph 2.6.140 of NPS EN-3).	Consultation with relevant statutory and non-statutory stakeholders has been carried out from the early stages of Hornsea Three. See section 9.5 for further details.
Assessments should include a desk-based assessment that should take into account any geotechnical or geophysical surveys that have been undertaken to inform the wind farm design (paragraph 2.6.141 of NPS EN-3).	An archaeological desk-based assessment and technical report has been produced which informs the archaeological assessment (see volume 5, annex 9.2: Marine Archaeology Technical Report). The archaeological review of geophysical and geotechnical data is included in section 9.6 below and in volume 5, annex 9.1: Marine Archaeology Technical Report.
Assessment should include any beneficial effects on the historic environment, for example through improved access or new knowledge (paragraph 2.6.142 of NPS EN-3).	The EIA has considered the potential adverse and beneficial impacts on the historic environment during each phase of the proposed development (see section 9.9.3). The work carried out to support this EIA, the measures adopted as part of Hornsea Three and any future geophysical and geotechnical surveys undertaken for Hornsea Three will produce significant and extensive new data and understandings of the historic marine environment of the area. This increased understanding will offset any temporary reduced access to palaeolandscapes for future research that may occur. This consideration is taken into account in the assessment presented in section 9.9.3 below.
Where elements of the proposed project interact with the historical/archaeological significance of a historic maritime feature that is located onshore this should be assessed. This potentially applies both to visual impacts and to impacts on heritage assets in the intertidal zone. The policy refers to the need, in assessing such impacts, to apply the guidance set out in section 5.8 of NPS EN-1 which calls for a description of the significance of the heritage assets affected by the proposed project and, if relevant, the contribution of their setting to that significance. Level of detail should be proportionate to the importance of the heritage assets (paragraph 2.6.143 of NPS EN-3).	There are no coastal or terrestrial designated assets which will be affected significantly by the offshore and intertidal export cable-laying process. The effect, if any, of Hornsea Three on the settings of onshore heritage assets is assessed in volume 3, chapter 5: Historic Environment. Further details regarding the offshore visual impacts of Hornsea Three are provided in chapter 10: Seascape and Visual Resources.

Table 9.2: Summary of NPS EN-3 policy on decision making relevant to this chapter.

Summary of NPS EN-3 policy on decision making (and mitigation)	How and where considered in the Environmental Statement
Decision-making is based on being satisfied that the development has been designed sensitively, taking into account known heritage assets and their status. Any negative effects will be weighed against the public interests of the proposed development (paragraph 2.6.144 of NPS EN-3).	Known heritage assets and their status have been identified (see section 9.6), and adverse effects on such assets have been assessed (see section 9.9.3). A thorough search has been carried out of all available sources of information relating to archaeological remains and deposits that might be affected by Hornsea Three.
The most effective form of protection for important heritage assets can be achieved through implementing exclusion zones around the heritage assets which stop development activities within their area (paragraph 2.6.145 of NPS EN-3).	Hornsea Three will incorporate AEZs, where appropriate, as stated in the measures adopted as part of Hornsea Three (see paragraphs 9.9.2.1 to 9.9.2.4).

9.5 Consultation

9.5.1.1 A summary of the key issues raised during consultation specific to marine archaeology is outlined below, together with how these issues have been considered in the production of this Environmental Statement chapter.

9.5.2 Hornsea Project One and Hornsea Project Two consultation

9.5.2.1 Hornsea Three has similarities, both in terms of the nature of the development and its location, to Hornsea Project One and Hornsea Project Two. The matters relevant to Hornsea Three, which were raised by consultees during the pre-application and examination phases of Hornsea Project One and Hornsea Project Two on marine archaeology matters, are set out in volume 4, annex 1.1: Hornsea Project One and Hornsea Project Two Consultation of Relevance to Hornsea Three.

9.5.3 Hornsea Three consultation

9.5.3.1 Table 9.3 below summarises the issues raised relevant to marine archaeology, which have been identified during consultation activities undertaken to date. Table 9.3 also indicates either how these issues have been addressed within this Environmental Statement chapter or how Hornsea Three has had regard to them. Further information on the consultation activities undertaken for Hornsea Three can be found in the Consultation Report (document reference number A5.1) that accompanies the application for Development Consent.

Table 9.3: Summary of key consultation issues raised during consultation activities undertaken for Hornsea Three relevant to marine archaeology.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
July 2016	Historic England - meeting	Consideration should be given to the potential for important offshore Palaeolithic deposits.	The potential for important offshore palaeolithic deposits within Hornsea Three are considered in section 9.6 and the potential impact on these deposits from Hornsea Three is considered in section 9.9.3.
July 2016	Historic England - meeting	Consideration should be given to the North Sea War Channels.	The North Sea War channels are considered in section 9.6, in particular at paragraph 9.6.4.18, and the potential impact on these channels from Hornsea Three is considered in section 9.9.3.
December 2016	PINS – Scoping Response	It is noted that the baseline data for the Environmental Statement will be based on a combination of data gained through desk study and additional geophysical survey. It is not clear whether the survey work has already been undertaken or not. The Applicant is strongly advised to agree survey protocols with Historic England if possible.	The following offshore survey protocols have been agreed with Historic England and completed to inform the marine archaeology chapter of the Environmental Statement: • Geophysical survey of the Hornsea Three array area; • Geophysical survey of the Hornsea Three offshore cable corridor; • Geotechnical sample in the Hornsea Three array area; and • Geotechnical survey of the Hornsea Three intertidal area. In addition, a walkover survey was completed of the Hornsea Three intertidal area. Further information on the surveys that have been undertaken are presented in volume 5, annex 9.1: Marine Archaeology Technical Report and a summary is presented in 9.5.5 below.
December 2016	PINS – Scoping Response	Any mitigation required should be fully explained within the Environmental Statement and appropriately secured.	An Outline WSI has been included as an annex to this marine archaeology Environmental Statement chapter (volume 5, annex 9.2). The Protocol for Archaeological Discoveries has been taken into account in the drafting of the Outline WSI (see paragraph 9.9.3).
November 2016	Historic England – Scoping Response	We reserve judgment on this matter until a decision to implement an Evidence Plan Process (EPP), as a means to structure technical stakeholder consultation during preparation of the Environmental Statement, is explained to us. However, we do acknowledge that we were supplied with a draft Hornsea Project Three Offshore Wind Farm Marine Archaeology Road Map and that an associated meeting was held on 20 July 2016. We recommend that in consideration of the potential risk to the historic environment, both known and unknown, that Historic England is officially invited by the Applicant to participate in any Evidence Plan Process as a priority action.	An Evidence Plan is a formal process for agreeing the information to be included in a Report to Inform Appropriate Assessment . The Evidence Plan is therefore not appropriate for the marine archaeology EIA. However Hornsea Three has utilised a similar consultation process for other EIA topics were appropriate. As such a Marine Archaeology Road Map has been developed and sent to Historic England which outlines the programme and approach to the EIA, a suggested programme for pre-application consultation meetings and any areas of agreement and disagreement identified during these meetings. The approach to consulting on marine archaeology matters was discussed with Historic England at a meeting on the 9 February 2017 and the road map approach was accepted.
November 2016	Historic England – Scoping Response	The impacts from Hornsea Three are likely to be both direct (permanent physical changes to the historic environment) and indirect (changes to the setting of heritage assets). Impacts would vary throughout the life of Hornsea Three. Some of the impact during the construction phase will be temporary, but elements of Hornsea Three would bring permanent changes. Impacts are not confined to the footprints of the wind farm, cable route and offshore HVAC booster station - there is a potential impact from all elements of Hornsea Three to impact upon the setting of heritage assets. Hornsea Three will also include additional areas of impact associated with the construction and decommissioning phases of the project - such as the dockside facilities and construction compounds.	The EIA has considered both the direct and indirect impacts from Hornsea Three, both on the physical environment and on the setting of heritage assets (see section 9.9.3). Specifically in relation to the construction, operation and maintenance, and decommissioning port/facility - the location is currently unknown and will not be considered as part of the EIA for Hornsea Three.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
November 2016	Historic England – Scoping Response	The provision of archaeological advice will be crucial given the statement (Scoping Report, paragraph 7.1.36) that the electricity export cable intertidal location is identified between Weybourne and Salthouse (Norfolk) and that crossing the Hornsea Three intertidal area could employ Horizontal Directional Drilling (HDD), trenching, dredging, jetting, ploughing, rock cutting or vertical injection. Similarly, advice will be highly relevant to inform any offshore cable installation programme that requires trenching to between 1-3 m below seabed, particularly given the proposed route across marine sand banks inclusive of Indefatigable Banks and Sheringham Shoal and Happisburgh Sand bank system off Norfolk.	The EIA has considered the direct physical changes to the historic environment in the Hornsea Three intertidal area and along the Hornsea Three offshore cable corridor (see section 9.9.3).
February 2017	Historic England – meeting	Historic England noted that cumulative effects would be a key area of assessment within the EIA	Cumulative effects are described and assessed in section 9.12 below.
February 2017	Historic England - meeting	Historic England noted that transboundary issues should be considered as both beneficial and adverse potential impacts are possible.	Transboundary effects are considered in section 9.13 below.
September 2017	Historic England – Section 42 Response	Geophysical surveys have taken place, although the line spacing used is generally much larger than is recommended in the Historic England Marine Geophysics guidance (2013), which considers a spacing of between 500 m to 1,000 m being used in the Hornsea Three array area, and 55 m to 67 m in the Hornsea Three offshore cable corridor. We are concerned that the resolution of the resulting surveys would not be able to identify feature/deposits of archaeological interest.	It is noted that Historic England has received and approved a WSI for the interpretation of the geophysical surveys undertaken to date. The WSI allows for archaeological input into the design of future surveys. Further discussion on survey methodology has taken place with Historic England's technical advisors, including during a conference call of 16 November 2017. These have indicated that Historic England accept the surveys to date and will be consulted on future scopes of work for Hornsea Three.
September 2017	Historic England – Section 42 Response	The Preliminary Environmental Information Report (PEIR) summarised a number of topographic features of archaeological interest, including Markhams Hole and the area in the northern part of the Hornsea Three array. Significant deposits may be present in these areas that preserve information on past activities, landscape and environmental change over time and we agree with the PIER report that that these areas have high archaeological potential and value. The impact of the proposal would have the potential to be significant in EIA terms.	Comment noted regarding the sensitivity of the receptor. However, given the widespread extent and depth of the palaeochannels and the relatively limited nature of the impacts by comparison, they are predicted to be local in spatial extent. On this basis, the magnitude of impact is considered to be negligible. The overall impact was therefore deemed to be not significant in EIA terms (see paragraph 9.10.1.15)..
September 2017	Historic England – Section 42 Response	The PEIR summarised the potential for prehistoric archaeology, including the importance of the evidence preserved within palaeochannels. Historic England agree with the statements included in this section, and the conclusion that there is strong potential for the survival of sites and material from the post-Devensian and Holocene periods. The strategy for mitigating this impact would need to be subject to further discussion.	The comment is noted and the measures adopted as part of Hornsea Three (section 9.9) and the Outline WSI (volume 5, annex 9.2) include the provision of archaeological input to future geotechnical surveys where deposits of known archaeological potential are likely to be affected.
September 2017	Historic England – Section 42 Response	The PEIR stated that no peat or organic deposits have so far been identified in any of the boreholes assessed to date, but that such deposits are known to exist in the wider area. Historic England note that there is potential that organic-rich deposits may be recovered within the proposed development area. The strategy for mitigating this impact would need to subject to further discussion.	The comment is noted and the measures adopted as part as Hornsea Three (section 9.9) and the Outline WSI (volume 5, annex 9.2) include the provision of archaeological input to future geotechnical surveys where deposits of known archaeological potential are likely to be affected.
September 2017	Historic England – Section 42 Response	Historic England agree that the measures adopted as part of Hornsea Three are sensible and appropriate, and demonstrate an integrated approach to investigate the archaeological potential alongside non-archaeological works that may impact on buried remains/deposits.	Noted.
September 2017	Historic England – Section 42 Response	The geophysical survey has identified a number of anomalies of interest, ranging from a possible collapsed wreck (Section 3.6.2.4) to anomalies of potential archaeological interest (Section 3.6.2.8). It would be necessary for future documents to present a strategy of how the medium and low potential anomalies would be handled in terms of their mitigation. Additional studies may need to be carried out (e.g. diver surveys) to investigate them further so that the exclusions zones can be defined in full. This would need to be considered in the WSI along with any proposal that would seek to sample any of the anomalies.	Noted – volume 5, annex 9.2: Outline Written Scheme of Investigation has been updated to ensure it fully captures this point.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
September 2017	Historic England – Section 42 Response	The PEIR stated that AEZs would be considered for all 239 low potential anomalies that were identified following the geophysical survey, in order to ensure their preservation in situ. If it is decided that AEZs are not appropriate for all of the anomalies, additional strategies would need to be developed and approved with Historic England to ensure that the anomalies can be, and are appropriate to be preserved by record. However, it is stated in Table 5.1 that an 'operational awareness' would be maintained for the areas of low archaeological potential, reporting through an agreed protocol should material of potential archaeological interest be encountered. This seems to contradict the statement in Section 3.3.1.3 and therefore needs to be clarified.	No AEZs are proposed at this stage around low potential anomalies. Should detailed design indicate potential disturbance of these low archaeological potential anomalies that cannot be avoided, then provision of AEZs around them will be considered prior to construction to ensure their preservation in situ.
September 2017	Historic England – Section 42 Response	The Draft WSI included in the PEIR summarised the proposed pre-application and pre-development offshore geophysical survey. Additional information is needed for aspects of this work, such as the line spacing, percentage coverage and expected resolution of the geophysical surveys.	Volume 5, annex 9.2: Outline Written Scheme of Investigation has been amended to reflect comment and provide additional information as requested.
September 2017	Historic England – Section 42 Response	The Outline WSI should reference the Historic England Marine Geophysics (2013) guidance document. Full coverage or greater should be achieved for side scan and multibeam surveys, and all data should be supplied to the retained archaeologist in raw format for interpretation and analysis.	Volume 5, annex 9.2: Outline Written Scheme of Investigation references the Historic England Marine Geophysics (2013) guidance document.
September 2017	Historic England – Section 42 Response	The Draft WSI included in the PEIR states that the material from future geotechnical samples would be selected for radiocarbon dating during Stage 3 of the phase's assessment. It is important to note that radiocarbon dating is effective only to approximately 60,000 BP and that alternative dating techniques would need to be applied to deposits expected to be older, such as those associated with Pleistocene and for parts of the Lower Palaeolithic periods. A number of the techniques that can be applied during these periods require a sampling strategy to be developed prior to the cores being collected, such as Optically Stimulated Luminescence (OSL) dating. Specialist involvement is also recommended as early as possible (before the samples are collected) to ensure that all of the necessary samples are collected (sediment samples within the cores, background radiation assessments etc.) and stored in appropriate ways to protect the luminescence signal preserved within the sediments. Furthermore, consideration needs to be given to the retention and appropriate storage of cores to allow for ongoing analysis via the staged approach.	Volume 5, annex 9.2: Outline Written Scheme of Investigation has been amended to reflect comment on OSL dating.
September 2017	Historic England – Section 42 Response	The Draft WSI included in the PEIR describes the use of future diver and ROV surveys to further investigate AEZ sites that would be directly impacted by the development. Consideration should also be given to the use of these surveys to examine sample features of medium or low archaeological potential not assigned AEZs in order to 'ground-truth' their archaeological significance.	Volume 5, annex 9.2: Outline Written Scheme of Investigation has been amended to reflect comment. It is not intended to carry out additional surveys purely for archaeological purposes, however it is noted that further geophysical surveys will allow more detailed examination of objects on the seabed.
September 2017	Historic England – Section 42 Response	We agree with the approaches set out in the Draft WSI included in the PEIR, whereby the performance of the WSI would be monitored, allowing for procedures to be reviewed and optimised during the life of Hornsea Three. We would recommend however that the WSI is fully agreed before any pre-commencement works take place in order to capture any impact arising from those works.	Comment noted.
September 2017	Historic England – Section 42 Response	All archaeological reports (inclusive of geophysical and geotechnical investigations) produced during the course of the development and construction process should be submitted to OASIS.	Noted – volume 5, annex 9.2: Outline Written Scheme of Investigation has been amended to reflect this comment.
November 2017	Historic England	A meeting was held with Historic England on the 3 November 2017 to discuss the Section 42 response from Historic England.	The discussions during this meeting have been incorporated into the responses above.
November 2017	Historic England	A telephone conference was held with Historic England on the 16 November 2017 to discuss offshore surveys undertaken to date and future Hornsea Three surveys.	This discussion concluded that Historic England accept that they have been consulted on the scopes of the surveys undertaken to date, that the scope is adequate and that they will be consulted on the scope of future surveys as outlined in volume 5, annex 9.2: Outline Written Scheme of Investigation.

9.6 Methodology to inform the baseline

9.6.1 Desktop review

9.6.1.1 A detailed literature search was carried out to establish the baseline of information available in the regional marine archaeology study area. The key data sources are summarised in Table 9.4, although this should not be considered an exhaustive list of references. Further detail is presented within volume 5, annex 9.1: Marine Archaeology Technical Report.

Table 9.4: Summary of key desktop reports.

Title	Source	Year	Author
Primary sources			
Records of United Kingdom Hydrographic Office (UKHO) wrecks and obstructions	SeaZone	2017	UKHO
Records held by the National Record of the Historic Environment	Includes reports of finds recovered as a result of aggregate extraction and reported under the British Marine Aggregates Producers Association's (BMAPA) Protocol for Reporting Finds of Archaeological Interest. This dataset also includes information on wrecks, obstructions and known losses/ casualties	2003; 2005	BMAPA and English Heritage
Admiralty charts	Admiralty Charts 1187 (Outer Silver Pit) and 1503 (Outer Dowsing to Smiths Knoll including Indefatigable Banks)	2014 and 2016 respectively	UKHO
Secondary sources			
Humber Regional Environmental Characterisation (REC)	Marine Aggregate Levy Sustainability Fund (MALSF)	2011	Tappin *et al.*
The North Sea Palaeolandscapes Project (NSPP)	NSPP	2007	Gaffney *et al.*
The Norfolk Rapid Coastal Zone Assessment	Norfolk Archaeological Unit	2005	Robertson *et al.*
Records of Second World War Air/Sea Rescue Operations	Aircraft Crash Sites at Sea	2008	Wessex Archaeology

9.6.2 Field surveys

Overview

9.6.2.1 Recent survey data collected from the Hornsea Three array area, offshore cable corridor and intertidal area in 2016 and 2017 have been used to inform the baseline characterisation. A summary of the surveys completed to date is outlined in Table 9.5 below and further information is provided in volume 5, annex 9.1: Marine Archaeology Technical Report.

9.6.2.2 Data was collected for the entire Hornsea Three offshore cable corridor; excluding those areas where the proposed route has been altered between the PEIR and the Environmental Statement and the Hornsea Three temporary working area (see section 9.6.10 below for a discussion on the data limitations).

Archaeological review of geophysical data

9.6.2.3 The archaeological potential was assigned to each contact identified during the geophysical surveys based on the criteria outlined in Table 9.6 below. In addition, magnetic anomalies of greater than 500 nT have been provisionally identified as areas of archaeological potential. Contacts assessed as having archaeological potential were then compiled into a gazetteer and a shapefile created for further assessment alongside known features such as wrecks, mooring buoys, third party assets such as cables and pipelines and other seabed structures. The data was subsequently assessed to ensure no unnecessary identification of archaeological potential when a non-archaeological origin can be identified.

9.6.2.4 It is important to note that the wrecks of high archaeological potential may not correlate to the most important wrecks on the seabed. They may represent the most clearly identifiable and best-preserved wrecks, generally dating to the past two centuries, the age of steel-hulled shipping. It is likely that archaeologically the most significant, and older wrecks are to be found within the group of medium archaeological potential. Low potential contacts have been assessed as being unlikely to be of archaeological significance and, other than those measures outlined in Table 9.12, are not discussed further within the Environmental Statement.

Ground model

9.6.2.5 In addition to the identification of anthropogenic contacts on the seabed, detailed analysis of geophysical survey data has been undertaken by Hornsea Three in order to formulate a multi-purpose ground model to inform the Environmental Statement. A brief initial review of the geotechnical samples collected for Hornsea Three was also undertaken to inform the ground model. The ground model has involved identifying those units overlying bedrock and determining their approximate depths and extents within the geophysical survey areas. In addition, a brief initial review of the geotechnical samples collected for Hornsea Three has been undertaken to inform the ground model.

Table 9.5: Summary of site-specific survey data.

Title	Extent of survey	Overview of survey	Survey contractor	Year	Reference to further information
Hornsea Three array area geophysical survey	Hornsea Three array area, including a 500 m buffer.	• Multibeam bathymetry: Multibeam echo sounder (MBES) with line spacing in the north-west of 500 by 1,000 m and in the south-east of 1,000 by 1,000 m; • Sidescan sonar: Line spacing in the north-west of 500 by 1,000 m and the south-east of 1,000 by 1,000 m; • Magnetometer: Line spacing in the north-west of 500 by 1,000 m and in the south-east of 1,000 by 1,000 m; and • Sub bottom profiler: Line spacing in the north-west of 500 by 1,000 m and in the south-east of 1,000 by 1,000 m.	EGS	2016	Volume 5, annex 9.1 Marine Archaeology Technical Report
Hornsea Three offshore cable corridor geophysical survey	Hornsea Three offshore cable corridor north eastern 'funnel' area.	• Multibeam bathymetry: MBES at 100% coverage; • Sidescan sonar: 100% coverage; and • Sub bottom profiler: 100 m line spacing.	Clinton Marine Survey	2016	Volume 5, annex 9.1 Marine Archaeology Technical Report
Hornsea Three offshore cable corridor geophysical survey	Hornsea Three offshore cable corridor (excludes temporary working areas).	• Multibeam bathymetry: MBES with line spacing of 55 by 67 m; • Sidescan sonar: Line spacing of 55 by 67 m; • Magnetometer: Line spacing of 55 by 67 m; and • Sub bottom profiler: Line spacing of 55 by 67 m.	Bibby Hydromap	2016	Volume 5, annex 9.1 Marine Archaeology Technical Report
Hornsea Three intertidal area geotechnical and geophysical survey	Intertidal area both above and below MHWS.	• Three boreholes in the Hornsea Three intertidal area; and • Five boreholes landward of MHWS in the Hornsea Three onshore cable corridor search area, see volume 3, chapter 5: Historic Environment for further information on these.	Oxford Archaeology	2017	Volume 5, annex 9.1 Marine Archaeology Technical Report

Hornsea Three intertidal area walkover	Intertidal area walkover survey between MHWS and MLWS.	• Field visit and walkover survey undertaken to:
		  • Establish the presence of previously unrecorded heritage assets;
		  • To further to assess the potential of recorded heritage assets; and
		  • To assess the suitability of any further survey techniques.
			RPS	2017	Volume 5, annex 9.1 Marine Archaeology Technical Report

Hornsea Three offshore cable corridor infill geophysical survey	Hornsea Three offshore cable corridor landward of 10 m contour.	• Multibeam bathymetry: MBES100% coverage;; • Sidescan sonar:100% coverage; • Magnetometer: Line spacing of 40 to 50 m; and • Sub bottom profiler: Line spacing of 40 to 50 m.	Fugro	2017	Volume 5, annex 9.1 Marine Archaeology Technical Report
Hornsea Three array area geotechnical survey of the Hornsea Three array area and offshore cable corridor	Hornsea Three array area and offshore cable corridor	• 141 geotechnical samples were collected in the Hornsea Three array area (consisting of 114 CPT, 12 borehole, five CPT/borehole and ten vibrocore locations); • 41 geotechnical samples (consisting of 20 CPT and five vibrocore locations) were collected in the Hornsea Three offshore cable corridor; and • Ten geotechnical samples (consisting of five CPT and five vibrocore locations) were collected in close proximity to the Hornsea Three offshore cable corridor.	Fugro	2017	Volume 5, annex 9.1 Marine Archaeology Technical Report

Table 9.6: Criteria for archaeological potential.

Archaeological Potential	Criteria
Low	A contact potentially of anthropogenic origin but that is unlikely to be of archaeological interest
Medium	A contact believed to be of anthropogenic origin but that would require further investigation to establish its archaeological potential
High	A contact almost certainly of anthropogenic origin and with a high potential of being of archaeological significance

9.7 Baseline environment

9.7.1 Designated sites

9.7.1.1 Within the regional marine archaeology study area, the wreck of HMS Umpire, a British submarine sunk northwest of Cromer in 1941 is a designated vessel under the provisions of the Protection of Military Remains Act 1986. The wreck of HMS Umpire is located some 9.2 km from the Hornsea Three offshore cable corridor.

9.7.1.2 There are no designated assets (designated under the Protection of Wrecks Act 1973, Ancient Monuments and Archaeological Areas Act 1979 and Protection of Military Remains Act 1986) within the Hornsea Three marine archaeology study area.

9.7.2 Seafloor Topography

9.7.2.1 The depth of water and character of the regional marine archaeology study area varies considerably, from shallow intertidal and subtidal waters at the Norfolk coast, to the ocean 'deeps', such as the Outer Silver Pit (see Figure 9.1). The varying topography of the seafloor and its relationship with the adjacent coast has a direct relationship with nature, density and character of the archaeological remains found on and under it.

9.7.2.2 The seafloor topography of the Hornsea Three marine archaeology study area is summarised below and further information is presented in volume 5, annex 9.1: Marine Archaeology Technical Report.

Hornsea Three array area

9.7.2.3 Within the Hornsea Three array area, the water extends in depth from some -26 m to some -73 m relative to LAT in the northern most part of the Hornsea Three array area. The Hornsea Three array area is characterised by relatively shallow banks separated by two deeper channels and a consistently deeper area to the north, Outer Silver Pit.

9.7.2.4 Glacial till deposits of the Bolders Bank Formation are present on the majority of the Hornsea Three array area. The Bolders Bank Formation is also characterised by a number of Botney Cut Channels that have eroded through the unit in the array area and more widely.

9.7.2.5 Markhams Hole, located in the centre and east of the Hornsea Three array area, is a glacial tunnel valley, partly infilled perhaps containing significant archaeological deposits related to the Late Pleistocene Botney Cut formation and directly overlain by deposits of recent origin. The deepest interpreted horizon is the Yarmouth Roads Formation. On the southwest side of Markham's Hole, a subglacial tunnel valley of the Swarte Bank Formation is present. This feature and unit was penetrated by a recent geotechnical intervention carried out as part of Hornsea Three (CPT057). Above the Swarte Bank Formation, the Eem is present and is also represented in the CPT057 location.

9.7.2.6 A second distinct channel located to the north of Markham's Hole, in the northern half of the Hornsea Three array area, is narrower than Markham's Hole. The feature connects to Outer Silver Pit and is interpreted as being a marine inlet into the Outer Silver Pit.

9.7.2.7 The northern part of the Hornsea Three array area lies at the southern edge of the Outer Silver Pit. This feature was a lake during the Early Holocene and likely to have been very attractive to hunter gathers. Archaeological remains of the Mesolithic and perhaps Upper Palaeolithic periods are likely to survive.

Hornsea Three offshore cable corridor (including temporary working areas)

9.7.2.8 The water depth along the Hornsea Three offshore cable corridor broadly shallows from the offshore terminus to the intertidal area.

9.7.2.9 The sub bottom profiler data indicates that the geology of the Hornsea Three offshore cable corridor from the offshore terminus to the Hornsea Three intertidal area is comprised of the following (see Figure 9.2 for Kilometre Post (KP) locations):

- Holocene sediments overlying Bolders Bank Formation from the northeastern end of the Hornsea Three offshore cable corridor, with a short section of Holocene sediments overlying Botney Cut Formation to KP110, in areas which were surveyed (see paragraph 9.5.5.2);
- Holocene sediments overlying Bolders Bank Formation from KP110 to KP82.5;
- Holocene sediments overlying Swarte Bank Formation from KP 82.5 to KP61.75;
- Holocene sediments overlying Egmond Ground Formation from KP61.75 to KP57;
- Holocene sediments overlying Bolders Bank Formation from KP57 to KP45;
- Holocene sediments overlying Swarte Bank Formation from KP 45 to KP39; and
- Shallow Chalk with isolated patches of Quaternary Sediments from KP39 to the intertidal area, in areas which were surveyed (see paragraph 9.5.5.2).

Hornsea Three intertidal area

9.7.2.10 The general topography of the Hornsea Three intertidal area is low-lying cliffs to the east of Weybourne Gap, rising rapidly to some 30 m AOD, with lower lying ground to the west.

9.7.2.11 Weybourne Gap, located at the centre of the intertidal area comprises a shallow former river valley that meets the sea within the centre of the Hornsea Three intertidal area. At the mouth of the valley there is a small valley mire, located close to the car park. On the foreshore are periodically exposed outcrops of organic sands, peats and muds (Norfolk HER No. 6256). These deposits are associated with prehistoric worked and burnt flint, animal bone and wood. These deposits therefore can be related to relict deposits associated with the former river valley that passes through Weybourne Gap.

9.7.2.12 The geology at the Hornsea Three intertidal area comprises chalk overlain by marine sands and gravels (see paragraph 9.6.8.6 for further details). Weybourne gap marks a change in the solid geology of the area, with steep chalk cliffs, apparently harder in nature than that to the west, which are being actively eroded by the sea to the east.

9.7.2.13 The cliffs are an eroding glacial till comprising a basal chalk overlain by the Sherringham Cliffs Formation. The cliffs consist of the 'Bacton Green Till Member', formed as the ice sheet from the west deposited a sandy till, which is sometimes visible in the cliffs. The Bacton Green Till Member is overlain in places by the subglacial 'Weybourne Town Till' and outcrops of the ice-marginal fan complex Briton's Lane Formation, the 'Briton's Land Sand and Gravel Member' (Holt-Wilson, 2011).

9.7.3 Submerged prehistoric archaeology

9.7.3.1 The prehistoric archaeological record of the British Isles covers the period from the earliest hominin occupation more than 780,000 BP to the Roman invasion of Britain in 43 AD. During this long span of time, sea level fluctuations caused by major glaciations (including the Anglian, Wolstonian and the Devensian) have shaped the submerged prehistoric landscape within the regional marine archaeology study area. The changes in sea level have at times exposed the floor of the southern North Sea, including within the regional marine archaeology study area, creating an inhabitable environment suitable for hominin occupation and exploitation. The submerged prehistoric archaeology of the regional marine archaeology study area, which includes the Hornsea Three marine archaeology study area, is summarised below and further information is presented in volume 5, annex 9.1: Marine Archaeology Technical Report.

Pre-Devensian (>780,000 to approximately 73,000 BP)

9.7.3.2 The potential for finding in situ archaeological sites and material attributable to the pre-Devensian glaciation within the regional marine archaeology study area is likely to be limited to deposits that have not been disturbed by fluvial or marine action.

Devensian to Last Glacial Maximum (73,000 BP to 18,000 BP)

9.7.3.3 The Devensian glaciation was the last glacial stage to occur before the present Holocene climatic amelioration. A dearth of evidence in the archaeological record to the middle of the Devensian (approximately 40,000 BP) suggests that the UK was uninhabited by hominins for nearly 200,000 years, with low populations of Homo neanderthal reflected in the archaeological record from approximately 59,000 BP. It is likely that early Devensian archaeological material will have been heavily impacted by the glacial ice, and, if present, should generally (though not exclusively) be expected to be found in secondary context within the Devensian Bolders Bank glacial till.

Post-Last Glacial Maximum and Early Holocene (18,000 to 6,000 BP)

9.7.3.4 The regional marine archaeology study area is unlikely to have been free of glacial ice until approximately 16,000 BP and thus not likely to have been occupied by humans until at least this date. Early archaeological indications of a human presence in the UK during the Late-glacial have been found at Creswell Crags in Nottinghamshire, for example, dated to approximately 12,300 BP (Smith, 1992; Mithen, 2003).

9.7.3.5 At the start of the Holocene, sea level was approximately 65 m below its current stand across the southern North Sea and sea level curves generated by Shennan (2000; 2002) indicate that most of the regional marine archaeology study area was an emergent terrestrial landscape from the beginning of the glacial retreat at approximately 16,000 BP (during the Late Upper Palaeolithic). From its post-glacial geographical maximum the terrestrial extent of the regional marine archaeology study area would have begun to shrink due to rising sea level from around 8,000 BP, a process that continued until approximately 6,000 BP when the marine transgression of the North Sea basin was completed.

9.7.3.6 Between the post-Last Glacial Maximum and the middle of the Holocene it is likely that much of the regional marine archaeology study area was occupied by nomadic Late Upper Palaeolithic and then Mesolithic hunter-gatherers who exploited the wide range of environments the area offered, until, by approximately 6,000 BP, the regional marine archaeology study area was inundated by the sea for the last time.

9.7.3.7 Although much post-Devensian and Holocene archaeological material will have been reworked and lost during the last marine transgression of the North Sea, there is a strong potential for the survival of sites and material from this period in the palaeolandscape features of the regional marine archaeology study area. For example, a number of palaeochannels noted in the geophysical data from the Hornsea Three array area, with several further such features visible within the area traversed by the Hornsea Three offshore cable corridor (see Figure 9.2 which illustrates the palaeochannels identified in the NSPP data). These areas are likely to have been foci of human activity during this period. The incised nature of such features means that they may preferentially preserve archaeological material and palaeoenvironmental data. Geotechnical surveys undertaken within and in the vicinity of the Hornsea Three array area, the results of the Humber REC palaeoenvironmental programme (Tappin *et al.*, 2011) and the interpretation of geophysical survey results further demonstrate that palaeochannels from the southern North Sea can preserve highly valuable palaeoenvironmental deposits.

9.7.3.8 The Holocene landscape of the wider southern North Sea and of the regional marine archaeology study area can be characterised as a low-lying plain, underlain across much of the area by Bolders Bank till, and sloping gently upwards from the east to the modern coast of the UK. During the Late Upper Palaeolithic and Early Mesolithic most of the regional marine archaeology study area would have begun with an open steppe environment that became inhabited by boreal and then later temperate woodland species as the climate warmed into the Early Holocene. The area also contained wetlands associated with lakes and rivers, along with other small wetlands colonising natural features upon the previously glaciated surface (such as pingo's). Such features would have supported grazing animals and also have been attractive to humans.

9.7.4 Maritime archaeology

9.7.4.1 Within the regional marine archaeology study area there is the potential for the discovery of remains dating from the Mesolithic period onwards. The maritime archaeological potential of the east coast of England has recently been addressed at a regional level in the Humber REC (Tappin *et al.*, 2011) which was used to inform this chapter. Maritime archaeology of the regional marine archaeology study area, which includes the Hornsea Three marine archaeology study area, is summarised below and further information is presented in volume 5, annex 9.1: Marine Archaeology Technical Report.

Early Prehistoric (Palaeolithic to Mesolithic)

9.7.4.2 The potential for the survival of evidence of early prehistoric maritime activity in the UK is low and there is currently no known archaeological evidence of watercraft that pre-date the Mesolithic in Western Europe. However, the technology and expertise required to construct small craft, such as longboats, was certainly available by the Mesolithic and there is circumstantial evidence from the UK, Denmark and Germany for the existence of watercraft during the Mesolithic (Van de Noort, 2011). The relatively low population and the effects of repeated glaciations, marine transgressions and associated fluvial activity across much of the Palaeolithic mean that the potential for the survival of any archaeology associated with the maritime environment from this period is unlikely.

Neolithic and Bronze Age (approximately 4,000 to 700 BC)

9.7.4.3 Neolithic journeying onto the open sea is suggested by Ellmers (1996) at Neolithic sites containing bones of deep water fish. Indirect archaeological evidence also points to maritime trade during the Neolithic. However no archaeological evidence for sea transport craft has yet been found.

9.7.4.4 The east coast of England has produced some of the earliest examples of Bronze Age ships and shipping in northwest Europe. The proximity of the regional marine archaeology study area to possible shipping routes across the North Sea and up and down the east coast of England suggests that during the Bronze Age vessels were passing through the regional marine archaeology study area. There is thus the potential for remains of such vessels to be present in the regional marine archaeology study area.

Iron Age and Roman (700 BC to 500 AD)

9.7.4.5 In the vicinity of the regional marine archaeology study area, there is extensive evidence of trade across the southern North Sea during the Roman period. It is likely that many more vessels of this period were lost than the available archaeological evidence suggests, which increases the potential that remains from this period are present in the regional marine archaeology study area.

Medieval (500 to 1508 AD)

9.7.4.6 Maritime activity in the southern North Sea, including the regional marine archaeology study area increased during the early medieval period due, in part, to Saxon and Viking raiding, the intensification of regional trade, the migration that followed and the growth of a number of major ports on the east coast of the UK

9.7.4.7 The Norman conquest in 1066 established new international trade links, with trade continuing throughout the medieval period, with Hull, located on the north bank of the River Humber, some 170 km west of the Hornsea Three array area, becoming a major English Port.

9.7.4.8 The establishment of the Hanseatic League in Lubeck in 1169 resulted in increased commercial shipping activity and the development of ports across north-western Europe. The League represented some 84 cities, including ports on the eastern coast of England, such as Newcastle, Kingston-upon-Hull, King's Lynn, Norwich and Great Yarmouth (Hutchinson, 1997; Woodman, 1997).

9.7.4.9 There were a number of smaller ports located on the Norfolk Coast during the medieval period and later. These included Wells-next-the-Sea, Weybourne, Brancaster Staithe, Burnham Overy Staithe, Ringstead, Heacham, Eccles and Caister-on-Sea.

9.7.4.10 The level of medieval maritime activity along the east coast of England suggests that the potential presence of medieval period shipwrecks in the regional marine archaeology study area is high, particularly where anaerobic sediments which aid shipwreck preservation, characterise the seabed. It is noted that wooden shipwrecks if they are buried may not be as visible in the survey data as those made of metal and that this lack of visibility is a function of the available suite of remote sensing techniques.

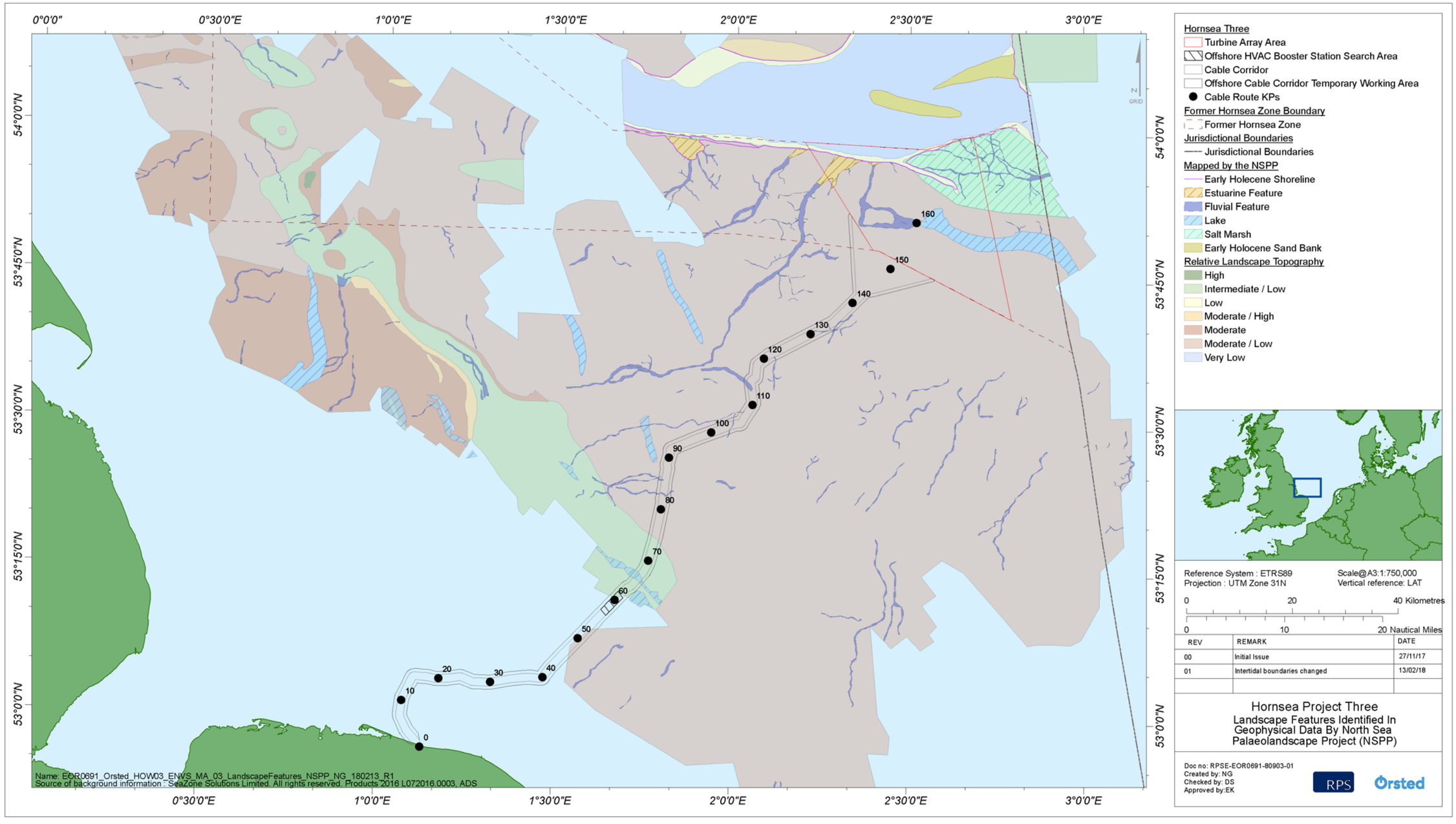

Figure 9.2: Landscape features identified in geophysical survey data from North Seas Palaeolandscapes Project (NSPP).

Post-medieval (1509 to 1815 AD)

9.7.4.11 The growth of commercial maritime trade, which began during the late medieval period, continued and expanded in the post-medieval period, with particularly strong links with the Netherlands and a strong trade in corn, fish and cloth. From an early date, coal was one of the most important cargoes to pass through the regional marine archaeology study area – mostly en route from Newcastle to London and the southeast. Alongside overseas ventures which were expanding rapidly, inland and local coasting trade continued to be important in the region in the post-medieval period.

9.7.4.12 Fishing was also an important component of post-medieval maritime activity in the regional marine archaeology study area. The discovery of fish stocks in the Great Silver Pit, in the northern extent of the regional marine archaeology study area (just north of the Hornsea Three array area), helped develop this local industry into one of national importance.

9.7.4.13 Concomitant with such an increase in shipping numbers is an increase in maritime casualties, and hence a greatly increased potential for post-medieval maritime archaeological sites and material in the regional marine archaeology study area. Material from the earlier Tudor and Stuart periods is however rare and discoveries of such sites are of potentially great significance.

Modern (post-1815)

9.7.4.14 Rapid industrialisation in the 18th and 19th centuries revolutionised shipbuilding, including the advent of the steam engine, the introduction of iron hulls and the development of the screw propeller. This resulted in major transformations on ships, encouraging the construction of larger self-propelled vessels (Lambert, 2001).

9.7.4.15 Shipping traffic across the North Sea increased exponentially during the modern period making the region one of the busiest shipping areas in the world (Parham, 2010). The increasing incorporation of metal structural elements into vessel designs during this period means that wrecks for the 19th and early 20th centuries are also often more visible on the seabed than their wooden predecessors. They are visible to bathymetric and geophysical survey and also generate strong magnetic anomalies, and this greater visibility is reflected in the increased number of known wrecks (i.e. those that have been located on the seabed) for the period under discussion, in contrast to the periods discussed previously.

9.7.4.16 Although steam and steel came to dominate shipping during the 19th century, there remained a strong local core of maritime activity around much of the coast of the UK which retained the more traditional, often wooden vessel types. The smaller local ports on the Norfolk coast were successful at different times, but all had declined by the early 20th century (Robertson *et al*., 2005).

9.7.4.17 A number of fishing vessel casualties listed in the SeaZone and National Record of the Historic Environment (NRHE) records (see section 9.6.5) highlight the importance of the regional marine archaeology study area as a fishing ground and are representative of the craft that fished the North Sea during the period from the late 19th century to the 1950s.

9.7.4.18 The two World Wars also left traces in the regional marine archaeology study area. The War Channels, specific routes along the East Coast which were swept of mines, were established as designated civilian shipping routes relatively early during the First World War and were again used from the start of the Second World War. The channels were marked with buoys and protected by defensive minefields. The concentration of shipping in the channels made them a target for enemy action (Firth, 2014).

9.7.5 Aviation archaeology

9.7.5.1 Thousands of military and civilian aircraft casualties have occurred in UK waters since the advent of powered flight in the early 20th Century. The bulk of these are casualties during the Second World War and most are concentrated off the south and southeast coasts of England. However, there is evidence for substantial numbers of aircraft casualties for most of the east coast of England (Wessex Archaeology, 2008). Whilst this aviation archaeology record is potentially very large, the ephemeral nature of aircraft wrecks ensures that many sites remain unknown and unrecorded. In addition, although records of aircraft losses at sea are extensive, they are seldom tied to an accurate position, which further complicates any assessment of the likely presence of aircraft wreckage on any particular area of the seabed. However a number of archaeological reports (Wessex Archaeology, 1997; 2003; 2006; 2008b) indicate that the identification of aircraft wrecks has become increasingly common in recent years, with a number of wrecks identified and located in the course of surveys in support of seabed development.

9.7.5.2 Aviation archaeology of the regional marine archaeology study area is summarised below and further information is presented in volume 5, annex 9.1: Marine Archaeology Technical Report.

First World War

9.7.5.3 By 1918 there were some 30 military airfields in Norfolk (http://www.heritage.norfolk.gov.uk/record-details?TNF405-Military-Airfields-in-Norfolk-(Article)) and some 37 military airfields in Lincolnshire (http://raf-lincolnshire.info/history.htm).

9.7.5.4 During the First World War only a small number of British and German aircraft and airships are recorded as having been lost around the UK during the First World War (Wessex Archaeology, 2008b) and although it is possible that some of these losses occurred at sea off the Lincolnshire and/or Norfolk coasts this study has found no evidence for First World War aircraft casualties in the regional marine archaeology study area. The lightweight construction of these early airframes (wood and cloth) also means they are unlikely to survive in the marine environment unless buried in seabed sediments.

Second World War

9.7.5.5 It is estimated that during the Second World War, an average of five aircraft were lost over the UK every day, many of these losses occurring over the sea (Bedoyere 2001). The geographical location of the regional marine archaeology study area and the known patterns of Second World War aircraft activity suggest that there were numerous aircraft losses in the area. The significant levels of aircraft traffic over the North Sea from 1940 onwards fall into two broad categories:

- Offensive German operations associated with bombing raids targeting Hull, the English Midlands and the north of England, and the associated, defensive British fighter response; and
- RAF, Allied and later American bombing operations against Germany from bases in the east of England which were routed over the North Sea to the Dutch coast where the topography meant that aircraft defences were less dense (Lyall, 1971).

9.7.5.6 Losses on both the Allied and Axis sides were the result of bombers damaged over England or the Continent crashing into the sea whilst returning to base, aircraft of both sides shot down in aerial combat, and accidents. Many of these losses would have occurred well offshore, and may represent aircraft listed as 'missing' in the records. The location of Hornsea Three suggests the potential for remains of some of these aircraft to survive within the regional marine archaeology study area.

Post 1945

9.7.5.7 Since the end of the Second World War, despite the volume of both military and civilian air traffic, there have been few aviation losses off the east coast of England and in the vicinity of the regional marine archaeology study area. Post-war aircraft remains are, therefore, unlikely to be discovered within Hornsea Three.

9.7.6 Known and Recorded Wrecks

9.7.6.1 Data for known shipwrecks and recorded shipping losses within the regional marine archaeology study area, including the Hornsea Three marine archaeology study area, were obtained from SeaZone and the NRHE (see Figure 9.3). The SeaZone and NRHE datasets provide a general picture of maritime casualties in the regional marine archaeology study area in the last 150 to 200 years, but provide no indication of the survival of any of the potential unrecorded or uncharted wrecks referred to above and should also not be viewed as representing the totality of even the more recent potential maritime archaeological remains in the area. On this basis, a geophysical survey of the Hornsea Three array area and offshore cable corridor has been undertaken to further understand the nature and extent of any such remains within the Hornsea Three marine archaeology study area.

9.7.6.2 Known and recorded wrecks within the regional marine archaeology study area is summarised below and further information is presented in volume 5, annex 9.1: Marine Archaeology Technical Report.

SeaZone

9.7.6.3 SeaZone data indicates that the UKHO holds data for a total of 169 live wrecks and 79 dead wrecks within the regional marine archaeology study area. Of these, a total of 26 lie within the Hornsea Three marine archaeology study area:

- Hornsea Three array area: 12 in total (two live and two dead wrecks, and one live and seven dead obstructions)
- Hornsea Three offshore cable corridor (including temporary working area): 14 in total (eight live and four dead wrecks, and one live and one dead obstructions);

9.7.6.4 The SeaZone records contain no references to aircraft crash sites within Hornsea Three.

National Record of the Historic Environment

9.7.6.5 The NRHE lists 126 recorded positions in the regional marine archaeology study area. All recorded positions lie within 45 km from the shoreline. Of the recorded positions in the regional marine archaeology study area, 100 are or may be wrecks, 71 of which are named vessels. There are two records of aircraft remains. Of the 118 recorded positions in the regional marine archaeology study area, 19 are located in the Hornsea Three offshore cable corridor (including temporary working areas).

9.7.6.6 The centre points of 24 NRHE Named Location polygons fall within the regional marine archaeology study area, of which three are located in the Hornsea Three offshore cable corridor (including temporary working areas). Together these Named Locations in the regional marine archaeology study area, contain records of 449 maritime casualties. The bulk of these Named Locations are of 19th and 20th century date. There are a number of aircraft losses recorded, including a total of nine records of Queen Bees within the regional marine archaeology study area, a low-cost radio-controlled target aircraft used for realistic anti-aircraft gunnery training during and after the Second World War. A further loss of a Tiger Moth aircraft is also recorded in the regional marine archaeology study area.

9.7.7 Hornsea Three geophysical survey

9.7.7.1 A series of marine geophysical surveys were undertaken within the Hornsea Three array area and offshore cable corridor. The surveys were undertaken from ships using a combination of built in and towed sensors which detect anomalies or contacts in or on the sea floor. A total of 254 contacts of archaeological potential have been recognised within or immediately adjacent to the Hornsea Three array area and offshore cable corridor (not including the temporary working areas). Of these 123 were identified within the Hornsea Three array area and a further 131 contacts were identified within the Hornsea Three offshore cable corridor. The positions of these archaeological contacts are shown in Figure 9.4 below and listed in volume 5, annex 9.1: Marine Archaeology Technical Report (see appendices B, C and D). These contacts are summarised in Table 9.7 below.

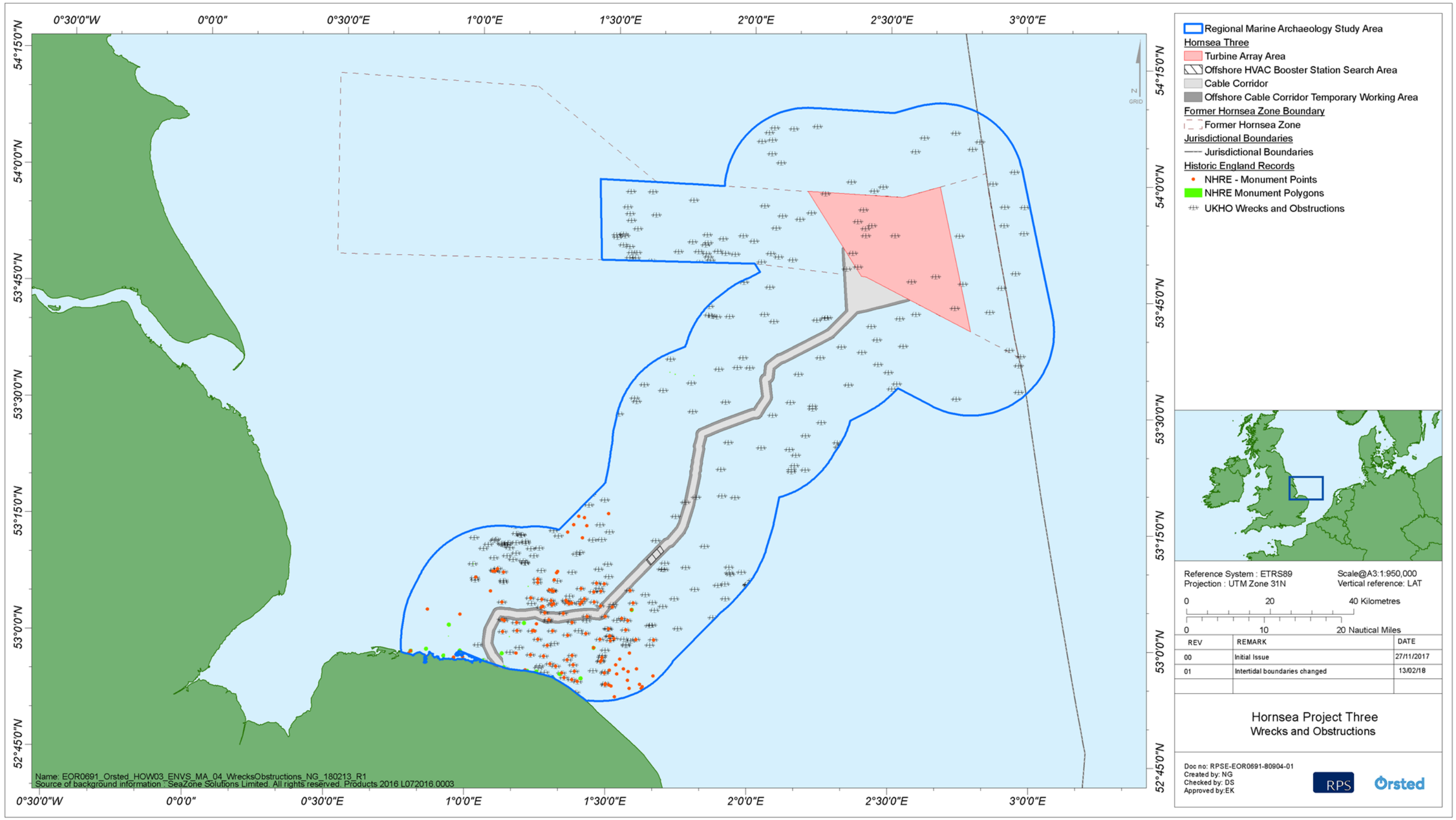

Figure 9.3: The positions of SeaZone and NRHE records within Hornsea Three.

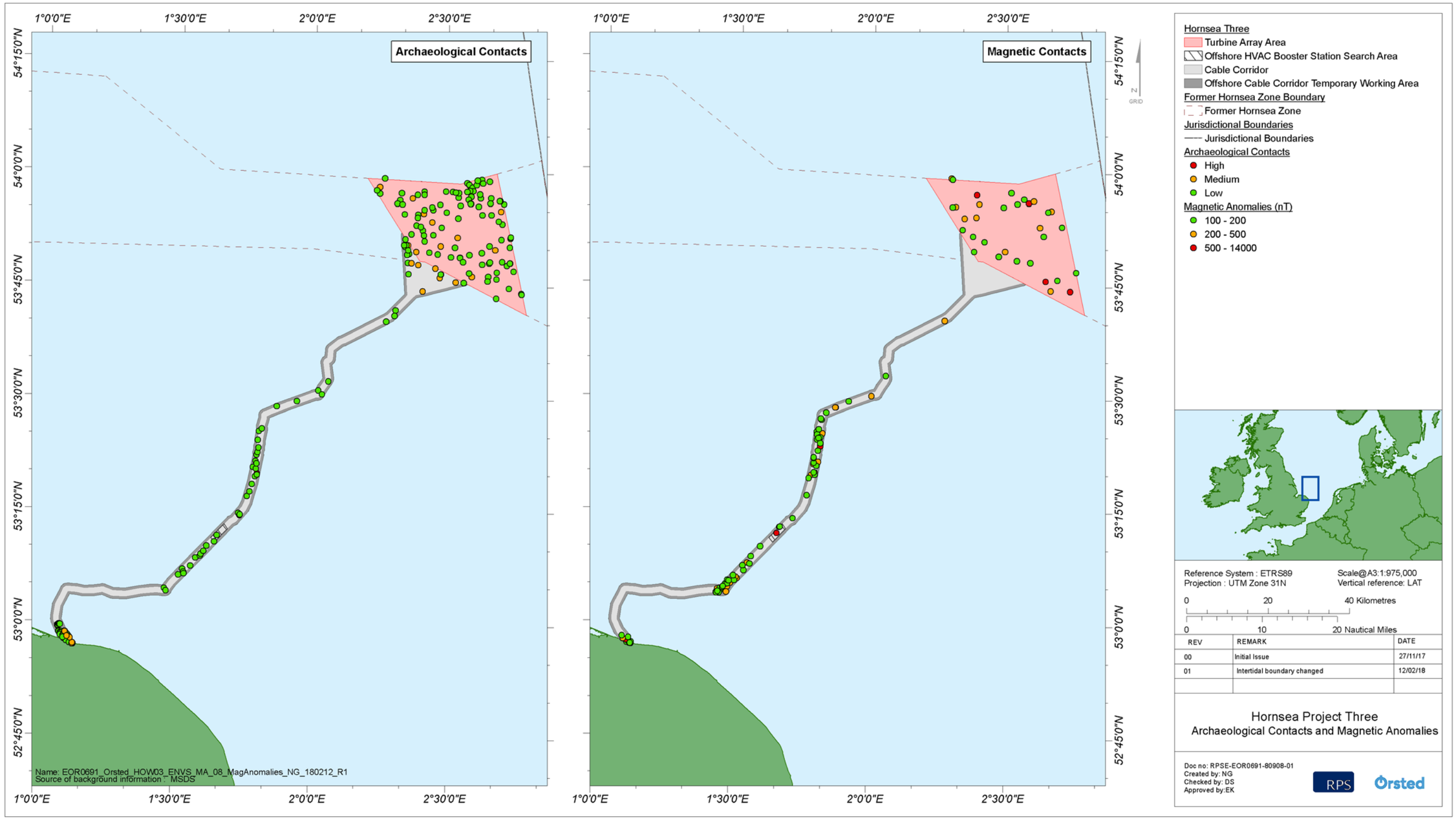

Figure 9.4: The positions of archaeological contacts and magnetic anomalies within Hornsea Three.

9.7.7.2 In addition, a total of 123 magnetic anomalies with an intensity >100 nT with no strong correlating seabed contact were identified across the Hornsea Three array area and offshore cable corridor (not including the temporary working areas). Of these, 31 lie within or immediately adjacent to the Hornsea Three array area and 92 lie within the Hornsea Three offshore cable corridor. There are 12 magnetic anomalies of greater than 500 nT which have been provisionally identified as areas of archaeological potential. Of these four are located within the Hornsea Three array area and eight within the Hornsea Three offshore cable corridor. The positions of these magnetic anomalies are shown in Figure 9.4 and listed in appendix E of volume 5: annex 9.1: Marine Archaeology Technical Report.

Table 9.7: Distribution of geophysical anomalies by archaeological potential.

Archaeological potential	Survey area	Number of contacts	Anomalies per potential rating
High	Hornsea Three array area	1	3
	Hornsea Three offshore cable corridor	2	
Medium	Hornsea Three array area	10	27
	Hornsea Three offshore cable corridor	17	
Low	Hornsea Three array area	112	224
	Hornsea Three offshore cable corridor	112	
Total			254

9.7.8 Hornsea Three intertidal area

9.7.8.1 The Norfolk Rapid Coastal Zone Assessment Survey (Robertson *et al.*, 2005) comprised of a desk based assessment and archaeological fieldwork through a reconnaissance survey in the intertidal zone along the coastline of the county, providing baseline information.

9.7.8.2 Weybourne Gap comprises a shallow former river valley that meets the sea within the centre of the proposed intertidal area. At the mouth of the valley there is a small valley mire, located close to the car park. On the foreshore are periodically exposed outcrops of organic sands, peats and muds (Norfolk HER No. 6256). These deposits are associated with prehistoric worked and burnt flint, animal bone and wood. These deposits therefore can be related to relict deposits associated with the former river valley that passes through Weybourne Gap. Flint flakes were found by the Norfolk Rapid Coastal Zone Assessment Survey (RCZAS) embedded in cliff-wash deposits (not in situ) at the base of the cliff at the western end of the Hornsea Three intertidal area (Robertson *et al.*, 2005), with a Romano-British copper alloy decorative strip/bracelet found loose on an eroded cliff ledge nearby (Robertson *et al.*, 2005).

9.7.8.3 The onshore historic environment desk assessment (volume 6, annex 5.1: Desk Based Assessment) revealed a concentration of material of Roman date around Weybourne. The settlement remained significant as a small port during the medieval period. Cartographic evidence indicates coastal erosion since the mid-19th century and the Coastguard Station shown on the tithe and first edition OS maps and formerly at Weybourne Gap has been lost to the sea.

9.7.8.4 An intertidal area walkover survey in connection with Hornsea Three was undertaken in February 2017. The beach was shingle covered with a relatively steep slope towards the sea. The cliffs are eroding, with a number of ditch type features cut into the chalk cliffs to the east of Weybourne Gap. These features, where material was visible within them, were of relatively modern origin and may have been associated with the Second World War coastal defences located on the cliff tops. The walkover survey revealed no new archaeological sites or finds.

9.7.8.5 A borehole survey was also undertaken of the Hornsea Three intertidal area (see Table 9.5). Boreholes were undertaken in two areas within the Hornsea Three intertidal area, two boreholes to the east of Weybourne Gap, and one borehole to its west (as well as a number of boreholes landward of MHWS, see volume 3, chapter 5: Historic Environment). At the site to the east of Weybourne Gap, one borehole was made through Head deposits, and the other borehole through Glacial Till. At the site to the west of Weybourne Gap, the borehole was made through Head deposits. At the site to the east of Weybourne Gap the sequence broadly comprised topsoil, sand, clay silt and natural chalk. At the site to the west of Weybourne Gap the sequence included made ground which may be associated with wartime defences.

9.7.8.6 BGS mapped the Hornsea Three intertidal area and identified sequences of Anglian date and later (<480,000 years BP), which included glacio-fluvial sands and gravels, and glacial till. There is some potential for channel sediments to be preserved beneath these deposits. While no Holocene organic or peat deposits were noted beneath the modern beach shingle on the foreshore, such deposits are known to exist in the wider area. These deposits are sometimes associated with prehistoric artefact scatters and human remains.

9.7.8.7 Historic records, including mapping, indicate that the coastline is receding in this area. Weybourne was a small port during the medieval period. This suggests that remains of coastal installations as well as wrecks of all periods may well exist below the relatively featureless shingle visible today. The evidence indicates that there are a number of remains of heritage interest at the intertidal area.

9.7.9 Future baseline scenario

9.7.9.1 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 Environmental Statement.

9.7.9.2 In the event that Hornsea Three does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section.

9.7.9.3 The baseline environment is not static and will exhibit some degree of change over time, with or without Hornsea Three in place, due to interactions between marine archaeology and other plans and activities. When undertaking impact assessments it is therefore necessary to place any potential impacts in the context of the envelope of change that might occur over the timescale of the project if the project did not in fact get developed.

9.7.9.4 Should Hornsea Three not be constructed it is likely that the baseline within the regional marine archaeology study area would evolve slowly. Parts of the regional marine archaeology study area would continue to be directly impacted by fishing and oil and gas operations, resulting in a potential impact on shipwrecks and aircraft wrecks.

9.7.9.5 Further to potential change associated with other human plans and activities, it is necessary to take account of potential effects of climate change on the marine archaeology. It is predicted in UKCP09 that UK seas will be between 1.5 and 4°C warmer by the end of the 21st century (Lowe *et al*., 2009). One particular effect of ocean warming already visible in UK waters is the northward migration of invasive species; such as the blacktip shipworm *Lyrodus pedicellatus*. *Lyrodus* p. is a species of shipworm that is active all year and has begun to invade the UK from more southerly latitudes as a result of sea temperature increase. It has been recorded off Cornwall, Langstone Harbour in Hampshire, the Mary Rose protected wreck site in the Solent and in 2005 it was recorded on the coast at Sandwich, Kent. *Lyrodus* p. is considered to be a major threat to wooden wrecks and other wooden structures (Dunkley, 2003).

9.7.9.6 The baseline in the regional study area described in sections 9.6 above can therefore be considered as a 'snapshot' of the present marine archaeology within a gradual yet continuously changing environment.

9.7.10 Data limitations

9.7.10.1 A large body of project and non-project specific data is available to characterise the environmental setting of the regional marine archaeology study area (section 9.6). Collectively, the combined datasets provide sufficient detail to enable robust characterisation of the Hornsea Three array area and offshore cable corridor in terms of the marine archaeology.

9.7.10.2 The main identified data limitation relating to available third party data (i.e. SeaZone and NRHE) include potential inaccuracies in gathering and transcription of data by others. Risks related to these have been reduced through the interpretation of geophysical survey data collected by Hornsea Three.

9.7.10.3 Although a geophysical survey has been undertaken of the Hornsea Three array area and offshore cable corridor, no geophysical survey was undertaken within the temporary working area, nor within those areas where the Hornsea Three offshore cable corridor was rerouted between the PEIR and Environmental Statement. The results of the geophysical survey undertaken to date, combined with SeaZone data and other publicly available data sources (see section 9.5.4), provides a sufficient characterisation of marine archaeology baseline environment to inform the EIA. In addition, although project specific geo-archaeological borehole fieldwork has been undertaken to inform Hornsea Three, most of this data was unavailable to inform the Environmental Statement. However an assessment was made on the basis of previously retrieved cores from other projects, both from published and unpublished data sources, as well as using data from the Ground Model constructed as part of Hornsea Three. On this basis the geoarchaeological data available for Hornsea Three is considered adequate for the purposes of characterising the baseline environment to inform the EIA. (see also Table 9.5).

9.8 Key parameters for assessment

9.8.1 Maximum design scenario

9.8.1.1 In assessing the effects of the proposals on marine archaeology the assessment has been undertaken on the basis of i) the greatest area of near-surface sediments disturbed and ii) the greatest penetration depth of foundations. These two assessments are undertaken as they have very different effects on the marine historic environment, making it difficult to identify which option can best be said to represent the greatest effect.

9.8.1.2 The maximum design scenarios identified in Table 9.8 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 the project description (volume 1, chapter 3: Project Description). Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme.

9.8.1.3 Impacts on the settings of terrestrial heritage assets (landward of MHWS), is considered in the onshore Historic Environment chapter (volume 3, chapter 5). Impacts on Historic Seascape Character (HSC) is considered in the Seascape and Visual Resources chapter (volume 2, chapter 10).

9.8.2 Impacts scoped out of the assessment

9.8.2.1 No impacts have been scoped out of the assessment.

Table 9.8: Maximum design scenario considered for the assessment of potential impacts on marine archaeology.

Potential impact	Maximum design scenario	Justification
Construction phase		

Construction activities within the Hornsea Three array area and offshore cable corridor causing the removal or disturbance of sediments resulting in a potential effect on near-surface prehistoric land surfaces.
 	
Construction activities within the Hornsea Three array area and offshore cable corridor resulting in a potential effect on shipwrecks and aircraft wrecks.
	Seabed affected (area) up to a total of 63,843,515 m^2 (1,623,182 m^2 + 1,560,000 m^2 + 158,700 m^2 + 109,200 m^2 + 85,883 m^2 + 1,301,520 m^2 + 19,920,000 m^2 +6,300,000 m^2 + 32,196,030 m^2 + 584,200 m^2 + 4,800 m^2) as a result of:
	Turbine foundation installation:
	• Up to a total of 1,623,182 m^2 due to the installation of up to 300 turbines with gravity base foundations with scour protection (each affecting up to 5,411m^2 of seabed); and
	• Up to a total of 1,560,000 m^2 from the clearance of sandwaves prior to turbine installations.
	Substation and platform foundation installation:
	• Up to a total of 158,700 m^2 due to the installation of up to 12 offshore transformer substations with box gravity base foundations and scour protection (each affecting up to 13,225 m^2 of seabed);
	• Up to a total of 109,200 m^2 due to the installation of up to four offshore HVDC substations with pontoon gravity base foundations and scour protection (each affecting up to 27,300 m^2 of seabed); and
	• Up to a total of 85,883 m^2 due to the installation of up to three offshore accommodation platforms with suction caisson jacket foundations and scour protection (each affecting up to 28,628 m^2 of seabed).
	Jack-up barges:
	• Up to a total of 1,301,520 m^2 due to jack-up barge deployments for foundations for up to 319 structures (maximum design scenario assumes up to 300 turbines, up to 12 offshore transformer substations, up to four offshore HVDC substations and up to three offshore accommodation platforms) assuming six spud cans per barge, 170 m^2 seabed area affected per spud can and four jack up operations per turbine (319 foundations x 6 spud cans x 170 m^2 per spud can x four jack ups).
	Cable laying activities:
	• Up to a total of 19,920,000 m^2 from burial of up to 830 km of array cables as follows:
	  • Up to a total of 14,490,000 m^2 due to 498 km of the array cable requiring sandwave clearance (up to 30 m wide corridor); and
	  • Up to a total of 4,980,000 m^2 due to boulder clearance and laying of up to 332 km of array cables by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 15 m wide corridor).
	• Up to a total of 6,300,000 m^2 from burial of up to 225 km of interconnector cables as follows:
	  • Up to a total of 4,050,000 m^2 due to 135 km of the interconnector cable requiring sandwave clearance (up to 30 m wide corridor); and
	  • Up to a total of 2,250,000 m^2 due to boulder clearance and laying of up to 90 km of interconnector cables by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor).
	• Up to a total of 32,196,030 m^2 from burial of up to 1,146 km of export cable (up to six trenches of 163 km length) as follows:
	  • Up to a total of 21,420,180 m^2 due to 714 km of the export cable requiring sandwave clearance (up to 30 m wide corridor);
	  • Up to a total of 10,775,850 m^2 due to boulder clearance and laying of up to 431 km of export cables by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 15 m wide corridor).
	• 584,200 m^2 from cable barge anchor placement associated with cable laying for all subtidal cables within the Hornsea Three array area and offshore cable corridor broken down as follows:
	  • First 20 km of export cable: Up to seven anchors (footprint of 100 m^2 each) repositioned every 500 m for up to six export cables (20,000 m x 7 x 100 m^2 x 6 / 500 m = 168,000 m^2);
		The maximum design scenario presented is associated with HVDC transmission due to the larger foundation sizes associated with the offshore HVDC substations compared to the HVAC booster substations.
		The maximum design scenario for seabed near-surface disturbance and to therefore subsequently affect prehistoric land surfaces, and shipwrecks and aircraft wrecks, will result from the use of:
		• Gravity base foundations for turbines;
		• Box gravity base foundations for offshore transformer substations;
		• Pontoon gravity base foundations for offshore HVDC substations; and
		• Suction caisson jacket foundations for accommodation platforms.
		Whilst the maximum design scenario assumes that all of the habitat within the boulder clearance corridor will be disturbed, it should be noted that, in reality, only a proportion of this will be via a displacement scour with other parts only requiring clearance via subsea grab which will be far more targeted and will be result in substantially less habitat disturbance.
		Seabed will also be affected by the presence of cable protection (for up to 10% of cables). However, the installation of this material will occur within the width of disturbance included in the maximum design scenario for cable installation and, therefore, no additional seabed will be affected as a result of cable protection.
		The maximum design scenario for seabed disturbance in the nearshore area from the installation of export cables has considered the installation of all cables via trenching, as the total seabed disturbance associated with this method is greater than the seabed disturbance associated with the installation of export cables via horizontal directional drilling (HDD).
		This maximum design scenario has the potential to affect the greatest area of near-surface sediment disturbance (e.g. prehistoric land surfaces, and shipwrecks and aircraft wrecks). Where gravity base foundations are identified as the maximum design scenario for the greatest near-surface sediment disturbance, only the top 5 m of the seabed sediment will be affected (due to seabed preparation). Gravity base foundations will not affect more deeply buried remains such as the lower parts of Early Holocene palaeo-channels and earlier sediments, such as the Swarte Bank and Yarmouth Roads formations.

Potential impact	Maximum design scenario	Justification
	• Export cables beyond 20 km: one anchor (footprint of 100 m^2 each) repositioned every 500 m for up to six export cables ((143,000 m – 20,000) x 1 x 100 m^2 x 6 / 500 m = 171,600 m^2). • Array and interconnector cables and export cable laying within the array, assuming one anchor (footprint 100 m^2) repositioned every 500 m ((830,000 m + 225,000 m + 168,000 m) x 1 x 100 m^2 / 500 m =244,600 m^2). • 4,800 m^2 from eight purposeful grounding of the cable laying barge (600 m^2 per barge) in the near shore region of the Hornsea Three offshore cable corridor.	
Construction of turbines, and substations and accommodation platforms within the Hornsea Three array area with jacket foundations causing the removal or disturbance of sediments resulting in a potential effect on deeply buried prehistoric land surfaces.	Seabed disturbance (volume) up to a total of 953,040 m^3 (442,400 m^3 + 253,344 m^3 + 193,960 m^3 + 63,336 m^3), consisting of: Turbine foundation installation: • Up to a total of 442,400 m^3 due to the installation of up to 160 turbines with jacket (driven pile) foundations (each with a spoil volume of up to 2,756 m^3) with a seabed penetration depth of up to 55 m. Substation and platform foundation installation: • Up to a total of 253,344 m^3 due to the installation of up to 12 offshore transformer substations with jacket (driven pile) foundations (each with a spoil volume of up to 21,112 m^3) with a seabed penetration depth of 70 m; • Up to a total of 193,960 m^3 due to the installation of up to four offshore HVDC converter substations with jacket (driven pile) foundations (each with a spoil volume of up to 48,490 m^3) with a seabed penetration depth of 70 m; and • Up to a total of 63,336 m^3 due to the installation of up to three accommodation platforms with offshore substation piled jacket foundations (each with a spoil volume of up to 21,112 m^3) with a seabed penetration depth of up to 70 m.	The maximum design scenario presented is associated with HVDC transmission due to the greater volume of spoil associated with the offshore HVDC substations compared to the HVAC booster substations. The maximum design scenario for deeply buried seabed disturbance and to therefore subsequently affect prehistoric land surfaces, will result from the use of jacket foundations for turbines, offshore transformer substations, offshore HVDC substations and accommodation platforms. Jacket foundations will cause less disruption in terms of the area of seabed affected but will penetrate to a considerably greater depth than gravity base foundations. There is therefore the potential for a greater effect on more deeply buried remains such as the lower parts of Early Holocene palaeo-channels and earlier sediments, such as the Swarte Bank and Yarmouth Roads formations.

Seabed preparation in connection with gravity base foundation installation and sand wave clearance causing sediment deposition on the seabed resulting in a potential effect on a variety of heritage assets.	Sediment deposition (area) up to a total of 6,336,254 m^2 (4,235,774 m^2 + 2,100,480 m^2) as a result of:
	Seabed preparation for turbine, substation and platform foundations:
	• Up to a total of 4,235,774 m^2 from deposition of material to a uniform thickness of 0.5 m as a result of seabed preparation works prior to the installation of all gravity base foundations. This assumes:
	  • Up to a total of 1,225,800 m^3 of material from seabed clearance due to the installation of up to 300 turbines with gravity base foundations (each with a seabed clearance volume of up to 4,086 m^3) affecting up to 2,451,600 m^2;
	  • Up to a total of 735,000 m^3 of material from seabed clearance due to the installation of up to 12 offshore transformer substations with box gravity base foundations (each with a seabed clearance volume of up to 61,250 m^3) affecting up to 1,470,000 m^2;
	  • Up to a total of 139,552 m^3 of material from seabed clearance for up to four offshore HVDC convertor substations with box gravity base foundations (each with a seabed clearance volume of up to 34,888 m^3) affecting up to 279,104 m^2; and
	  • Up to a total of 17,535 m^3 of material from seabed clearance for up to three offshore accommodation platforms (each with a seabed clearance volume of up to 5,845 m^3) affecting up to 35,070 m^2.
	Sandwave clearance:
	• Up to a total of 2,100,480 m^2 from deposition of material to a uniform thickness of 0.5 m as a result of sandwave clearance. This assumes:
	  • Up to a total of 142,300 m^2 from placement of dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance within the Hornsea Three array area, assuming a volume of up to 71,150 m^3, placed on the seabed within the Hornsea Three array area; and
	  • Up to a total of 1,958,180 m^2 from placement of dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance in the Hornsea Three offshore cable corridor, assuming a volume of up to 979,090 m^3, placed on the seabed within the Hornsea Three offshore cable corridor.
		The maximum design scenario presented is associated with HVAC transmission due to the greater volume of seabed clearance associated with the offshore HVAC booster stations compared to the offshore HVDC substations.
		Dredging as part of seabed preparation for gravity base foundations results in the release of relatively smaller overall volumes of relatively coarser sediment, at relatively higher rates, than similar potential impacts for drilling of individual monopile or piled jacket foundations.
		The area affected by the deposition of material as a result of seabed preparation and sandwave clearance has been calculated based on the maximum volume of sediment deposited across the entire Hornsea Three array area, assuming all this sediment is coarse material and therefore deposited on the seabed. The total area of seabed affected was calculated assuming a mound of uniform thickness of 0.5 m height. As detailed in volume 5, annex 1.1: Marine Processes Technical Report, the area of seabed affected by this scenario broadly aligns with the scenario of a cone shaped mound of 1.7 m maximum height (see Table 4.24 of volume 5, annex 1.1). Seabed disturbance is assumed beneath this within the Hornsea Three array area.
		The deposition from these spoil arisings has the potential to affect elements of the historic environment on the seabed (i.e. shipwrecks and aircraft wrecks). It will not affect more deeply buried remains such as Early Holocene palaeochannels and earlier sediments, such as the Swarte Bank and Yarmouth Roads formations.
		Deposition of sediment from cable burial installation activities has not been considered in this assessment on the basis that any material deposited will be localised to within metres downstream of the cable for gravels and within tens of metres for sands. Irrespective of sediment type, the volumes of sediment being displaced and deposited locally are relatively limited (up to 6 m^3 per metre of cable burial) which also limits the combinations of sediment deposition thickness and extent that might realistically occur. Furthermore, all known shipwrecks and aircraft protected by AEZs will be located at such a distance from the cable installation activities that no sediment deposition is likely to occur in their vicinity.

Potential impact	Maximum design scenario	Justification
Cable installation within the Hornsea Three intertidal area may affect buried shipwrecks, navigation poles or remains or other archaeological evidence for past coastal activities.	Seabed disturbance (area) up to a total of 12,642 m^2 as a result of: • Up to 12,642 m^2 from works to bury up to 3 km of export cable in the Hornsea Three intertidal area (up to six cables of 0.5 km length) by trenching (assuming impacts within the entire Hornsea Three intertidal area) including associated construction activities.	Disturbance within the entire 240 m wide intertidal corridor and temporary working area has been considered as the maximum design scenario. Intertidal construction activities will affect elements of the historic environment on or within the top approximate 6 m of the Hornsea Three intertidal area. Cable installation in the Hornsea Three intertidal area will not affect more deeply buried remains such as the lower parts of Early Holocene palaeo-channels and earlier sediments, such as the Swarte Bank and Yarmouth Roads formations, except possibly if trenchless methods are extensively used.
Operation phase		

Maintenance operations which may affect prehistoric land surfaces through the removal or disturbance of sediments.
 	
Maintenance operations may affect may affect shipwrecks and aircraft wrecks
	Seabed disturbance of up to 9,770,400 m^2 (5,508,000 m^2 + 65,280 m^2 + 340,000 m^2 + 910,700 m^2 + 2,400,000 m^2 + 546,420 m^2) comprising:
	• Up to 5,508,000 m^2 as a result of up to 5,400 jack-ups per year over the 35 year design life for turbine component replacement and access ladder replacement events, assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 5,400 x six x 170);
	• Up to 65,280 m^2 as a result of up to 64 jack-ups in total over the 35 year design life for offshore substation component replacements and J-tube repair/replacement events, assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 64 x six x170);
	• For array and interconnector cables:
	  ◦ Up to 340,000 m^2 due to up to 17 remedial burial events over the 35 year design life affecting up to 2 km of cable per event and a width of disturbance of up to 10 m (i.e. 17 x 2,000 m x 10 m).
	  ◦ Up to 910,700 m^2 as a result of up to one cable repair event per year, over the 35 year design life, affecting up to 25,000 m^2 per repair event and requiring one jack up per repair event assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 35 x 25,000 m^2 + (35 x six x 170 m^2)).
	• For export cables:
	  ◦ Up to 2,400,000 m^2 due to up to 15 remedial burial events over the 35 year design life affecting up to 2 km of cable per event and a width of disturbance of up to twice the water depth (i.e. 15 x 2,000 m x (two x 40 m)).
	  ◦ Up to 546,420 m^2 as a result of up to 21 cable repair events over the 35 year design life, affecting up to 25,000 m^2 per repair event and requiring one jack up per repair event assuming six spud cans per jack-up barge and 170 m^2 seabed area affected per spud can (i.e. 21 x 25,000 m^2 + (21 x six x 170 m^2)).
		The greatest area of seabed disturbance (resulting from the maximum number of turbine, substations and accommodation platforms) has the largest potential to impact upon, and subsequently affect, prehistoric land surfaces, and shipwrecks and aircraft wrecks.
		Jack-up spud can placements have the potential to affect elements of the historic environment on the seabed or just below the seabed sediment (i.e. prehistoric land surfaces). It will not affect more deeply buried remains such as the lower parts of Early Holocene palaeo-channels and earlier sediments, such as the Swarte Bank and Yarmouth Roads formations.
		No substantive maintenance works on the export cables in the Hornsea Three intertidal area is anticipated, only access will be required periodically as outlined to inspect the cable and for geophysical surveys. Though the burial depth of the cables will be designed so they will remain buried for the full lifetime of the project and beyond, it will be necessary to bury the cables if erosion or other natural processes cause them to become exposed. The most appropriate means of reburying any exposed cables will be assessed on an ad-hoc basis but will be no more intrusive than those used during construction.

Decommissioning phase		
Foundation cutting/removal and cable removal which may affect prehistoric land surfaces through the removal or disturbance of sediments. Foundation cutting/removal and cable removal may affect may affect shipwrecks and aircraft wrecks.	Maximum design scenario for seabed disturbance (area) as per construction phase, excluding seabed preparation works and removal of scour and cable protection: • Hornsea Three array area and offshore cable corridor: 63,843,515 m^2 (see the first impact in this table ("*construction activities within the Hornsea Three array area and offshore cable corridor causing the removal or disturbance of sediments*) for a breakdown of this calculation"); and • Hornsea Three intertidal area: 12,642 m^2 (see the fifth impact in this table ("*cable installation within the Hornsea Three intertidal area*") in this table for a breakdown of this calculation).	The greatest area of seabed disturbance (resulting from the maximum number of turbines, offshore transformer substations, offshore HVDC substations and accommodation platforms) has the largest potential to impact upon, and subsequently affect, prehistoric land surfaces, and shipwrecks and aircraft.

9.9 Impact assessment methodology

9.9.1 Overview

9.9.1.1 The impact assessment methodology was designed to evaluate potential changes to the baseline conditions of archaeological receptors, both beneficial and adverse, as a result of planned construction, operation and maintenance, and decommissioning activities.

9.9.1.2 The marine archaeology EIA has followed the methodology set out in volume 1, chapter 5: Environmental Impact Assessment Methodology. Specific to the marine archaeology EIA, the following guidance documents have also been considered:

- Highways Agency (2008) Design Manual for Roads and Bridges. London, Department for Transport;
- Chartered Institute for Archaeologists (2014a) Code of Conduct. Reading, Chartered Institute for Archaeologists;
- Chartered Institute for Archaeologists (2014b) Standard and Guidance for Historic Environment Desk Based Assessment. Reading, Chartered Institute for Archaeologists; and
- Drury, P. and McPherson, A. (2008). Conservation Principles. London: English Heritage.

9.9.2 Impact assessment criteria

9.9.2.1 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 Design Manual for Roads and Bridges (DMRB) methodology, which is described in further detail in volume 1, chapter 5: Environmental Impact Assessment Methodology.

9.9.2.2 The criteria for defining sensitivity in this chapter are outlined in Table 9.9 below.

9.9.2.3 The criteria for defining magnitude in this chapter are outlined in Table 9.10 below.

9.9.2.4 The significance of the effect upon marine archaeology is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The particular method employed for this assessment is presented in Table 9.11. Where a range of significance of effect is presented in Table 9.11, the final assessment for each effect is based upon expert judgement.

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

Table 9.9: Definition of terms relating to the sensitivity of the receptor.

Sensitivity	Definition used in this chapter
Very High	Receptors of national or international importance that are highly vulnerable to impacts that may arise from the project and recoverability is long term or not possible.
High	Asset of International/National Importance or best known/above average example and/or significant/high potential to contribute to knowledge and understanding and/or outreach. Includes all wrecks of ships and aircraft with statutory protection under the Protection of Wrecks Act 1973, Ancient Monuments and Archaeological Areas Act 1979 or Protection of Military Remains Act 1986, plus as-yet undesignated sites that are demonstrably of equivalent significance. Known submerged prehistoric sites with the confirmed presence of largely in situ artefactual material and landscape features with demonstrable potential to include artefactual material are also of High sensitivity.
Medium	Asset of Regional Importance or average example and/or moderate potential to contribute to knowledge and understanding and/or outreach. Includes wrecks of ships and aircraft that do not have statutory protection or equivalent significance, but have regional importance or moderate potential based on a formal assessment of their importance. Other submerged palaeo-landscape features and deposits likely to date to periods of prehistoric archaeological interest are of Medium sensitivity.
Low (or lower)	Asset of Local Importance or below average example and/or low potential to contribute to knowledge and understanding and/or outreach. Includes wrecks of ships and aircraft that do not have statutory protection or equivalent significance, but have local importance or low potential based on a formal assessment of their importance in terms of build, use, loss, survival and investigation ('BULSI' system).
Negligible	Poor example and/or little or no potential to contribute to knowledge and understanding and/or outreach. Assets with little or no surviving archaeological interest.

Table 9.10: Definition of terms relating to the magnitude of an impact.

Magnitude of impact	Definition used in this chapter
Major	Total loss of, or major alteration to, key elements/features of the baseline (pre-development) conditions such that post development character/composition/attributes will be fundamentally changed and may be lost from the site altogether.
Moderate	Loss of, or alteration to, more key elements/features of the baseline conditions such that post development character/composition/attributes of baseline will be partially changed.
Minor	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/attributes of baseline condition will be similar to pre-development circumstances/patterns.
Negligible	Very slight change from baseline condition. Change barely distinguishable, approximating to the 'no change' situation.
No change	No change from baseline conditions.

Table 9.11: Matrix used for the assessment of the significance of the effect.

	Magnitude of impact					
Sensitivity of receptor		*No change*	*Negligible*	*Minor*	*Moderate*	*Major*
	Negligible	Negligible	Negligible	Negligible or minor	Negligible or minor	Minor
	Low	Negligible	Negligible or minor	Negligible or minor	Minor	Minor or moderate
	Medium	Negligible	Negligible or minor	Minor	Moderate	Moderate or major
	High	Negligible	Minor	Minor or moderate	Moderate or major	Major or substantial
	Very high	Negligible	Minor	Moderate or major	Major or substantial	Substantial

Beneficial and adverse effects

9.9.2.6 Offshore wind farms can result in adverse and beneficial impacts on marine archaeology. Adverse impacts will arise on marine archaeology as a result of the disturbance of prehistoric land surfaces, and on shipwrecks and aircraft wrecks from the construction, operation and maintenance, and decommissioning of the offshore wind farm. Results of the assessment work carried out in support of Hornsea Three, including during the lifetime of the project through the implementation of a WSI, will however be of benefit through improved understanding of human history and prehistory in this region of the southern North Sea.

9.9.2.7 As set out in NPS EN-3 (paragraph 2.6.142; DECC, 2011), it is important that the beneficial benefit to the historic environment resulting from the project is recognised and acknowledged. Unfortunately, it is not possible in advance to quantify or assess the level of benefit from a project in detail, although it is possible to conclude that the information retrieved from surveys, such as from the Hornsea Three field surveys, represents a rare and valuable opportunity to increase our understanding of complex and little explored remains of our past. For the purposes of this assessment, effects have therefore been defined based on the disturbance of prehistoric land surfaces, and on shipwrecks and aircraft wrecks. Effects are therefore defined as adverse throughout the assessment. Nevertheless, it is noted that they could, in fact, also be seen as beneficial through improved understanding of human history and prehistory.

9.10 Measures adopted as part of Hornsea Three

9.10.1.1 As part of the project design process, a number of designed-in measures have been proposed to reduce the potential for impacts on marine archaeology (see Table 9.12). As there is a commitment to implementing these measures, they are considered inherently part of the design of Hornsea Three and have therefore been considered in the assessment presented in section 9.9.3 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures). These measures are considered standard industry practice for this type of development.

9.10.1.2 The measures outlined in Table 9.12 are designed to mitigate the impact of the construction, operation and maintenance and decommissioning phases upon known sites, and to establish the presence of unknown sites. These form the basis for the detailed procedures set out in the Outline WSI (volume 5, annex 9.2: Outline Written Scheme of Investigation), intended to i) identify archaeologically sensitive remains encountered during the development, ii) to avoid them wherever possible and iii) to enable recording of any remains that are directly affected.

9.10.2 Archaeological Exclusion Zones (AEZs)

9.10.2.1 Best practice favours the preservation in situ of archaeological remains; therefore the ideal preferred mitigation for archaeological remains is avoidance (COWRIE, 2007). For Hornsea Three, AEZs have been established that prohibit development-related activities within their extents, which vary depending upon the nature of the wreck. The final development layout will take into account these preliminary zones, which may evolve or be removed (with the agreement of Historic England) as the project progresses, subject to layout designs and additional subsequent surveys that may be required.

9.10.2.2 All AEZs will be marked on final detailed design drawings. If impacts cannot be avoided, measures to reduce, remedy or offset disturbance will be agreed.

9.10.2.3 In view of their potential archaeological significance, AEZs (either in the form of individual AEZs or clusters) will be placed around the three anomalies classified as being of high archaeological potential within Hornsea Three.

9.10.2.4 Wrecks will be protected by AEZs with buffers ranging in radius from 15 to 100 m from the maximum known extents of the identified anomalies. These AEZs are listed in the Outline WSI (volume 5, annex 9.2: Outline Written Scheme of Investigation) and illustrated in Figure 9.5 below. Scope is allowed for their amendment in light of further evidence and with the involvement of consultees (see section 10.4 of volume 5, annex 9.2: Outline Written Scheme of Investigation).

9.10.2.5 Magnetic anomalies >500 nT have been identified to characterise the Hornsea Three array area and offshore cable corridor, and identify areas of archaeological potential. No formal AEZs are recommended at this stage but the submission of positions of significant magnetic anomalies identifies the potential for archaeological contacts and that the areas will be monitored during future assessments.

Table 9.12: Designed-in measures adopted as part of Hornsea Three.

Measures adopted as part of Hornsea Three	Justification
Provision by Hornsea Three, of archaeological input into specifications for and ensure archaeological analysis of any further pre-construction geophysical surveys.	To avoid impacts on sites of archaeological importance.
Provision by Hornsea Three of archaeological input to future geotechnical surveys where deposits of known archaeological potential are likely to be affected. This may include the presence of a geoarchaeologist on board the survey vessel and a provision for sampling, analysis and reporting of recovered cores. Analysis and dating of samples recovered during pre-construction geotechnical surveys in areas where impacts on deposits of geoarchaeological and/or palaeoenvironmental significance seem likely.	To offset the impacts of development on sediments of geoarchaeological/ palaeoenvironmental importance and enhance knowledge of the offshore marine archaeological resource.
Hornsea Threes archaeologists to be consulted in the preparation of any pre-construction ROV/diver surveys and, if appropriate, in monitoring/checking of data.	To avoid impacts on unrecognised archaeological sites and/or to improve understanding of identified sites of potential archaeological significance.
Further investigation of those SeaZone/UKHO records classified as 'dead' (where there has been no evidence of the wreck or obstruction over successive surveys) will be undertaken during the future assessment of higher resolution geophysical survey data, with action taken as appropriate on the basis of the measures outlined in the remainder of this table	To avoid impacts on sites of archaeological importance.
The identification and implementation of AEZs around those sites identified as having high and medium archaeological potential (see Table 9.6). Final turbine locations to avoid any known archaeological constraints identified in pre-construction surveys through micrositing.	To avoid direct impacts on sites of identified archaeological significance.
Where no archaeological significance has been interpreted from the archaeological analysis of the results of the geophysical survey, those sites have been identified as having low archaeological potential (see Table 9.6). There will be maintenance of an operational awareness of the location of those contacts. Reporting through the agreed protocol will be undertaken should material of potential archaeological interest be encountered.	To avoid/record impacts on sites of identified archaeological significance.
The identification and implementation of Temporary Archaeological Exclusion Zones (TAEZs) based on all available information including the stated positional accuracy, the recorded size of the target and the potential archaeological significance around those records for wrecks and obstructions outside of the survey data coverage but within the Hornsea Three boundary.	To avoid impacts on sites of archaeological importance.
Archaeologists to be consulted in the preparation of pre-construction cable route clearance or other pre-construction clearance operations and, if appropriate, to carry out watching briefs of such work.	To record archaeological remains that may be affected by pre-construction clearance operations.
Mitigation of unavoidable direct impacts on known sites of archaeological significance: Options include i) preservation by record; ii) stabilisation; iii) detailed analysis and safeguarding of otherwise comparable sites elsewhere.	To offset the effects of disturbance/ destruction of irreplaceable archaeological remains.
Implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b) for unexpected archaeological discoveries made during the course of development.	The protection and, if necessary recording of sites/objects of archaeological significance affected by the development.

9.10.2.6 Wreck material can often be spread over a wide area in the vicinity of a wreck site and the buffers are expected to incorporate such material within their boundaries, the details of which are outlined in the Outline WSI (volume 5, annex 9.2: Outline Written Scheme of Investigation). In order to further refine the exclusion zone the results of any pre-construction seabed survey (i.e. diver or ROV), and any other sites of potential archaeological interest will be inspected by a suitably qualified archaeologist. A suitably qualified archaeologist(s) will be involved in such survey work. In addition, in order to maximise the potential benefits of such work, archaeological advice will be incorporated prior to the implementation of those surveys. The results of such surveys will be used to inform the final siting of wind turbines.

9.10.2.7 A further 28 geophysical anomalies of medium unconfirmed archaeological potential were identified as of potential anthropogenic origin and archaeological interest, although the geophysical signatures were not clear enough to identify what they represent. These will also be subject to AEZs.

9.10.2.8 In addition, Temporary AEZs (TAEZs) will be established as appropriate around those seven recorded sites located within Hornsea Three but not recorded through project specific geophysical survey.

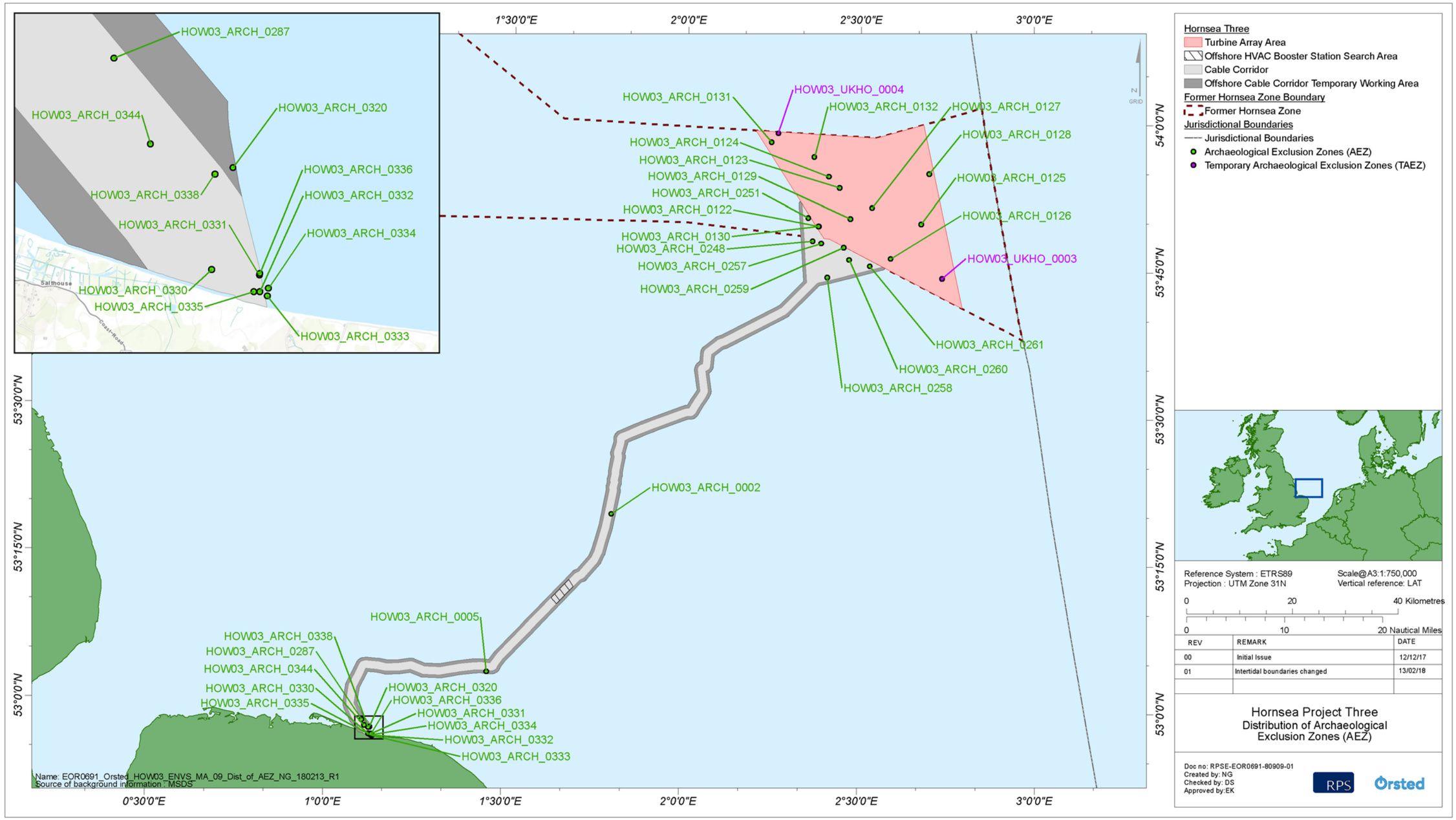

Figure 9.5: Distribution of AEZs.

9.10.3 Perseveration by record

9.10.3.1 Where preservation in situ is not practicable, disturbance of archaeological sites or material will be offset by appropriate and satisfactory measures, also known as 'preservation by record'. In these circumstances, the effects of the development will be offset by carrying out excavation and recording prior to the impact occurring (COWRIE, 2007).

9.10.3.2 It is likely that previously unknown wrecks, archaeological sites or material may only be encountered during the course of the construction, maintenance and/or decommissioning of Hornsea Three. Procedures will therefore be in place to allow for such eventualities.

9.10.3.3 The Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b) will be adopted, which will provide for the reporting of archaeological discoveries made during the lifetime of Hornsea Three. This covers the reporting and investigating of unexpected archaeological discoveries encountered during construction, maintenance and decommissioning activities, informed by the guidance of appropriately and qualified archaeologists. This protocol further makes provision for the institution of TAEZs around areas of possible archaeological interest, for prompt archaeological advice and, if necessary, for archaeological inspection of important features prior to further construction, maintenance or decommissioning activities in the vicinity. It complies with the Merchant Shipping Act 1995, including notification of the Receiver of Wreck, and accords with the JNAPC Code of Practice for Seabed Developers.

9.10.3.4 In view of the potential for the presence of palaeolandscapes and associated prehistoric sites, and unidentified wrecks, there would be archaeological involvement during the pre-construction export cable route clearance, and any similar activity undertaken within the Hornsea Three array area. Watching briefs will be appropriate where seabed material is brought to the surface, for example during pre-lay grapnel runs. These proposals may be refined on the basis of the results of any further marine geophysical, geotechnical or diver/ROV+ surveys.

9.11 Assessment of significance

9.11.1 Construction phase

9.11.1.1 The impacts of the offshore construction of Hornsea Three have been assessed on marine archaeology. The potential impacts arising from the construction of Hornsea Three are listed in Table 9.8 above, along with the maximum design scenario against which each construction phase impact has been assessed.

9.11.1.2 A description of the potential effect on marine archaeology receptors caused by each identified impact is given below.

Construction activities within the Hornsea Three array area and offshore cable corridor causing the removal or disturbance of sediments resulting in a potential effect on near-surface prehistoric land surfaces.

9.11.1.3 The NSPP, the Humber REC and the analysis of geophysical and geotechnical information together provide a relatively detailed understanding of submerged prehistoric archaeology and palaeo-land surfaces, notably the Holocene Botney Cut channels in the Hornsea Three array area and relatively discreet groups of channels along the Hornsea Three offshore cable corridor (see Figure 9.2).

9.11.1.4 The Holocene Botney Cut channels within the Hornsea Three array area are thought to contain a series of infilled Late Pleistocene/Early Holocene river valleys draining northwards into what is now the Outer Silver Pit, the southern edge of which also lies within the Hornsea Three array area. It has been demonstrated that these channels contain relatively undisturbed organic remains and sediments deposited when these features were important terrestrial waterways, almost certainly attractive to contemporary human populations. This evidence combines to suggest that exceptionally well-preserved archaeological sites of this period are very likely to exist within and alongside these channels, although it is impossible to tell exactly where they may occur.

9.11.1.5 In certain discreet portions of the Hornsea Three offshore cable corridor there are palaeochannels containing preserved Late Pleistocene and Early Holocene sediments and land surfaces. Similarly to the Holocene Botney Cut channels within the Hornsea Three array area, these features are likely to contain relatively undisturbed organic remains and sediments deposited when these features were important terrestrial waterways, almost certainly attractive to contemporary human populations.

Magnitude of impact

9.11.1.6 The total maximum area of seabed disturbance due to construction activities, as described in Table 9.8 above, is predicted to be approximately 63,843,515 m^2 (63.84 km^2) as a result of:

- Installation of gravity base foundations for turbines and substations,
- Installation of suction caisson jacket foundations for accommodation platforms;
- Scour protection for turbines, substation and accommodation platform foundations;
- Jack-up barge operations to install foundations;
- Burial of array, interconnector and export cables; and
- Anchor placements and grounding of cable laying barge associated with construction operations.

9.11.1.7 The impact of the construction of foundations for the turbines, and offshore substations and platforms will be localised. Gravity base foundations in particular are likely to affect shallower sediments within relict Early Holocene features and channels, although it may well leave substantial proportions of underlying palaeochannels intact. Where impacts do occur they will generally be adverse and irreversible and result in a permanent change to the receptor.

9.11.1.8 The laying of array, interconnector and export cables, as well as the anchoring of cable-lay vessels during the construction phase will take place in an area where the buried remains of Early Holocene palaeolandscapes, while widespread, is intermittent. Where such impacts coincide with Early Holocene features, impacts are likely as the sediments within these features tend to be close to the surface of the seafloor. In places, particularly along the Hornsea Three offshore cable corridor, the impact may be limited given the presence of seafloor silts of varying depth overlying in situ Late Pleistocene/Early Holocene deposits. However where impacts do occur they will generally be adverse and irreversible and result in a permanent change to the receptor.

9.11.1.9 The measures adopted as part of the project (see section 9.9) provide as high a measure as is currently practicable of enabling preservation by record, through further survey and analysis of the palaeoenvironmental record.

9.11.1.10 Any impacts on palaeolandscapes and any associated archaeological remains will be permanent and the impact will affect the receptor directly. However, given the widespread extent and depth of the palaeochannels and the relatively limited nature of the impacts by comparison, they are predicted to be local in spatial extent. Furthermore, the palaeochannels along the Hornsea Three offshore cable corridor occur in discreet groups with large areas of low potential in between. On this basis, the magnitude of impact is considered to be negligible.

Sensitivity of the receptor

9.11.1.11 Prehistoric archaeological receptors of the kind known to exist within the Hornsea Three array area and offshore cable corridor can be regarded as of potential national and international importance in contributing to our understanding of the UK and Europe's earliest human populations and should be regarded as high value receptors.

9.11.1.12 Due to their non-renewable and finite nature, prehistoric archaeological receptors will not recover from direct construction impacts, such as foundation or cable installation. This will result in a permanent change to the receptor.

9.11.1.13 It is likely that early Holocene sediments, if present, will be affected by the construction of foundations and laying of cables. It is less easy to assess the impact of the development on archaeological sites and objects, which are most likely to be relatively ephemeral remains of Mesolithic settlement. While no sites are known to exist for certain, it seems highly probable that they exist in this area and in all probability, given their waterlogged nature, are exceptionally well-preserved. Such sites could be of national significance.

9.11.1.14 Buried prehistoric land surfaces are deemed to be of moderate vulnerability, irrecoverable and of high value. The sensitivity of the receptor is considered to be high.

Significance of the effect

9.11.1.15 The magnitude of impact of the construction activities within the Hornsea Three array area and offshore cable corridor will be negligible on prehistoric landscapes, which are receptors of high sensitivity. The effect of the removal or disturbance of sediments on near-surface prehistoric land surfaces will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Construction activities within the Hornsea Three array area and offshore cable corridor resulting in a potential effect on shipwrecks and aircraft wrecks.

9.11.1.16 One anomaly of high potential, ten of medium potential and 112 of low potential have been identified within the Hornsea Three array area, as well as one recorded wreck and eight recorded obstructions not identified within the geophysical datasets. Within the Hornsea Three offshore cable corridor, two anomalies of high potential, 18 of medium potential and 116 of low potential have been recognised, as well as eight recorded wrecks and no recorded obstructions not identified within the geophysical datasets, located within the rerouted area at the southern end of the Hornsea Three offshore cable corridor.

Magnitude of impact

9.11.1.17 The total maximum area of seabed disturbance due to construction activities, as described in Table 9.8 and paragraph 9.10.1.6 above, is predicted to be approximately 63,843,515 m^2 (63.84 km^2).

9.11.1.18 Impacts of the construction of foundations on shipwrecks and aircraft wrecks will be localised, but should they occur they will generally be adverse and irreversible and result in a permanent change to the receptor. The impacts of and the laying of array, interconnector and export cables on shipwrecks and aircraft wrecks will be limited to the relatively narrow corridor of the cable trench. The extent of the impacts on these archaeological receptors can thus be considered to be local, but should they occur they will generally be adverse and irreversible and result in a permanent change to the receptor.

9.11.1.19 Where wreck locations are already known, measures adopted as part of the project for their avoidance and protection, including the implementation of AEZs, are set out in paragraphs 9.9.2.3 to 9.9.2.4, Table 9.12 and in volume 5, annex 9.2: Outline Written Scheme of Investigation.

9.11.1.20 Measures to protect and record wrecks whose existence has not yet been identified and are discovered during construction, including the implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b), are set out in paragraphs 9.9.3.2 to 9.9.3. On the basis of these measures adopted as part of the project, the magnitude of impact on wrecks is considered to be negligible.

Sensitivity of the receptor

9.11.1.21 The value assigned to a shipwreck or aircraft wreck site is, to a large degree, site specific and will vary from site to site. A ship may have historical importance at a local, national or international level as a result of its association with a historical event or figure. Wartime losses, or a vessel whose sinking was associated with a loss of life, may have a level of importance directly associated with that loss of life. Vessels which are key to, or representative of, specific periods of maritime development may also be regarded as important. Alternatively, a vessel may have a level of archaeological importance based on the rarity of its representation within the maritime archaeological record and/or its cargo.

9.11.1.22 Aircraft crash sites have significance for remembrance and commemoration, an implicit heritage value as historic artefacts, and automatic legal protection through the Protection of Military Remains Act 1986. Any shipwreck and aircraft wreck receptor must be regarded as a high value receptor.

9.11.1.23 Due to the non-renewable and finite nature of wrecks, where construction impacts associated with foundation or cable installation coincide with the receptor, it will not recover, resulting in a permanent change. The information available regarding wrecks and aerial losses indicates the density of recorded historic wrecks and the density of geophysical survey anomalies grows substantially from approximately the southern extent of the offshore HVAC booster station search area to the Hornsea Three intertidal area. Some of these may have sunk as the result of striking mines during the two world wars.

9.11.1.24 Shipwrecks and aircraft wrecks are deemed to be of high vulnerability, irrecoverable and of medium to high value. The overall sensitivity of this class of receptor in the array is therefore, considered to be medium to high.

Significance of the effect

9.11.1.25 The magnitude of impact of the construction activities within the Hornsea Three array area and offshore cable corridor will be negligible on shipwreck and aircraft wrecks, which are receptors of medium to high sensitivity. The effect of construction activities on shipwrecks and aircraft wrecks will, therefore, be minor adverse, which is not significant in EIA terms.

Construction of turbine, and substation and accommodation platforms with jacket foundations causing the removal or disturbance of sediments resulting in a potential effect on deeply buried prehistoric land surfaces.

Magnitude of impact

9.11.1.26 The total maximum volume of seabed disturbance due to construction activities, as described in Table 9.8 above, is predicted to be approximately 953,040 m^3 as a result of:

- Installation of jacket (driven pile) foundations for turbines, offshore transformer substations and offshore HVDC converter substations; and
- Installation of offshore substation piled jacket foundations for accommodation platforms.

9.11.1.27 The impacts of jacket (driven pile) foundations on buried ancient land surfaces and associated archaeological remains will be localised and will leave most underlying palaeochannels intact. However, where impacts do occur they will generally be adverse and irreversible and result in a permanent change to prehistoric land surfaces.

9.11.1.28 Jacket (driven pile) foundations, where they do disturb Early Holocene palaeofeatures and associated archaeology, which are generally less than 15 m deep and rarely more than 40 m, may affect the full sediment sequence. The depth of the jacket (driven pile) foundations means that they may also disturb more deep remains that have the potential to contain Lower and/or Middle Palaeolithic hominin remains.

9.11.1.29 The measures adopted as part of the project (see section 9.9) proposed provide as high a measure as is currently practicable of enabling preservation by record, through further survey and analysis of the palaeoenvironmental record.

9.11.1.30 Any impacts on palaeolandscapes and any associated archaeological remains will be permanent and the impact will affect the receptor directly. However, given the widespread extent and depth of the palaeochannels and the relatively limited nature of the impacts by comparison, they are predicted to be local in spatial extent. On this basis, the magnitude of impact is considered to be negligible.

Sensitivity of receptor

9.11.1.31 Our understanding and knowledge of submerged prehistoric archaeology and palaeo land surfaces is relatively detailed thanks to the NSPP, the Humber REC and archaeological analysis of geophysical and geotechnical surveys. This evidence combines to suggest that exceptionally well-preserved archaeological sites of this period are very likely to exist within and beside these channels.

9.11.1.32 Prehistoric archaeological receptors of this kind can be regarded as of potential national and international importance in contributing to our understanding of the UK and Europe's earliest human populations and should be regarded as high value receptors.

9.11.1.33 Due to their non-renewable and finite nature, prehistoric archaeological receptors will not recover from direct construction impacts, such as foundation installation. This will result in a permanent change to the receptor.

9.11.1.34 It is less easy to assess the impact of Hornsea Three on archaeological sites and objects, which are most likely to be relatively ephemeral remains of Mesolithic settlement. While no sites are known to exist for certain, it seems highly probable that they exist in this area and in all probability, given their waterlogged nature, are exceptionally well-preserved. Such sites would be of national significance.

9.11.1.35 Buried prehistoric land surfaces are deemed to be of moderate vulnerability, irrecoverable and of high value. The sensitivity of the receptor is considered to be high.

Significance of effect

9.11.1.36 The magnitude of impact of the construction of turbines, and substation and accommodation platforms with jacket (driven pile) foundations will be negligible on prehistoric landscapes, which are receptors of high sensitivity. The effect of the removal or disturbance of sediments on deeply buried prehistoric land surfaces will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Seabed preparation in connection with gravity base foundation installation and sandwave clearance causing sediment deposition on the seabed resulting in a potential effect on a variety of heritage assets.

Magnitude of impact

9.11.1.37 Sediment deposition is predicted to occur during the construction phase as a result of foundation and cable installation (including seabed preparation and sandwave clearance). Chapter 1: Marine Processes and volume 5, annex 1.1: Marine Processes Technical Report provide a full description of the physical assessment, including the numerical modelling used to inform the predictions made with respect to sediment deposition.

9.11.1.38 The maximum design scenario for the deposition of sediments from foundation installation is predicted to occur as a result of seabed preparation works prior to gravity base installation. The release of granular material as a result of seabed preparation is predicted to result in depositions with a uniform thickness of 0.5 m and will cover an area of 4,235,774 m^2.

9.11.1.39 Sandwave clearance is also expected to be required at discrete locations both within the Hornsea Three array area and along the Hornsea Three offshore cable corridor. The release of granular material as a result of sandwave clearance along the Hornsea Three offshore cable corridor is predicted to result in depositions with a uniform thickness of 0.5 m and will cover an area of 142,300 m^2 within the Hornsea Three array area and 1,958,180 m^2 within the Hornsea Three offshore cable corridor.

9.11.1.40 Impacts on marine archaeology (including primarily ship and aircraft wrecks and to a lesser extent buried prehistoric remains) from sediment deposition will be permanent and the impact will affect archaeological receptors indirectly. The magnitude of impact is considered to be negligible.

Sensitivity of receptor

9.11.1.41 The deposition of sediment on the seabed is considered to be potentially beneficial in nature as it may contribute to the preservation of non-renewable archaeological sites and material through burial.

9.11.1.42 Marine archaeological receptors are deemed to be of moderate to high vulnerability, irrecoverable and of high value. Where sediment deposition occurs, archaeological receptors are not likely to be affected and their sensitivity to this impact can therefore be considered negligible.

Significance of effect

9.11.1.43 The magnitude of impact will be negligible and the sensitivity of the receptor is also negligible. The effect of sediment deposition will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Cable installation within the Hornsea Three intertidal area may affect buried shipwrecks, navigation poles, jetty revetments or remains or other archaeological evidence for past coastal activities.

9.11.1.44 A number of remains of potential heritage interest are known to be located within the Hornsea Three intertidal area (see section 9.6.7.2).

Magnitude of impact

9.11.1.45 The cable will be laid within the Hornsea Three intertidal area using one or more of several options (such as Horizontal Directional Drilling (HDD), trenching, dredging, jetting, ploughing, rock cutting or vertical injection) to cross the intertidal area. If any remains of archaeological importance are disturbed by this, impacts will be adverse and irreversible and result in a permanent change to the receptor. The total maximum area of intertidal habitat disturbance is estimated at approximately 12,642 m^2. This includes all cable laying activity and associated construction activities.

9.11.1.46 Any impacts on archaeological remains will be permanent and any impact will affect the receptor directly. Given the relatively limited, linear nature of the proposed impacts, it is assessed that they will be local in extent. The magnitude of impact is considered to be negligible.

Sensitivity of receptor

9.11.1.47 The Norfolk RCZAS has made a number of finds of material of all periods within the Hornsea Three intertidal area (see volume 5, annex 9.1: Marine Archaeology Technical Report). Historic records, including mapping, indicate that the coastline is receding in this area. Weybourne was a small port during the medieval period. This suggests that remains of coastal installations as well as wrecks of all periods may well exist below the relatively featureless shingle visible today.

9.11.1.48 Due to their non-renewable and finite nature, such remains are likely to be adversely and permanently damaged by the proposed cable installation.

9.11.1.49 Buried remains of this kind are deemed to be of high vulnerability, irrecoverable and of low to high value depending on their character. The sensitivity of the receptor is considered to be high.

Significance of effect

9.11.1.50 The magnitude of impact of cable installation within the Hornsea Three intertidal area will be negligible on archaeological receptors of high sensitivity. The overall significance of effect will, therefore, be minor adverse which is not significant in EIA terms.

Future monitoring

9.11.1.51 Other than those measures described in the Outline WSI (volume 5, annex 9.2: Outline Written Scheme of Investigation) no future monitoring with respect to any of the above construction phase effects is warranted or recommended.

9.11.2 Operational and maintenance phase

9.11.2.1 The impacts of the offshore operation and maintenance of Hornsea Three have been assessed on marine archaeology. The potential impacts arising from the operation and maintenance of Hornsea Three are listed in Table 9.8 along with the maximum design scenario against which each operation and maintenance phase impact has been assessed.

9.11.2.2 A description of the potential effect on marine archaeology receptors caused by each identified impact is given below.

Maintenance operations which may affect prehistoric land surfaces through the removal or disturbance of sediments.

Magnitude of impact

9.11.2.3 The most significant impacts upon prehistoric remains on or buried beneath the sea floor will take place during construction. However, where maintenance impacts coincide with Early Holocene features, impacts are likely as the sediments within these features tend to be close to the surface of the seafloor. Where impacts do occur they will generally be adverse and irreversible and result in a permanent change to the receptor.

9.11.2.4 The operation and maintenance phase is assumed to involve up to:

- 5,400 jack-up operations per year over the 35 year design life for turbine component replacement and access ladder replacement events, which will lead to a total area of seabed disturbance of up to 5,508,000 m^2; and
- 64 jack-ups in total over the 35 year design life for offshore substation component replacements and J-tube repair/replacement events, which will lead to a total area of seabed disturbance of up to 65,280 m^2.

9.11.2.5 In addition, the operation and maintenance phase could involve up to 17 remedial burial events over the 35 year design life and one cable burial repair event per year over the 35 year design life for array and interconnector cables and 15 remedial burial events over the 35 year design life and 21 cable burial repair event over the 35 year design life for export cables. This will lead to a total area of seabed disturbance of up to 4,197,120 m^2.

9.11.2.6 Impacts will be limited to the immediate area around the foundations, where spud-can legs will come into contact with the seabed. The spatial extent of this impact is very small in relation to the total area of Hornsea Three and relatively shallow. Similarly, cable reburial/repair works (if and when necessary) will only affect seabed in direct contact with the actual cable reburial operations.

9.11.2.7 The measures adopted as part of the project (see section 9.9) proposed provide as high a measure as is currently practicable of enabling preservation by record, through further survey (during the operation and maintenance phase) and analysis of the palaeoenvironmental record.

9.11.2.8 Any impacts on palaeolandscapes and any associated archaeological remains will be permanent and any impact would affect the receptor directly. Given the widespread extent and depth of the palaeochannels and the relatively limited nature of the impacts by comparison; they are predicted to be local in spatial extent. On this basis, given the very limited nature of the likely disturbance, the magnitude of impact is considered to be negligible.

Sensitivity of receptor

9.11.2.9 As established within the baseline assessment, there are widespread relict landscape features of late glacial/early Holocene date of archaeological potential within the Hornsea Three marine archaeology study area. They are relatively vulnerable to shallow disturbance of the seafloor; the older Pleistocene sediments being much too deeply buried to be affected by operation and maintenance activities.

9.11.2.10 Prehistoric archaeological receptors of this kind can be regarded as of potential national and international importance in contributing to our understanding of the UK and Europe's earliest human populations and should be regarded as high value receptors.

9.11.2.11 Due to their non-renewable and finite nature, prehistoric archaeological receptors will not recover from direct operation and maintenance impacts which would result in a permanent change to the receptor.

9.11.2.12 Buried prehistoric land surfaces are deemed to be of moderate vulnerability, irrecoverable and of high value. The sensitivity of the receptor is considered to be medium.

Significance of effect

9.11.2.13 The deployment of jack-up vessel spud feet and other vessel moorings will therefore represent a negligible magnitude of impact on prehistoric landscapes, a receptor of medium sensitivity. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Maintenance operations may affect may affect shipwrecks and aircraft wrecks.

Magnitude of impact

9.11.2.14 The most significant impacts upon shipwrecks and aircraft wrecks in the Hornsea Three marine archaeology study area will take place during construction. However, should maintenance impacts coincide with shipwrecks and aircraft wrecks, impacts are likely as these features tend to be close to the surface of the seafloor.

9.11.2.15 The extent of any maintenance impacts on shipwrecks and aircraft wrecks can be considered to be local, but where they do occur they will generally be adverse and irreversible and result in a permanent change to the receptor.

9.11.2.16 Wrecks, by their nature, are limited in extent. Where wreck locations are already known, measures adopted as part of Hornsea Three for their avoidance and protection, including the implementation of AEZs, are set out in paragraphs 9.9.2.3 to 9.9.2.4, and in volume 5, annex 9.2: Outline Written Scheme of Investigation. Measures to protect and record wrecks whose existence have not yet been identified and are discovered during maintenance, including the implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b), are set out in paragraphs 9.9.3.1 to 9.9.3, and in volume 5, annex 9.2: Outline Written Scheme of Investigation. Based upon these measures adopted as part of the project, the magnitude of impact on known and unknown wrecks is expected to be negligible.

Sensitivity of receptor

9.11.2.17 The value assigned to a shipwreck or aircraft wreck site is, to a large degree, site specific and will vary from site to site. As a whole, shipwreck and aircraft wrecks must be regarded as high value receptors.

9.11.2.18 Due to the non-renewable and finite nature of wrecks, where maintenance impacts coincide with the receptor, it will not recover, resulting in a permanent change. The information available regarding shipwrecks and aerial losses in the Hornsea Three marine archaeology study area indicates a fairly even distribution of such wrecks.

9.11.2.19 Shipwreck and aircraft wrecks are deemed to be of high vulnerability, irrecoverable and of medium to high value. The overall sensitivity of this receptor is expected to be medium to high.

Significance of effect

9.11.2.20 Maintenance activities are expected to represent a negligible magnitude of impact on shipwrecks and aircraft, receptors of medium to high sensitivity. The effect of maintenance activities on shipwrecks and aircraft wrecks are therefore predicted to be of **minor** adverse significance, which is not significant in EIA terms.

Future monitoring

9.11.2.21 Other than those measures described in the Outline WSI (volume 5, annex 9.2: Outline Written Scheme of Investigation), no future monitoring with respect to any of the above operation and maintenance phase effects is warranted or recommended.

9.11.3 Decommissioning phase

9.11.3.1 The impacts of the offshore decommissioning of Hornsea Three have been assessed on marine archaeology. The potential impacts arising from the decommissioning of Hornsea Three are listed in Table 9.8 along with the maximum design scenario against which each decommissioning phase impact has been assessed. Impacts during decommissioning additional to those caused by construction and operation could take the form of damage to marine archaeological remains not affected by construction (i.e. an aircraft wreck survives construction through avoidance but is then damaged by decommissioning) or damage to palaeoenvironmental remains through jack ups or similar.

9.11.3.2 A description of the potential effect on marine archaeology receptors caused by each identified impact is given below.

Foundation cutting/removal and cable removal which may affect prehistoric land surfaces through the removal or disturbance of sediments.

Magnitude of impact

9.11.3.3 The most significant impacts upon prehistoric remains on or buried beneath the sea floor will take place during construction. The anticipated activities during decommissioning will involve only relatively shallow and localised disturbance of the sea-floor as a result of cutting existing foundations, removing cables using grapples (if this is required) and, perhaps most significantly, anchoring and mooring of vessels carrying out the decommissioning work.

9.11.3.4 The nature and extent of sediment disturbance during decommissioning (i.e. from cable removal operations and working areas etc.) is likely to be similar or the same as that described for the same activities during the construction phase in paragraph 9.10.1.6 above (i.e. for cable installation, anchor placements and jack-up operations). However it should be noted that this approach is considered precautionary as there is no statutory requirement for decommissioned cables to be removed. Therefore, cables may be left buried in place or alternatively partially removed by pulling the cables back out of the ducts (see volume 1; chapter 3: Project Description). In addition, as seabed preparation works and the same extent of sandwave clearance would not be required, the magnitude of this impact will be lower than during the construction phase. The exact details of decommissioning will be included within the Decommissioning Programme which will be developed to minimise environmental disturbance and will be updated throughout the lifetime of Hornsea Three to account for changing best practice.

9.11.3.5 The total maximum area of direct sediment disturbance that may be affected by cable removal in the Hornsea Three intertidal area is approximately 12,642 m^2 (see paragraph 9.10.1.45 above). This is the area predicted for maximum impact during construction, so decommissioning works are likely to be substantially lower than this.

9.11.3.6 The total maximum area of direct sediment disturbance in the Hornsea Three array area and offshore cable corridor due to the decommissioning activities is predicted to be 63,843,515 m^2 (63.84 km^2). As noted the total area of direct sediment disturbance is predicted to be lower than this, as foundation installation and sandwave clearance will not be required.

9.11.3.7 The measures adopted as part of the project (see section 9.9) proposed provide as high a measure as is currently practicable of enabling preservation by record, through further survey (during the construction phase) and analysis of the palaeoenvironmental record.

9.11.3.8 Any impacts on palaeolandscapes and any associated archaeological remains will be permanent and any impacts would affect the receptor directly. Given the widespread extent and depth of the palaeochannels and the relatively limited nature of the impacts by comparison, they are predicted to be local in spatial extent. Based upon the information available at the time of writing (the very limited nature of the likely disturbance) the magnitude of impact is expected to be negligible.

Sensitivity of receptor

9.11.3.9 As established within the baseline assessment, there are widespread relict landscape features of late glacial and early Holocene date of archaeological potential within the Hornsea Three marine archaeology study area. They are relatively vulnerable to shallow disturbance of the seafloor; the older Pleistocene sediments being much too deeply buried to be affected by decommissioning activities.

9.11.3.10 Prehistoric archaeological receptors of this kind can be regarded as of potential national and international importance in contributing to our understanding of the UK and Europe's earliest human populations and should be regarded as high value receptors.

9.11.3.11 Due to their non-renewable and finite nature, prehistoric archaeological receptors will not recover from direct decommissioning impacts which would result in a permanent change to the receptor.

9.11.3.12 Buried prehistoric land surfaces are deemed to be of moderate vulnerability, irrecoverable and of high value. Based on the information available at the time of writing, the sensitivity of the receptor is expected to be medium.

Significance of effect

9.11.3.13 Based upon the information available at the time of writing, decommissioning activities are expected to represent a negligible magnitude of impact on prehistoric landscapes, a receptor of medium sensitivity. The effect of decommissioning activities on prehistoric landscapes is therefore predicted to be of **minor** adverse significance, which is not significant in EIA terms.

Foundation cutting/removal and cable removal may affect may affect shipwrecks and aircraft wrecks.

Magnitude of impact

9.11.3.14 The impacts of decommissioning activities on shipwrecks and aircraft wrecks in the Hornsea Three marine archaeology sturdy area will occur as a result of decommissioning activities (see paragraphs 9.10.3.4 to 9.10.3.6). The extent of any decommissioning impacts on shipwrecks and aircraft wrecks can be considered to be local, but where they do occur they will generally be adverse and irreversible and result in a permanent change to the receptor.

9.11.3.15 Wrecks, by their nature, are limited in extent. Any impacts would be permanent and any impacts would affect the receptor directly. Where wreck locations are already known, measures adopted as part of the project for their avoidance and protection, including the implementation of AEZs, are set out in in paragraphs in paragraphs 9.9.2.3 to 9.9.2.4, Table 9.12 and in volume 5, annex 9.2: Outline Written Scheme of Investigation. Measures to protect and record wrecks whose existence have not yet been identified and are discovered during decommissioning, including the implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b), are set out in paragraphs 9.9.2.7 to 9.9.3 and in volume 5, annex 9.2: Outline Written Scheme of Investigation. Based upon these measures adopted as part of the project, the magnitude of impact on wrecks is expected to be negligible.

Sensitivity of receptor

9.11.3.16 The value assigned to a shipwreck or aircraft wreck site is, to a large degree, site specific and will vary from site to site. As a whole, shipwreck and aircraft wrecks must be regarded as high value receptors.

9.11.3.17 Due to the non-renewable and finite nature of wrecks, where decommissioning impacts coincide with the receptor, it will not recover, resulting in a permanent change. The information available regarding wrecks and aerial losses in the Hornsea Three marine archaeology study area indicates a fairly even distribution of such wrecks.

9.11.3.18 Shipwreck and aircraft wrecks are deemed to be of high vulnerability, irrecoverable and of medium to high value. Based on the information available at the time of writing, the overall sensitivity of this receptor is expected to be medium to high.

Significance of effect

9.11.3.19 Based upon the information available at the time of writing, decommissioning activities are expected to represent a negligible magnitude of impact on wrecks, receptors of medium to high sensitivity. The effect of decommissioning activities on shipwrecks and aircraft wrecks is therefore predicted to be of minor adverse significance, which is not significant in EIA terms.

Future monitoring

9.11.3.20 Other than those measures described in the Outline WSI (volume 5, annex 9.2: Outline Written Scheme of Investigation), no future monitoring with respect to any of the above decommissioning phase effects is warranted or recommended.

9.12 Cumulative Effect Assessment methodology

9.12.1 Screening of other projects and plans into the Cumulative Effect Assessment

9.12.1.1 The Cumulative Effect Assessment (CEA) takes into account the impact associated with Hornsea Three together with other projects and plans. The projects and plans selected as relevant to the CEA presented within this chapter are based upon the results of a screening exercise undertaken as part of the 'CEA long list' of projects (see annex 4.5: Cumulative Effects Screening Matrix and Location of Schemes). Each project on the CEA long list has been considered on a case by case basis for scoping in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

9.12.1.2 In undertaking the CEA for Hornsea Three, it is important to bear in mind that other projects and plans under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to a cumulative impact alongside Hornsea Three. For example, relevant projects and plans that are already under construction are likely to contribute to cumulative impact with Hornsea Three (providing effect or spatial pathways exist), whereas projects and plans not yet approved or not yet submitted are less certain to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors. For this reason, all relevant projects and plans considered cumulatively alongside Hornsea Three have been allocated into 'Tiers', reflecting their current stage within the planning and development process. This allows the CEA to present several future development scenarios, each with a differing potential for being ultimately built out. Appropriate weight may therefore be given to each Tier in the decision making process when considering the potential cumulative impact associated with Hornsea Three (e.g. it may be considered that greater weight can be placed on the Tier 1 assessment relative to Tier 2). An explanation of each tier is included below:

- Tier 1: Hornsea Three considered alongside:
    - Other project/plans currently under construction; and/or
    - Those with consent, and, where applicable (i.e. for low carbon electricity generation projects), that have been awarded a Contract for Difference (CFD) but have not yet been implemented; and/or
    - Those currently operational that were not operational when baseline data was collected, and/or those that are operational but have an on-going impact.
- Tier 2: All projects/plans considered in Tier 1, as well as:
    - Those project/plans that have consent but, where relevant (i.e. for low carbon electricity generation projects) have no CFD; and/or
    - Submitted but not yet determined.

- Tier 3: All projects/plans considered in Tier 2, as well as those on relevant plans and programmes likely to come forward but have not yet submitted an application for consent (the PINS programme of projects and the adopted development plan including supplementary planning documents are the most relevant sources of information, along with information from the relevant planning authorities regarding planned major works being consulted upon, but not yet the subject of a consent application). Specifically, this Tier includes all projects where the developer has advised PINS in writing that they intend to submit an application in the future, those projects where a Scoping Report is available and/or those projects which have published a PEIR.

9.12.1.3 It is noted that offshore wind farms seek consent for a maximum design scenario and the 'as built' offshore wind farm will be selected from the range of consented scenarios. In addition, the maximum design scenario quoted in the application (and the associated Environmental Statement) are often refined during the determination period of the application. For example, it is noted that the Applicant for Hornsea Project One considered a maximum of turbines 332 turbines within the Environmental Statement, but has gained consent for 240 turbines. In addition, it is now known that Hornsea Project One 'as built' will consist of 174 turbines. Similarly, Hornsea Project Two has gained consent for an overall maximum number of turbines of 300, as opposed to 360 considered in the Environmental Statement and the as built number of turbines is likely to be less than this. A similar pattern of reduction in the project envelope from that assessed in the Environmental Statement, to the consented envelope and the 'as built' project is also seen across other offshore wind farms of relevance to this CEA. This process of refinement can result in a reduction to associated project parameters, for example the number and length of cable to be installed and the number of offshore substations. The CEA presented in this marine archaeology chapter has been undertaken on the basis of information presented in the Environmental Statements, for the other projects, plans and activities. Given that this broadly represents a maximum design scenario, the level of cumulative impact on marine archaeology would highly likely be reduced from those presented here.

9.12.1.4 The CEA has been undertaken in accordance with the Guidance for Assessment of Cumulative Impact on the Historic Environment from Offshore Renewable Energy (COWRIE 2008). The geographical scope of this cumulative assessment of the impacts of regional offshore development on the historic environment comprises the regional marine archaeology study area.

9.12.1.5 The specific projects scoped into this CEA and the Tiers into which they have been allocated, are outlined in Table 9.13 and shown on Figure 9.6. The projects included as operational in this assessment have been commissioned since the baseline studies for this project were undertaken and as such were excluded from the baseline assessment.

9.12.2 Maximum design scenario

9.12.2.1 The maximum design scenarios identified in Table 9.14 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative impact presented and assessed in this section have been selected from the details provided in the Hornsea Three project description (volume 1, chapter 3: Project Description), as well as the information available on other projects and plans, in order to inform a 'maximum design scenario'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme.

Table 9.13: List of other projects and plans considered within the CEA.

Tier	Phase	Project/Plan	Distance from Hornsea Three		Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
			Hornsea Three array area	Hornsea Three offshore cable corridor				
1	*Offshore wind farms*							
	Operational	Dudgeon	87 km	11 km	168 turbines consented, of which 67 turbines were constructed.	2015 to 2017	No	Yes
	Under construction	Hornsea Project One	7 km	7 km	332 turbines assessed in the Environmental Statement (although 240 turbines actually consented), of which 174 turbines to be constructed.	2017 to 2019	No	Yes
		Hornsea Project Two	7 km	18 km	360 turbines assessed in the Environmental Statement (although 300 turbines actually consented).	2020 to 2022	No	Yes
	Aggregate extraction sites							
	Operational (with on-going effects)	Humber 3 - 484	43 km	0 km	Operational	N/A	N/A (aggregate sites have no construction Phase)	Yes
		Humber 4 - 490	19 km	13 km	Operational	N/A	N/A (aggregate sites have no construction Phase)	Yes
		Humber 7 - 491	4 km	0 km	Operational	N/A	N/A (aggregate sites have no construction Phase)	Yes
		Humber 4 and 7 - 506	13 km	8 km	Application for operation sought up to 31 December 2029	N/A	N/A (aggregate sites have no construction Phase)	Yes
	Disposal areas							
	Operational (with on-going effects)	Well Beneficial use site2	137 km	15 km	Open	N/A	N/A (disposal sites have no construction Phase)	Yes
		Wells outer harbour site A	138 km	15 km	Open	N/A	N/A (disposal sites have no construction Phase)	Yes
		Wells outer harbour site B1	138 km	15 km	Open	N/A	N/A (disposal sites have no construction Phase)	Yes
		Wells outer harbour site C	139 km	15 km	Open	N/A	N/A (disposal sites have no construction Phase)	Yes
	Cables and pipelines							
	Under-construction	PL0219_PR K4-Z to K5-A	20 km	35 km	6-inch under construction gas pipeline operated by Total E&P Nederland B.V.	2017 to 2018	No	Yes
	Under-construction	PL0219_UM K4-Z to K5-A	20 km	35 km	5-inch under construction control pipeline operated by Total E&P Nederland B.V.	2017 to 2018	No	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three		Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation phase with Hornsea Three operation phase
			Hornsea Three array area	Hornsea Three offshore cable corridor				
	Proposed	PL0221_HS D18-A to D15-FA-1	19 km	45 km	2-inch proposed methanol pipeline operated by GDF SUEZ E&P Nederland B.V.	2019 to 2021	Yes	Yes
	Proposed	PL0221_PR D18-A to D15-FA-1	19 km	45 km	8-inch proposed gas pipeline operated by GDF SUEZ E&P Nederland B.V.	2019 to 2021	Yes	Yes
	Other activities							
	Operational (with on-going effects)	Commercial Fishing	-	-	Activity within the area consists of beam and demersal trawling, pelagic trawling, potting, purse seining and scallop dredging.	Ongoing	Yes	Yes
2	*Aggregate extraction sites*							
	Application	Humber 5 - 483	14 km	2 km	Application for operation sought up to 31 December 2029	N/A	N/A (aggregate sites have no construction Phase)	Yes
	Cables and pipelines							
	Proposed	Viking Interconnector	13 km	18 km	High voltage (up to 500 kV) Direct Current (DC) electricity interconnector	2019 to 2022	Yes	Yes

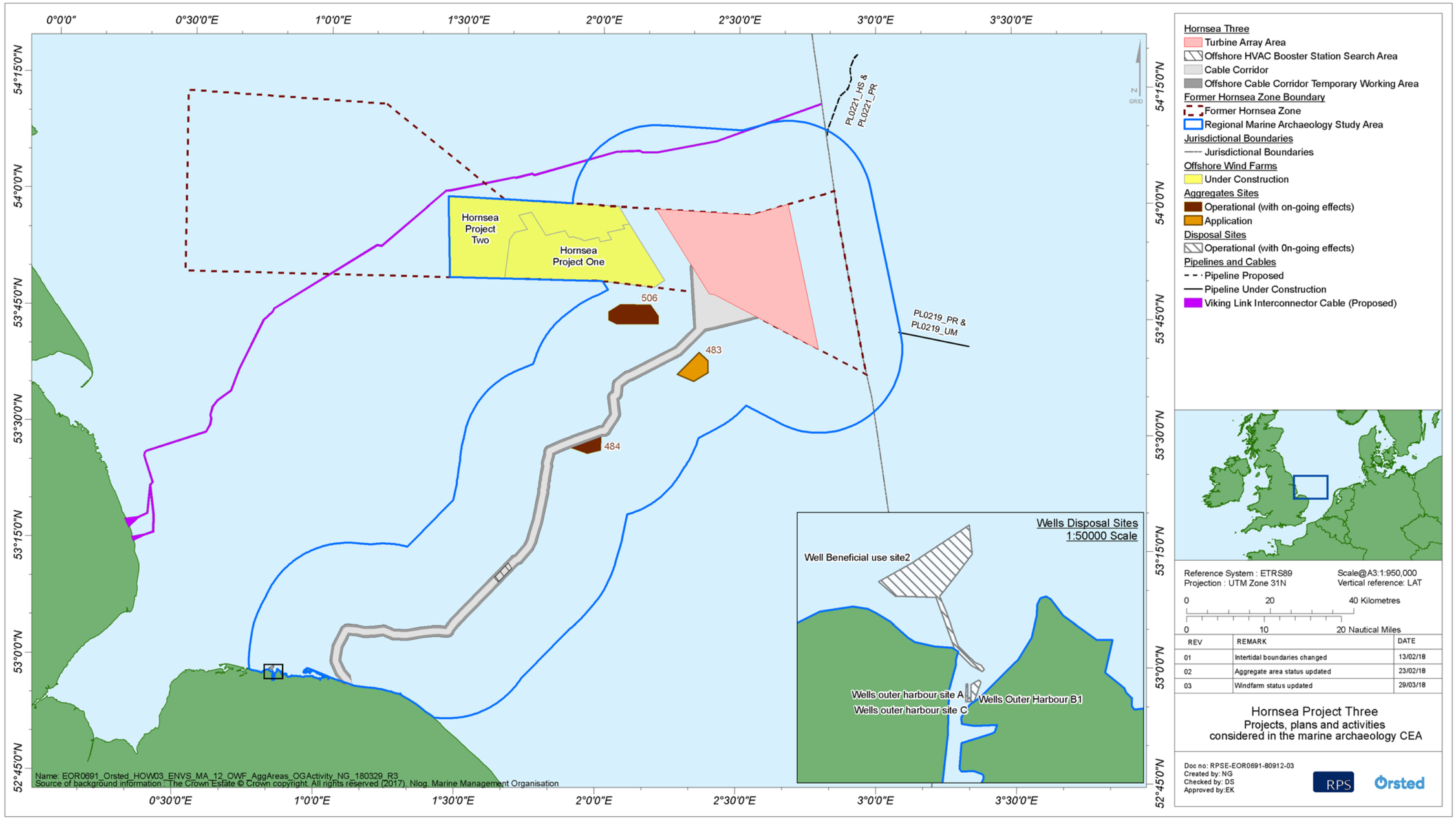

Figure 9.6: Offshore wind farm projects, aggregate areas, disposal areas and cables and pipelines within the regional marine archaeology study area and considered within the CEA.

Table 9.14: Maximum design scenario considered for the assessment of potential cumulative impacts on Marine Archaeology.

Potential impact	Maximum design scenario	Justification
Construction, operation and maintenance, and decommissioning phases		
Cumulative sediment disturbance from Hornsea Three, alongside offshore wind farms, aggregate extraction areas, cables and pipelines, and commercial fisheries activities, may damage or result in loss of prehistoric archaeological sites and materials and/or palaeoenvironmental information. Cumulative sediment disturbance from Hornsea Three, alongside offshore wind farms, aggregate extraction areas, cables and pipelines, and commercial fisheries activities, may damage or result in loss of maritime and aviation archaeological sites and materials in or on the seabed.	Maximum design scenario as described for construction phase assessed cumulatively with the full development of the following projects within a representative 20 km buffer, extended to include the Hornsea Project One and Hornsea Project Two array areas, of Hornsea Three: Tier 1: • Offshore wind farm projects operational and under construction (Dudgeon, Hornsea Project One and Hornsea Project Two); • Licenced aggregate extraction areas (Humber 3 – 484, Humber 4 – 490, Humber 7 – 491 and Humber 4 and 7 – 506) • Proposed cables and pipelines (PL0221_HS D18-A to D15-FA-1 and PL0221_PR D18-A to D15-FA-1); and • Commercial fisheries activities. Tier 2: • Application aggregate areas (Humber 5 - 483); and • Proposed cables and pipelines (Viking Interconnector). Tier 3: • No tier 3 projects.	Maximum additive sediment disturbance is calculated within a representative 20 km buffer of Hornsea Three as this area is considered to be a fair representation of the marine archaeology resources within the southern North Sea. Areas of sediment disturbance for other offshore wind farms have been taken from the respective Environmental Statement chapters, where available.
Cumulative deposition of sediments from Hornsea Three, alongside offshore wind farms and disposal sites, resulting in a potential effect on a variety of heritage assets.	Maximum design scenario as described for construction phase assessed cumulatively with the full development of the following projects within a representative 20 km buffer, extended to include the Hornsea Project One and Hornsea Project Two array areas, of Hornsea Three: Tier 1: • Offshore wind farm projects under construction (Hornsea Project One and Hornsea Project Two); and • Open disposal sites (Wells Beneficial Use site 2, Wells outer harbour site A, Wells outer harbour site B1 and Wells outer harbour site C). Tier 2: • No tier 2 projects. Tier 3: • No tier 3 projects.	Maximum additive deposition is calculated within a representative 20 km buffer of Hornsea Three as this area is considered to be a fair representation of the marine archaeology resources within the southern North Sea. Deposition for other offshore wind farms have been taken from the respective Environmental Statement chapters.

9.13 Cumulative Effect Assessment

9.13.1.1 A description of the significance of cumulative effects upon marine archaeology receptors arising from each identified impact is given below.

9.13.1.2 All plans/projects/activities screened into the assessment for cumulative effects are either ongoing activities (i.e. licensed and application aggregate extraction areas, commercial fisheries, disposal sites and oil and gas activities), projects which have been consented or submitted (i.e. replacement pipelines and offshore wind farms) or projects which have submitted a Scoping Report. There are no plans/projects listed on the PINS Programme of Projects where the developer has advised PINS in writing that they intend to submit an application in the future but have not submitted a Scoping Report within the regional marine archaeology. On this basis, there is no Tier 3 assessment.

Cumulative sediment disturbance from Hornsea Three, alongside offshore wind farms, aggregate extraction areas, cables and pipelines, and commercial fisheries activities, may damage or result in loss of prehistoric archaeological sites and materials, and/or palaeoenvironmental information.

9.13.1.3 There is the potential for cumulative temporary sediment disturbance as a result of activities associated with Hornsea Three and other offshore wind farm projects (i.e. from cable burial, anchor placements and construction of foundations for turbines and substations), aggregate extraction activities and cable and pipeline installation (see Table 9.13 and Figure 9.6). For the purposes of this Environmental Statement, this additive impact has been assessed within a representative 20 km buffer of Hornsea Three, extended to include the Hornsea Project One and Hornsea Project Two array areas, using the tiered approach outlined above in section 9.11.1.2).

Tier 1

Magnitude of impact

9.13.1.4 The range of activities considered here, especially aggregate extraction, has the potential to cause significant impacts on a finite and highly significant source of information about the human prehistory of the region. The potential for impacting these receptors increases with the effects of multiple projects on the seabed: the greater the number of interventions in the seabed, the greater the risk of impact on prehistoric archaeological receptors.

9.13.1.5 Predicted cumulative sediment disturbance from each of the Tier 1 plans, projects and activities is presented in Table 9.15 together with a breakdown of the sources of this data from the relevant Environmental Statements and any assumptions made where necessary information was not presented in these Environmental Statements. Table 9.15 shows that for all projects, plans, activities in the Tier 1 assessment, the cumulative sediment disturbance is estimated at 516.48 km^2. This will represent approximately 5.1% of the regional marine archaeology study area (10,091 km^2).

9.13.1.6 Predicted overall impacts on the seabed from offshore wind farm, aggregate extraction and cable and pipeline projects is presented in Table 9.15 (note that where only a part of an offshore wind farm project or aggregate extraction site overlaps with the regional marine archaeology study area, the entire project has been considered).

9.13.1.7 Commercial fishing, especially invasive techniques such as pelagic, demersal trawling and dredging for scallops, will cause some degree of disturbance to seafloor sediments, albeit generally to depths less than 0.2 m. The distribution of such techniques across the regional marine archaeology study area is very uneven, with trawling scars on the seafloor only identified by the Humber REC in the eastern half of the Humber REC area (including within the Hornsea Three array area) where these techniques are most used. Generally it seems unlikely that effects on sediments of geoarchaeological sensitivity will be anything more than superficial and localised.

9.13.1.8 The impact of sediment disturbance from Hornsea Three, cumulatively with other offshore wind farms, aggregate extraction areas, cables and pipelines and commercial fisheries is predicted to be of local spatial extent, long term duration, continuous and limited reversibility. The impact will affect the receptor directly. The magnitude of impact is therefore, considered to be negligible.

Sensitivity of receptor

9.13.1.9 Early Holocene landscapes on the seafloor within the regional marine archaeology study area are described in the Humber REC (Tappin *et al.*, 2011) and in the NSPP (Gaffney *et al.*, 2007). Early Holocene landscapes are limited and discrete in their distribution, surviving largely within palaeochannels. The widespread extent and depth of palaeochannels is noted. In some cases the sediments in question have been found to be unprotected by any overburden and therefore open to marine erosion (Tappin *et al.*, 2011).

9.13.1.10 Due to their non-renewable and finite nature, prehistoric archaeological receptors will not recover from direct impacts from projects, plans and activities screened into the tier 1 assessment. This will result in a permanent change to the receptor. It is likely that early Holocene sediments, if present, will be affected by these projects, plans and activities. It is less easy to assess the cumulative impact on archaeological sites and objects, which are most likely to be relatively ephemeral remains of Mesolithic settlement. While no sites are known to exist for certain, it seems highly probable that they exist in this area and in all probability, given their waterlogged nature, are exceptionally well-preserved. Such sites could be of national significance.

9.13.1.11 The preserved landscape features are deemed to be of high vulnerability, irrecoverable and high value. The sensitivity of the receptor is therefore, considered to be high.

Table 9.15: Cumulative sediment disturbance for Hornsea Three and other plans/projects/activities in the CEA.

Project	Total predicted seabed disturbance	Source
Hornsea Three	63.86 km²	See Table 9.8.
Tier 1		
Offshore wind farms		
Dudgeon	1.65 km²	Values taken from Environmental Statement (Dudgeon Offshore Wind Limited, 2009, 2009): 1.2 km² from cable installation, 0.0315 km² from jack-up barges and 0.42 km² from foundations for turbines and substations.
Hornsea Project One	14.16 km²	Values taken from Environmental Statement (SMart Wind, 2013): 2.167 km² from turbines, 0.697 km² from jack-up barges, 5.3 km² from array and inter-connector cable burial and 6 km² from export cable burial.
Hornsea Project Two	27.83 km²	Values taken from Environmental Statement (SMart Wind, 2015): 0.47 km² from jack up barges, 10.34 km² from array and inter-connector cable burial (including anchor placements), 12.60 km² from export cable burial, and 2.23 km² from installation of turbines and substations.
Total offshore wind farms (including Hornsea Three)	107.48 km²	-
Aggregate extraction areas		
Licensed areas	345.10 km²	Total licenced area.
Cables and Pipelines		
PL0219_PR and PL0219_UM K4-Z to K5-A pipeline route and umbilical	0.01 km²	Assumptions made for the cumulative assessment: trench width of 21 m along the 430 m within the regional marine archaeology study area.
PL0221_HS D18-A to D15-FA-1 and PL0221_PR D18-A to D15-FA-1	0.03 km²	Assumptions made for the cumulative assessment: trench width of 21 m along the 1,205 m within the regional marine archaeology study area.
Total cables and pipelines	0.04 km²	-
Total Tier 1	*516.486 km²*	-
Tier 2		
Aggregate extraction areas		
Application areas	28.2 km²	-
Cables and Pipelines		
Viking Interconnector	0.86 km²	Assumptions made for the cumulative assessment: trench width of 10 m for up to 2 cable circuits along the 42,812 m interconnector length within the regional marine archaeology study area.
Total Tier 2 (including Tier 1)	*545.54 km²*	-

Significance of Effect

9.13.1.12 Overall, the sensitivity of prehistoric archaeological sites and materials, and/or palaeoenvironmental information is considered to be high and the magnitude is deemed to be negligible. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Tier 2

Magnitude of impact

9.13.1.13 The Tier 2 assessment includes all Tier 1 projects and the proposed Viking Interconnector and aggregate application area 483. Table 9.15 shows that for all projects, plans, activities in the Tier 2 assessment, the cumulative sediment disturbance is estimated at 545.54 km².

9.13.1.14 The cumulative impact of seabed disturbance is predicted to be of local spatial extent, long term duration, continuous and limited reversibility. The impact will affect the receptor directly. The magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

9.13.1.15 As noted in paragraphs 9.12.1.9 to 9.12.1.11 above, the preserved landscape features are deemed to be of high vulnerability, irrecoverable and high value. The sensitivity of the receptor is therefore, considered to be high.

Significance of the effect

9.13.1.16 Overall, the sensitivity of prehistoric archaeological sites and materials, and/or palaeoenvironmental information is considered to be high and the magnitude is deemed to be negligible. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Cumulative sediment disturbance from Hornsea Three, alongside offshore wind farms, aggregate extraction areas, cables and pipelines, and commercial fisheries activities, may damage or result in loss of maritime and aviation archaeological sites and materials in or on the seabed.

9.13.1.17 There is the potential for cumulative temporary sediment disturbance as a result of activities associated with Hornsea Three and other offshore wind farm projects (i.e. from cable burial, anchor placements and construction of foundations for turbines and substations), aggregate extraction activities and cable and pipeline installation (see Table 9.13 and Figure 9.6). For the purposes of this Environmental Statement, this additive impact has been assessed within a representative 20 km buffer of Hornsea Three using the tiered approach outlined above in section 9.11.1.2).

Tier 1

Magnitude of impact

9.13.1.18 The cumulative effects of seabed development within the regional marine archaeology study area on shipwrecks and aviation wrecks will generally be adverse and irreversible and where they occur will result in a permanent change to the receptor at a regional level. While the baseline review established that the potential for a number of maritime and aviation sites in the regional marine archaeology study area is high, measures as listed in paragraphs 9.9.3.1 to 9.9.3 are generally taken to avoid impacts on maritime, aviation and archaeological sites and materials on the seabed by other projects, plans and activities. To a large extent, therefore, overall levels of seabed disturbance, as shown in Table 9.15, are mitigated.

9.13.1.19 Techniques of commercial fishing involving disturbance of the seafloor are known to cause some damage to wrecks which varies considerably according to their age, character and condition. This is likely to have led to limited degradation of the condition of shipwrecks and aviation wrecks across much of the regional marine archaeology study area, particularly in the north eastern part of the Humber REC area (including within the Hornsea Three array area) where invasive techniques are most commonly used.

9.13.1.20 Impacts resulting from the construction, operation and maintenance, and decommissioning phases of offshore wind and oil and gas developments, together with the operational phases of aggregate extraction and commercial fisheries, are likely to be local and permanent. Any impacts would affect the receptor directly. Standard industry practice should be applied across all projects in consultation with Historic England meaning that impacts on shipwrecks and aviation wreck will normally be avoided, with the possible exception of the impacts arising from commercial fishing.

9.13.1.21 On this basis the impact is predicted to be of local spatial extent, long term duration, continuous and limited reversibility. The impact will affect the receptor directly. The magnitude is therefore, considered to be negligible.

Sensitivity of receptor

9.13.1.22 SeaZone data indicates that the UKHO holds records for 169 live wrecks and 79 dead wrecks within the regional marine archaeology study area. The NRHE Named Locations include 24 records within the regional marine archaeology study area, which contain records for 449 maritime casualties, of which 46 are aircraft. The character and date of these wrecks varies greatly, a substantial proportion being the result of combat in the First World War and Second World War, with the largest number being sunk by mines.

9.13.1.23 All shipwrecks and aircraft wrecks are highly vulnerable to seafloor development. On this basis they are deemed to be of medium to high vulnerability, irrecoverable and high value. The sensitivity of the receptor is therefore, considered to be medium to high.

Significance of effect

9.13.1.24 Overall, the sensitivity of the receptor is considered to be medium to high and the magnitude is deemed to be negligible. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Tier 2

Magnitude of impact

9.13.1.25 The Tier 2 assessment includes all Tier 1 projects and the proposed Viking Interconnector. There is currently no detailed information on the impact of seabed disturbance during cable installation for this project and therefore the same assumptions have been made as for Hornsea Three (see Table 9.15). If further detailed information becomes available prior to the compilation of the Hornsea Three Environmental Statement, this will be included in the CEA.

9.13.1.26 The cumulative impact of seabed disturbance is predicted to be of local spatial extent, long term duration, continuous and limited reversibility. The impact will affect the receptor directly. The magnitude is therefore, considered to be low.

Sensitivity of the receptor

9.13.1.27 As noted in paragraphs 9.12.1.22 to 9.12.1.22 above, all shipwrecks and aircraft wrecks are highly vulnerable to seafloor development. On this basis they are deemed to be of medium to high vulnerability, irrecoverable and high value. The sensitivity of the receptor is therefore, considered to be medium to high.

Significance of the effect

9.13.1.28 Overall, the sensitivity of the receptor is considered to be medium to high and the magnitude is deemed to be negligible. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

Cumulative deposition of sediments from Hornsea Three, alongside offshore wind farms and disposal sites, resulting in a potential effect on a variety of heritage assets.

9.13.1.29 There is the potential for cumulative sediment deposition as a result of construction activities associated with Hornsea Three and other offshore wind farm projects (e.g. from sandwave clearance, cable installation and seabed preparation for the installation of gravity base foundations) and dredge disposal activities (see Table 9.14 and Figure 9.6). For the purposes of this Environmental Statement, this additive impact has been assessed within a representative 20 km buffer, extended to include Hornsea Project One and Hornsea Project Two array areas, of Hornsea Three using the tiered approach outlined above in section 9.11.1). No Tier 2 or Tier 3 projects have been identified.

Tier 1

Magnitude of impact

9.13.1.30 Sediment deposition is predicted to occur during the construction phases of Hornsea Project One and Hornsea Project Two as a result of seabed clearance for foundation installation, cable installation and sandwave clearance activities. The disposal of other material (e.g. harbour dredging works) in the disposal sites at Wells Beneficial Use site 2, Wells outer harbour site A, Wells outer harbour site B1 and Wells outer harbour site C will also result in the deposition of material on the seabed.

9.13.1.31 Predicted cumulative sediment disturbance from each of the Tier 1 plans, projects and activities is presented in Table 9.16 together with a breakdown of the sources of this data from the relevant Environmental Statements and any assumptions made where necessary information was not presented in these Environmental Statements. Table 9.16 shows that for all projects, plans, activities in the Tier 1 assessment, the cumulative sediment deposition area is estimated at 43.44 km^2. This will represent approximately 0.43% of the regional marine archaeology study area (10,210 km^2*).*

9.13.1.32 The resulting impacts on heritage assets are likely to be local and permanent, and any impacts would affect the receptor indirectly.

9.13.1.33 On this basis the impact is predicted to be of local spatial extent, long term duration, continuous and limited reversibility. The impact will affect the receptor directly. The magnitude is therefore, considered to be negligible.

Table 9.16: Cumulative sediment deposition for Hornsea Three and other plans/projects/activities in the CEA.

Project	Total predicted area seabed deposition	Source
Hornsea Three	6.34 km^2	See Table 9.8.
Tier 1		
Offshore wind farms		
Hornsea Project One	16.8 km^2	Values taken from Environmental Statement (SMart Wind, 2013): 16.8 km^2 from seabed preparation activities for gravity base foundations.
Hornsea Project Two	19.7 km^2	Values taken from Environmental Statement (SMart Wind, 2015): 18.1 km^2 from seabed preparation activities for gravity base foundations and 1.6 km^2 from sandwave clearance activities.
Total offshore wind farms (including Hornsea Three)	42.84 km^2	-
Open Disposal Sites		
Wells Beneficial Use site 2	0.57 km^2	Total area of disposal site.
Wells outer harbour site A	0.02 km^2	Total area of disposal site.
Wells outer harbour site B1	0.002 km^2	Total area of disposal site.
Wells outer harbour site C	0.006 km^2	Total area of disposal site.
Total disposal sites	0.60 km^2	-
Total Tier 1	*43.44 km^2*	-

Sensitivity of receptor

9.13.1.34 The deposition of sediment on the seabed is considered to be potentially beneficial in nature as it may contribute to the preservation of non-renewable archaeological sites and material through burial.

9.13.1.35 Marine archaeological receptors are deemed to be of moderate to high vulnerability, irrecoverable and of high value. Where sediment deposition occurs, archaeological receptors are not likely to be affected and their sensitivity to this impact can therefore be considered negligible.

Significance of Effect

9.13.1.36 Overall, the sensitivity of marine archaeology receptors is considered to be negligible and the magnitude is deemed to be negligible. The effect will, therefore, be of **minor** adverse significance, which is not significant in EIA terms.

9.14 Transboundary effects

9.14.1.1 A screening of transboundary impacts has been carried out and is presented in Volume 4 Annex 5.3: Transboundary Impacts Screening Note. This screening exercise identified that there was no potential for significant transboundary effects with regard to marine archaeology from Hornsea Three upon the interests of other EEA States.

9.15 Inter-related effects

9.15.1.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, operational and maintenance, and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project stages (e.g. seabed disturbance during the construction, operation and maintenance and decommissioning phases); and
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on marine archaeology, such as direct seabed disturbance and sediment plumes, may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.

9.15.1.2 A description of the likely inter-related effects arising from Hornsea Three on marine archaeology is provided in volume 2, chapter 12: Inter-Related Effects (Offshore).

9.16 Conclusion and summary

9.16.1.1 The desktop study and Hornsea Three field surveys have identified extensive remains within the regional marine archaeology study area of marine archaeological potential and/or significance. These comprise largely buried remains of palaeolandscapes, wrecks and possible aviation losses. The evidence indicates that palaeolandscapes are discreetly grouped within the regional marine archaeology study area. Seabed remains of wrecks and aviation losses are relatively easy to recognise from geophysical surveys and thus are likely to be largely avoided and preserved.

9.16.1.2 Offshore wind farms can result in adverse and beneficial impacts on marine archaeology. For the purposes of this assessment, effects have been defined based on the disturbance of prehistoric land surfaces, and on shipwrecks and aircraft wrecks. Effects are therefore defined as adverse throughout the assessment. Nevertheless, it is noted that they could, in fact, also be seen as beneficial through improved understanding of human history and prehistory.

9.16.1.3 The significance of effect (see Table 9.17) on marine archaeology was based on a substantial package of measures, designed into the project, set out in the accompanying Outline WSI (volume 5, annex 9.2: Outline Written Scheme of Investigation) intended to i) identify archaeologically sensitive remains encountered during the development, ii) to avoid them wherever possible and iii) to enable recording of any remains that are directly affected.

9.16.1.4 Construction activities within the Hornsea Three array area and offshore cable corridor have the potential to result in a range of potential impacts on marine archaeology. These include the removal or disturbance of sediments resulting in a potential effect on near-surface prehistoric land surfaces and deeply buried prehistoric land surfaces along with potential effects on shipwrecks, aircraft wrecks and a variety of heritage assets; These potential impacts have all been assessed as being of **minor** adverse significance (not significant in EIA terms).

9.16.1.5 Maintenance operations may affect prehistoric land surfaces through the removal or disturbance of sediments and also have the potential to affect shipwrecks and aircraft wrecks. These impacts have also been assessed to be of **minor** adverse significance (not significant in EIA terms).

9.16.1.6 Decommissioning activities are predicted to have an impact of **minor** adverse significance (not significant in EIA terms) on prehistoric landscapes and shipwrecks and aircraft wrecks.

9.16.1.7 The cumulative impact upon marine archaeology when the construction, operation and decommissioning phases of Hornsea Three has been considered together with the construction and operation of other planned nearby wind farm projects, planned oil and gas operations, cables and pipelines and applications for aggregate extraction. Overall, effect will be of **minor** adverse significance (not significant in EIA terms).

9.16.1.8 A screening of transboundary impacts has been carried out and identified that there was no potential for significant transboundary effects with regard to marine archaeology from Hornsea Three upon the interests of other EEA States.

Table 9.17: Summary of potential environment effects, mitigation and monitoring.

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Construction Phase							
Construction activities within the Hornsea Three array area and offshore cable corridor causing the removal or disturbance of sediments resulting in a potential effect on near-surface prehistoric land surfaces.	Archaeological input into specifications for and analysis of geophysical surveys. Archaeological input to geotechnical surveys where deposits of known archaeological potential are likely to be affected. Analysis and dating of samples recovered during pre-construction geotechnical surveys in areas where impacts on deposits of geoarchaeological and/or palaeoenvironmental significance seem likely. Archaeologists to be consulted in the preparation of pre-construction cable route clearance or other pre-construction clearance operations and, if appropriate, to carry out watching briefs of such work. Implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b).	Negligible	High	Minor adverse	None required	N/A	None
Construction activities within the Hornsea Three array area and offshore cable corridor resulting in a potential effect on shipwrecks and aircraft wrecks.	Hornsea Threes archaeologists to be consulted in the preparation of any pre-construction ROV/diver surveys and, if appropriate, in monitoring/checking of data. Investigation of SeaZone/UKHO records classified as 'dead' during the future assessment of higher resolution geophysical survey data. The identification and implementation of AEZs around sites identified as having high and medium archaeological potential. Final turbine locations to avoid any known archaeological constraints identified in pre-construction surveys through micrositing. There will be maintenance of an operational awareness of the location of low archaeological potential contacts. The identification and implementation of TAEZs. Archaeologists to be consulted in the preparation of pre-construction cable route clearance or other pre-construction clearance operations and, if appropriate, to carry out watching briefs of such work. Mitigation of unavoidable direct impacts on known sites of archaeological significance. Implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b).	Negligible	Medium to high	Minor adverse	None required	N/A	None
Construction of turbines, and substations and accommodation platforms within the Hornsea Three array area with jacket foundations causing the removal or disturbance of sediments resulting in a potential effect on deeply buried prehistoric land surfaces.	Archaeological input into specifications for and analysis of geophysical surveys. Archaeological input to geotechnical surveys where deposits of known archaeological potential are likely to be affected. Analysis and dating of samples recovered during pre-construction geotechnical surveys in areas where impacts on deposits of geoarchaeological and/or palaeoenvironmental significance seem likely. Archaeologists to be consulted in the preparation of pre-construction cable route clearance or other pre-construction clearance operations and, if appropriate, to carry out watching briefs of such work. Implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b).	Negligible	High	Minor adverse	None required	N/A	None

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Seabed preparation in connection with gravity base foundation installation and sand wave clearance causing sediment deposition on the seabed resulting in a potential effect on a variety of heritage assets.	Hornsea Threes archaeologists to be consulted in the preparation of any pre-construction ROV/diver surveys and, if appropriate, in monitoring/checking of data. Investigation of SeaZone/UKHO records classified as 'dead' during the future assessment of higher resolution geophysical survey data. The identification and implementation of AEZs around sites identified as having high and medium archaeological potential. Final turbine locations to avoid any known archaeological constraints identified in pre-construction surveys through micrositing.	Negligible	Negligible	Negligible	None required	N/A	None
Cable installation within the Hornsea Three intertidal area may affect buried shipwrecks, navigation poles, jetty revetments or remains or other archaeological evidence for past coastal activities.	There will be maintenance of an operational awareness of the location of low archaeological potential contacts. The identification and implementation of TAEZs. Archaeologists to be consulted in the preparation of pre-construction cable route clearance or other pre-construction clearance operations and, if appropriate, to carry out watching briefs of such work. Mitigation of unavoidable direct impacts on known sites of archaeological significance. Implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b).	Negligible	High	Minor adverse	None required	N/A	None
Operation Phase							
Maintenance operations which may affect prehistoric land surfaces through the removal or disturbance of sediments.	Archaeological input into specifications for and analysis of geophysical surveys. Archaeological input to geotechnical surveys where deposits of known archaeological potential are likely to be affected. Analysis and dating of samples recovered during pre-construction geotechnical surveys in areas where impacts on deposits of geoarchaeological and/or palaeoenvironmental significance seem likely. Archaeologists to be consulted in the preparation of pre-construction cable route clearance or other pre-construction clearance operations and, if appropriate, to carry out watching briefs of such work. Implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b).	Negligible	Medium	Minor adverse	None required	N/A	None
Maintenance operations may affect may affect shipwrecks and aircraft wrecks	Hornsea Threes archaeologists to be consulted in the preparation of any pre-construction ROV/diver surveys and, if appropriate, in monitoring/checking of data. Investigation of SeaZone/UKHO records classified as 'dead' during the future assessment of higher resolution geophysical survey data. The identification and implementation of AEZs around sites identified as having high and medium archaeological potential. Final turbine locations to avoid any known archaeological constraints identified in pre-construction surveys through micrositing. There will be maintenance of an operational awareness of the location of low archaeological potential contacts. The identification and implementation of TAEZs. Archaeologists to be consulted in the preparation of pre-construction cable route clearance or other pre-construction clearance operations and, if appropriate, to carry out watching briefs of such work. Mitigation of unavoidable direct impacts on known sites of archaeological significance. Implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b).	Negligible	Medium to high	Minor adverse	None required	N/A	None

Description of impact	Measures adopted as part of the project	Magnitude of impact	Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
Decommissioning Phase							
Foundation cutting/removal and cable removal which may affect prehistoric land surfaces through the removal or disturbance of sediments.	Archaeological input into specifications for and analysis of geophysical surveys. Archaeological input to geotechnical surveys where deposits of known archaeological potential are likely to be affected. Analysis and dating of samples recovered during pre-construction geotechnical surveys in areas where impacts on deposits of geoarchaeological and/or palaeoenvironmental significance seem likely. Archaeologists to be consulted in the preparation of pre-construction cable route clearance or other pre-construction clearance operations and, if appropriate, to carry out watching briefs of such work. Implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b).	Negligible	Medium	Minor adverse	None required	N/A	None
Foundation cutting/removal and cable removal may affect may affect shipwrecks and aircraft wrecks.	Hornsea Threes archaeologists to be consulted in the preparation of any pre-construction ROV/diver surveys and, if appropriate, in monitoring/checking of data. Investigation of SeaZone/UKHO records classified as 'dead' during the future assessment of higher resolution geophysical survey data. The identification and implementation of AEZs around sites identified as having high and medium archaeological potential. Final turbine locations to avoid any known archaeological constraints identified in pre-construction surveys through micrositing. There will be maintenance of an operational awareness of the location of low archaeological potential contacts. The identification and implementation of TAEZs. Archaeologists to be consulted in the preparation of pre-construction cable route clearance or other pre-construction clearance operations and, if appropriate, to carry out watching briefs of such work. Mitigation of unavoidable direct impacts on known sites of archaeological significance. Implementation of the Offshore Renewables Protocol for Archaeological Discoveries (Crown Estate, 2010b).	Negligible	Medium to high	Minor adverse	None required	N/A	None

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