Preliminary Environmental Information Report Volume 2

Appendix 26.3
Stage 2 Marine Geoarchaeological Recording

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Stage 2 Marine Geoarchaeological Recording

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Summary

Wessex Archaeology (WA) have been commissioned by Collaborative Environmental Advisers (CEA) (the 'Client'), on behalf of National Grid Lion Link Limited (NGLLL) ('the Applicant'), to undertake a Stage 2 geoarchaeological recording of selected geotechnical vibrocores. The vibrocores were acquired during two surveys undertaken in 2024 from within the Proposed Scheme, defined as the part of the LionLink Project (hereafter referred to as the 'Project') within the British jurisdiction. The marine elements of the Proposed Scheme (the 'Proposed Offshore Scheme') will route from the proposed Landfall across the southern North Sea to the boundary between the UK and Netherlands Exclusive Economic Zone (EEZ).

This Stage 2 geoarchaeological assessment follows the Stage 1 review undertaken in March 2025 from which a series of recommendations were proposed, focusing on the physical recording of selected sub-samples considered as geoarchaeologically significant.

A total of 41 vibrocores were recommended for Stage 2 geoarchaeological recording, which contained units of archaeological potential, including fluvial deposits of the Yarmouth Roads Formation, upper organic bedded sediments of the Eem Formation, possible estuarine to intertidal sands of the Upper Brown Bank Formation, fluvial sands and gravels and alluvial sands, peat and organic interbedded deposits.

A series of deposits in the nearshore were reinterpreted as representing sediments of the Undifferentiated Crag Formations and the Westkapelle Ground Formation. The Westkapelle Ground Formation pre-dates the earliest known occupation of Britain and are considered to have low archaeological potential. However, if present within the Undifferentiated Crag Formations, the Wroxham Crag Formation may contain terrestrial sediments equivalent to the Cromer Forest Bed Formation, which could contain internationally significant archaeological and palaeoenvironmental records.

Grey sands with laminae and shells were recovered in vibrocores across the Proposed Offshore Scheme and correlate to Lower to Middle Pleistocene deltaic sediments of the Yarmouth Roads Formation (MIS >13). Offshore, these deposits are typically shell-rich and reflect deposition in a shallow marine setting with low archaeological and geoarchaeological potential; however, shell-free sands with organic laminae are present, and may represent floodplain deposits. Floodplain environments are rich ecological settings favoured by early human hunter-gatherers. In the nearshore, grey sands with clay beds and peats may correlate to the Yarmouth Roads Formation, which is thought to contain units that are broadly contemporary with terrestrial deposits of the Cromer Forest Bed Formation. Peat deposits of Cromerian age are rare and are therefore assigned a high priority status.

Possible upper estuarine to intertidal deposits associated with the Upper Brown Bank Formation are also recorded, and are suggested to reflect increasing depositional energy in response to the regression of the shallow lagoon embayment which was present in the southern North Sea between MIS 5d-3. Without a clear understanding of the depositional history, the archaeological importance of this unit is poorly understood.

Peat was recovered in the offshore and nearshore areas of the Proposed Offshore Scheme. The offshore peat deposits were located stratigraphically above possible estuarine to intertidal deposits of the Upper Brown Bank and are therefore likely to date from the Late Glacial to Early Holocene. Nearshore, peats possibly within the Yarmouth Roads Formation were identified which may contain a significant palaeoenvironmental record of Cromerian age. Peat deposits formed in terrestrial wetland environments are assigned a high priority status due to their potential to preserve palaeoenvironmental material.

No organic interbedded deposits were identified in the Stage 2 recording and as such were re-defined as ‘Interbedded sand and clay’. In the nearshore, these deposits are associated with channel features and may represent fluvial, estuarine or intertidal fill deposits.

Recommendations for further geoarchaeological works include radiocarbon dating and luminescence dating of Peat and Upper Brown Bank deposits, respectively, to develop a robust chronology and age constrain these deposits. It is also recommended the assessment of foraminifera, ostracods, diatoms, pollen (and non-pollen palynomorphs) and plant macrofossils is undertaken for a number of vibrocores recovered from the Proposed Offshore Scheme. The assessment of microfossils will improve our understanding of environmental change in this landscape and confirm the depositional environment of deposits and potentially allow biostratigraphic correlation with specific intervals of the Pleistocene (relative dating).

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Stage 2 Geoarchaeological Recording of 2024 Geotechnical Data

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology (WA) have been commissioned by Collaborative Environmental Advisers (CEA) (the 'Client'), on behalf of National Grid Lion Link Limited (NGLLL) ('the Applicant'), to undertake a Stage 2 geoarchaeological recording of selected geotechnical vibrocores. The vibrocores were acquired during two surveys undertaken in 2024 from within the marine elements of the LionLink (hereafter referred to as 'the Proposed Scheme') within the British jurisdiction. The Proposed Offshore Scheme will route from the proposed Landfall Site across the southern North Sea to the boundary between the UK and Netherlands Exclusive Economic Zone (EEZ) (**Figure 1**).

1.1.2 LionLink project is a proposed electricity interconnector between Great Britain and the Netherlands that will supply up to 2 gigawatts (GW) of electricity and will connect to Dutch offshore wind via an offshore converter platform in Dutch waters. LionLink project will play an important role in reducing the UK's reliance on fossil fuels and supporting the UK government's objectives to create a secure, reliable, and affordable energy supply for UK households.

1.1.3 The Proposed Offshore Scheme would involve the construction of a converter station and the installation of offshore and onshore underground high voltage direct current cables (HVDC) to the onshore converter station and underground high voltage alternating current cables (HVAC) between the converter station and the proposed Friston substation.

1.1.4 This Stage 2 report will focus on the area defined as the Proposed Offshore Scheme, covering from Mean High Water Springs (MHWS) to the GB/NL EEZ boundary.

1.2 Summary of previous work

1.2.1 This Stage 2 geoarchaeological assessment follows the previous Stage 1 review undertaken in March 2025 (Wessex Archaeology 2025a) from which a series of recommendations were proposed, focusing on the physical recording of selected sub-samples considered as geoarchaeologically significant.

1.2.2 A total of 224 geotechnical vibrocores were reviewed as part of the Stage 1 geoarchaeological assessment, with 10 key Quaternary deposits identified comprising lowermost grey sands (Yarmouth Roads Formation), marine to shallow marine deposits (Eem Formation), intertidal to shallow marine sands (Lower Brown Bank Formation), estuarine alluvium (Upper Brown Bank Formation), estuarine to intertidal sands (Upper Brown Bank Formation), fluvial sands and gravels and alluvial sands, peat, organic interbedded and head. These deposits are frequently overlain by a thin veneer of seabed sediments. A summary of key stratigraphic units proposed during the review process is presented in **Table 1**, as presented in the Stage 1 review report (Wessex Archaeology 2025a).

Table 1 Shallow stratigraphy of deposits within the Proposed Offshore Scheme

Unit	WA Unit Name	Description	Formation	Epoch
8	Seabed sediment	Fine to coarse sand with shell fragments	Seabed sediment	Modern/Late Holocene
7	Head	Soft to firm slightly sandy and gravelly clay	n/a	Early to mid-Holocene
6b	Organic interbedded	Olive to reddish brown silty sand with beds of organic silt and clay	n/a	Early Holocene (pre-transgression)
6a	Peat	Dark brown peat	n/a	
5	Fluvial sands and gravels/ alluvial sands	Orangish brown gravelly sands and sandy gravels (fluvial) and laminated sands (alluvial)	n/a	Early Holocene to Cromerian (MIS >13-1)
4b	Estuarine to intertidal sands	Gravelly fine to coarse sands with shell fragments and thin beds and laminae of silts and clays	Upper Brown Bank Formation	Early to Mid-Devensian (MIS 5d-3)
4a	Estuarine alluvium	High strength greenish grey sandy silty clay and clayey silt	Upper Brown Bank Formation	
3	Intertidal to shallow marine	Greenish grey fine to coarse occasionally gravelly sand with occasional faint laminae	Lower Brown Bank Formation	Early Devensian (MIS 5e-5d)
2	Marine to shallow marine	Dense brown sands with frequent shell fragments. Frequently overlain by organic silt/sand	Eem Formation	Ipswichian Interglacial (MIS 5e)
1	Grey sands	Light greenish grey fine to medium silty sand and clayey sand with thin beds of stiff clay	Yarmouth Roads Formation	Cromerian (>MIS 13)

1.2.3 Based on the Stage 1 review, a series of deposits interpreted as representing possible former terrestrial landscapes were recommended for further Stage 2 geoarchaeological recording, in order to corroborate interpretations and determine the suitability of these deposits for Stage 3 palaeoenvironmental assessment. A full list of vibrocores recommended for Stage 2 recording is outlined in **Table 2** and includes details of core recovery, outlining if samples were retained by the geotechnical contractor prior to geotechnical testing, or were re-acquired during a later geotechnical survey for geoarchaeological purposes.

Table 2 Recommendations for Stage 2 geoarchaeological recording

ID	Easting	Northing	Interpretation/Unit	Recovery
VC_001_A	412606	5798283	Organic interbedded (Unit 6b)	Retained
VC_002_A	413690	5798598	Fluvial sands and gravels/alluvial sands (Unit 5)	Retained
VC_003	414312	5798932	Organic interbedded (Unit 6b) and Fluvial sands and gravels/alluvial sands (Unit 5)	Retained
VC_005	415720	5799682	Organic interbedded (Unit 6b) and Peat (Unit 6a)	Retained
VC_073	465417	5834162	Upper Brown Bank (Unit 4b)	Retained
VC_075	466479	5835397	Upper Brown Bank (Unit 4b)	Retained
VC_088	472420	5846137	Organic interbedded (Unit 6b)	Retained
VC_095	472437	5853142	Upper Brown Bank (Unit 4b)	Retained
VC_114	473080	5871274	Organic interbedded (Unit 6b)	Retained
VC_120	474361	5877455	Organic interbedded (Unit 6b)	Retained
VC_154	494754	5899907	Eem Formation - bedded organics (Unit 2)	Retained
VC_166	498090	5911436	Eem Formation - bedded organics (Unit 2)	Retained
VC_167	498368	5912396	Eem Formation - bedded organics (Unit 2)	Retained

ID	Easting	Northing	Interpretation/Unit	Recovery
VC_168	498646	5913357	Eem Formation - bedded organics (Unit 2)	Retained
VC_169	498924	5914318	Eem Formation - bedded organics (Unit 2)	Retained
VC_170	499202	5915279	Eem Formation - bedded organics (Unit 2)	Retained
VC_172	499758	5917200	Eem Formation - bedded organics (Unit 2)	Retained
VC_173	500036	5918160	Eem Formation - bedded organics (Unit 2)	Retained
VC_209	456159	5822064	Upper Brown Bank (Unit 4b)	Retained
Geoarch_VC_006	416751	5800232	Yarmouth Roads (Unit 1) - with possible peats	Reacquired
Geoarch_VC_007	417516	5800853	Organic interbedded (Unit 6b) and Fluvial sands and gravels/alluvial sands (Unit 5)	Reacquired
Geoarch_VC_009	418707	5802617	Organic interbedded (Unit 6b), Fluvial sands and gravels/alluvial sands (Unit 5) and Yarmouth Roads (Unit 1 - fluvial)	Reacquired
Geoarch_VC_013	422198	5803526	Organic interbedded (Unit 6b), Fluvial sands and gravels/alluvial sands (Unit 5) and Yarmouth Roads (Unit 1 - fluvial)	Reacquired
Geoarch_VC_017	426383	5803435	Yarmouth Roads (Unit 1 - fluvial)	Reacquired
Geoarch_VC_031	439054	5806209	Organic interbedded (Unit 6b)	Reacquired
Geoarch_VC_060	456898	5823861	Organic interbedded (Unit 6b)	Reacquired
Geoarch_VC_063	458807	5826168	Organic interbedded (Unit 6b)	Reacquired
Geoarch_VC_102	471914	5860110	Organic interbedded (Unit 6b)	Reacquired
Geoarch_VC_106	471569	5864069	Organic interbedded (Unit 6b) and Upper Brown Bank (Unit 4b)	Reacquired
Geoarch_VC_109	473133	5866281	Organic interbedded (Unit 6b) and Upper Brown Bank (Unit 4b)	Reacquired
Geoarch_VC_111	473110	5868273	Organic interbedded (Unit 6b) and Upper Brown Bank (Unit 4b)	Reacquired
Geoarch_VC_118	473233	5875263	Organic interbedded (Unit 6b)	Reacquired
Geoarch_VC_128	481090	5880573	Organic interbedded (Unit 6b) and Peat (Unit 6a)	Reacquired
Geoarch_VC_130	482914	5881386	Organic interbedded (Unit 6b)	Reacquired
Geoarch_VC_138	486078	5887702	Eem Formation - bedded organics (Unit 2)	Reacquired
Geoarch_VC_140	486466	5888920	Eem Formation - bedded organics (Unit 2)	Reacquired
Geoarch_VC_152	494197	5897984	Eem Formation - bedded organics (Unit 2)	Reacquired
Geoarch_VC_177	410682	5796100	Organic interbedded (Unit 6b), Fluvial sands and gravels/alluvial sands (Unit 5) and Yarmouth Roads (Unit 1 - fluvial)	Reacquired
Geoarch_VC_178	411534	5796443	Organic interbedded (Unit 6b) and Fluvial sands and gravels/alluvial sands (Unit 5)	Reacquired
Geoarch_VC_180	414455	5797743	Organic interbedded (Unit 6b) and Fluvial sands and gravels/alluvial sands (Unit 5)	Reacquired
Geoarch_VC_202	410143	5795908	Organic interbedded (Unit 6b) and Fluvial sands and gravels/alluvial sands (Unit 5)	Reacquired

1.3 Scope of work

1.3.1 To help frame geoarchaeological investigations of this nature, Wessex Archaeology has developed a five-stage approach, encompassing different levels of investigation appropriate to the results obtained, accompanied by formal reporting of the results. This staged approach has been developed following these Historic England guidance documents

- Historic England 2015. 'Geoarchaeology: Using Earth Sciences to Understand the Archaeological Record (Historic England 2015).

- Historic England 2020. 'Deposit Modelling and Archaeology. Guidance for Mapping Buried Deposits' (Historic England 2020).

- Historic England Advice and Guidance HEAG0325. 'Scientific Dating of Pleistocene Sites: Guidelines for Best Practice' (Grant and Marshall 2025).

1.3.2 The stages are summarised below (**Table 3**).

1.3.3 This report outlines the results of a Stage 2 recording and monitoring of selected sub-samples from the Proposed Offshore Scheme, acquired during surveys undertaken in 2024, as detailed in **Section 1.2.3**.

Table 3 Staged approach to geoarchaeological investigations

Stage	Description
Stage 1: Geoarchaeological review	Desk-based review of geotechnical and geological data. Establish likely presence/ absence/ distribution of archaeologically relevant deposits. Identify deposits or samples for Stage 2 works.
Stage 2: Geoarchaeological recording/monitoring	Target deposits or samples identified in Stage 1. Describe the sequences recovered and undertake deposit modelling (if suitable). Interpret depositional environment (if possible). Identify if suitable deposits are present for Stage 3 works.
Stage 3: Palaeoenvironmental assessment	Sub-sample deposits of archaeological interest for paleoenvironmental assessment (e.g. pollen, plant macrofossils, foraminifera, ostracod and diatoms) and associated scientific dating. Provide an outline interpretation of the archaeological and palaeoenvironmental context. Any recommendations for Stage 4 works will depend on the potential for further analysis and the project research objectives.
Stage 4: Palaeoenvironmental analysis	Full analysis of samples and additional scientific dating as specified in Stage 3, together with a detailed synthesis of the results, in their local, regional or wider archaeological and palaeoenvironmental context. Publication would usually follow from a Stage 4 report.
Stage 5: Publication	Publication of the results of Stage 1-4 works for submission in a peer reviewed journal, book or monograph, depending on the archaeological significance of the work. The scope and location of the final publication will be agreed in consultation with the client and regulatory bodies where appropriate.

2 GEOARCHAEOLOGICAL BACKGROUND

2.1 Introduction

2.1.1 Geoarchaeological assessments are typically undertaken with reference to geological periods (e.g. Quaternary), epochs (e.g. Pleistocene) and sub-epochs (e.g. Weichselian) that reflect major climate sea-level and/or environmental changes. Here we adopt European nomenclature correlated to the Marine Isotope Stage (MIS) record to distinguish between different climatic periods, with dates given in Kya (thousands of years before present). Marine Isotope Stages are deduced from marine palaeoclimatic records and reflect alternating warm (interglacial and interstadial) and cold (glacial and stadial) periods throughout the Quaternary.

2.2 Geological baseline

2.2.1 The Proposed Offshore Scheme is located in an area characterised by Pleistocene and Holocene sediments (Cameron *et al.* 1992), comprising clays, silts, sands and gravels with occasional organic-rich deposits (peats), overlain by recent, unconsolidated marine shelly sands.

2.2.2 The Pleistocene geological history of the North Sea basin is dominated by repeated glacial/interglacial cycles, resulting in rising and falling sea levels and deposition of terrestrial, marine and glacially-derived sediments. The area of the Proposed Offshore Scheme, and the southern North Sea in general, is known to contain an important sedimentary archive including material dating from the earliest occupation of northwestern Europe (Parfitt *et al.* 2010) up to more recent post-glacial reoccupation of Britain (Waddington 2015).

2.2.3 Only one glacial episode is thought to have directly affected the area. This was during the Anglian period (MIS 12, 480–423 Kya) when ice extended into the southernmost North Sea. During subsequent glacial episodes, ice sheets terminated further north so did not directly affect the region. However, indirect affects resulting from changing sea levels and cold periglacial conditions will have influenced landscape evolution in the region. The exact southern extent of the Anglian glaciation is debatable. However, bathymetric data suggests part of the Anglian ice sheet may have extended as far south as offshore from Felixstowe (Emu Ltd. 2009), and Dix and Sturt (2011) argue for an Anglian glacial origin for over-deepened valleys (tunnel valleys) identified within the Outer Thames estuary.

2.2.4 East Anglia and Suffolk, and areas immediately offshore, are currently thought to have experienced only one glacial advance during the Pleistocene. Palaeolandscape features from periods of low relative sea level are therefore more likely to be preserved here than further north (approximately north of the north Norfolk coast), where they have been impacted on during the subsequent Saalian (MIS 10-6) and Devensian (MIS 5d-2) glacial advances. Some surviving Pleistocene deposits may have been reworked or redeposited to a certain extent during subsequent marine transgressions (Cameron *et al.* 1992), but there is potential for them to survive on the seabed.

2.2.5 The bedrock geology mapped across the Proposed Offshore Scheme is the Crag Group, with outcrops of the Red Crag Formation, representing marine shelly sands deposited during warm, shallow marine conditions during the Plio-Pleistocene, mapped in the nearshore area (Cameron *et al.* 1992). The archaeological potential of these deposits is considered to be low as their deposition predates human occupation in Britain.

2.2.6 Some of the oldest deposits likely to be encountered to the far west of the Proposed Offshore Scheme belong to the Westkapelle Ground Formation, which are located near to the present-day Norfolk coast and have been mapped extending up to 20 km offshore. The Westkapelle Formation is Praetiglian and Tiglian in age (2.3 – 1.6 Ma) and therefore predates the earliest known occupation of Britain. This formation represents deposition in a pro-delta setting (Cameron *et al.* 1992).

2.2.7 The earliest deposits of archaeological interest belong to the Yarmouth Roads Formation which are non-marine sands with clay beds laid down in a fluvial to intertidal (deltaic) setting during the early Pleistocene prior to the Anglian glaciation (MIS 12). The Yarmouth Roads Formation is thought to contain units that are broadly contemporary with terrestrial deposits belonging to the Cromer Forest bed Formation recorded on the foreshore at Pakefield, approximately 14.08 km north north-east of the proposed Landfall at Walberswick, Suffolk. These deposits are associated with internationally significant Lower Palaeolithic

archaeology dated to around 700 Kya, and palaeoenvironmental evidence (Parfitt *et al.* 2005, Parfitt 2008).

2.2.8 Based on British Geological Survey (BGS) mapping, the Proposed Offshore Scheme transects a large area associated with a geological formation defined as the Brown Bank Formation. The Brown Bank Formation includes deposits of silty sand, sandy silt and sandy silty clay, which is in places up to 20 m thick. The sandy silty clay deposits are here termed the Upper Brown Bank, to distinguish them from the underlying deposits of shelly silty sand and sandy silt that characterise both the Lower Brown Bank (Early Devensian) and underlying Eem Formation (Ipswichian Interglacial) (Limpenny et al. 2011; Bicket and Tizzard 2015). However, geotechnical and geophysical data has highlighted the presence of additional phases of deposition associated with the Brown Bank Formation (Waajen *et al.* 2024).

2.2.9 The Brown Bank Formation is present as a blanket deposit and has traditionally been interpreted to represent a shallow lagoon environment, comprising clayey silty sands (Cameron *et al.*1992; Limpenny *et al.* 2011) although more recently studies have shown that the upper sequence largely comprises clayey silt (Eaton *et al.* 2020; Wessex Archaeology 2018a) with channel-like features present to the west (Bicket and Tizzard 2015; Limpenny *et al.* 2011).

2.2.10 The Brown Bank Formation has been previously dated using optically stimulated luminescence (OSL) dating (Limpenny *et al.* 2011; Tizzard *et al.* 2014; 2015; Wessex Archaeology 2019a; 2019b) and ages fell into two broad ranges: MIS 3 and MIS 5d-5c. Based on this evidence, it is not clear if Brown Bank Formation was deposited over the duration of the early Devensian, or if deposition was more episodic punctuated by periods of hiatus and subaerial exposure (Tizzard *et al.* 2015). The date of the Brown Bank Formation therefore has significant implications both for our understanding of the palaeogeographic development of the North Sea, when connections would have allowed access to Britain, as well as the nature and significance of any archaeology, if preserved. As the Proposed Offshore Scheme transects the mapped extent of the Brown Bank, it presents an opportunity to identify the terrestrial margins of this extensive shallow water feature. Coastal margins have been suggested to have formed corridors for early human colonisation around North West Europe (Bailey 2004).

2.2.11 In places across the southern North Sea, sequences of early Holocene deposits are mapped overlying Pleistocene sediments. The Holocene sediments include organic-rich peats along with more minerogenic fluvial and alluvial sediments, most often infilling channels (Limpenny *et al.* 2011; Tappin *et al.* 2011; Tizzard *et al.* 2015; Gearey *et al.* 2017; Brown et al. 2018) but also preserved on the Brown Bank Formation or overlying periglacial aeolian sediment. The peats are of high geoarchaeological potential, preserving a range of palaeoenvironmental remains and material suitable for radiocarbon dating.

2.2.12 Pleistocene and early Holocene sediments are capped by post-transgression marine sands. The progressive inundation of the North Sea occurred over an extended time scale, with particularly rapid sea-level rise during the early Holocene (11.5-7 Kya), and with fully marine conditions occurring by around 6 Kya (Sturt *et al.* 2013). However, limitations in the availability of reliable sea-level index-points (Hazell 2008), combined with uncertainty around the glacio-isostatic response of the southern North Sea, make it difficult to accurately reconstruct sea-level history and the timing of inundation across the Proposed Offshore Scheme.

2.3 Archaeological background

2.3.1 The southern North Sea off the east coast of East Anglia and Suffolk is known to contain well preserved palaeolandscape features such as fluvial channels that formed during periods of lower sea level when the southern North Sea was free of ice. The archaeological remains of these terrestrial landscapes are frequently recovered by dredging and fishing activities in numerous areas around the southern North Sea, generally in the form of the remains of extinct megafauna (e.g. various Mammoth species, various rhinoceros species, bison, horse, lion and hyena).

2.3.2 The discovery of actual human artefacts, such as stone tools and worked bone is a rarer occurrence, but artefacts have been recovered (e.g. Hublin *et al.* 2009). Reported finds from offshore activity has, to date, produced a range of lithic artefacts indicating early prehistoric activity in submerged palaeolandscapes from Lower, Middle, and Upper Palaeolithic periods (Tizzard *et al.* 2015).

2.3.3 The earliest records of Lower Palaeolithic archaeology from northern Europe are associated with terrestrial deposits on the margins of the North Sea basin in East Anglia and Suffolk, most notably from Pakefield (Parfitt *et al.* 2005), located c. 18.40 km north of the proposed Landfall, and Happisburgh Site 3 (Parfitt et al. 2010). Whilst the archaeology at Pakefield was created during a fully interglacial, more Mediterranean climate, at around MIS 17, the remains at Happisburgh Site 3 are older (MIS 21 or MIS 25) and the environmental evidence is indicative of cool conditions at the edge of the boreal zone (Candy *et al.* 2011) which implies that these early hominins were capable of surviving in northern Europe in periods not associated with fully interglacial environments (Parfitt *et al.* 2010). The importance of these sites is international, as they are currently unique at this latitude for this early date.

2.3.4 Cohen *et al.* (2012) highlighted the North Sea basin as a key region for understanding Pleistocene hominins within a northerly, coastal environment. The east of England, particularly East Anglia, but also the southeast of England, are important regions for later Middle Pleistocene, Lower Palaeolithic archaeology (MIS 13-MIS 9). During this timeframe British archaeology reflects repeated episodes of hominin occupation during temperate interglacial and cool conditions, separated by phases of hominin absence during fully glacial periods.

2.3.5 Archaeological evidence is particularly abundant onshore in Britain during MIS 13 and MIS 11 (Wymer 1999; Pettitt and White 2012) and includes the key Lower Palaeolithic assemblage dating to c. 500 Kya (MIS 13) at Happisburgh 1 (Lewis *et al.* 2019). During this period, warmer climate conditions meant Britain was again available to be recolonised by hominin communities, after a period of absence during the preceding Anglian glaciation (MIS 12). Lower Palaeolithic archaeological assemblages of this date tend to be characterised by handaxes, although during the earlier part of MIS 11, collections lacking handaxes (termed Clactonian) have been recognised. The foreshore, cliffs and hinterland at Clacton-on Sea (Essex) comprise an important Lower Palaeolithic site which is a designated geological Site of Special Scientific Interest (SSSI). Channel sediments from the area are also an important site for the Lower Palaeolithic Clactonian flint industry and have yielded the earliest wooden tool in the world, a spear, alongside lithic artefacts and bone tools (Parfitt *et al.* 2022). This archaeology dates from the Hoxnian interglacial period (MIS 11, c. 423 – 380 Kya) (Sumbler 1996; Bridgland *et al.* 1999), and the type site for the Hoxnian (the Hoxne Brick Pit) is located a relatively short distance inland outside of Diss, Suffolk (Ashton *et al.* 2008).

2.3.6 During the MIS 10 glaciation, there appears to have been a hiatus in hominin activity in Britain (Pettitt and White 2012). The post-MIS 10 occupation of Britain is associated with

the emergence of the Neanderthals and their associated archaeology and patterns of behaviour. From the later part of MIS 9 the archaeological record attests to the development of Levallois core working strategies (White and Ashton 2003). This is also seen to mark the end of the Lower Palaeolithic and the beginning of the Middle Palaeolithic. The Levallois technique comes to dominate the British archaeological record during the early Middle Palaeolithic (late MIS 8 and MIS 7), with handaxe production occurring infrequently (Scott 2011, Scott and Ashton 2011).

2.3.7 The potential for early Middle Palaeolithic archaeology to be preserved in contexts beneath the North Sea is indicated by the recovery of likely early Middle Palaeolithic lithic artefacts during marine aggregate dredging from licence Area 240 in the Palaeo-Yare catchment. Over 120 artefacts have now been recovered from this locale, some of which are identifiable as Levallois, likely dating to the late Middle Palaeolithic, with many recovered from in situ or minimally disturbed contexts (Tizzard *et al.* 2014; 2015; Shaw *et al.* 2024).

2.3.8 Palaeogeographically, Area 240 is one of the most northerly Neanderthal sites in northwest Europe and of primary archaeological importance for defining Middle Palaeolithic potential and the contemporary palaeogeography across the southern North Sea basin (Tizzard *et al.* 2014). Area 240 is located approximately 16 km north of the Proposed Offshore Scheme and highlights the archaeological potential of preserved Pleistocene fluvial deposits within the southern North Sea.

2.3.9 Evidence of hominin presence in Britain during the Ipswichian (MIS 5e) or the early Devensian (MIS 5d-a) is sparse, though there is increasing evidence that humans were present (Wenban-Smith *et al.* 2010; Shaw *et al.* 2025). Substantial areas of the southern North Sea basin would have been dry land during the warming and cooling limbs of the various sub-stages (MIS 5d to 5a) and archaeological sites of this age are relatively abundant in northern France (Locht *et al.* 2016). Therefore, the potential exists for human activity to have occurred sporadically both within Britain and in any sub-aerially exposed parts of the southern North Sea basin, during the early Devensian.

2.3.10 From late MIS 4 to MIS 3 there is evidence onshore in Britain and offshore in the British and Dutch sectors of the North Sea (Hublin *et al.* 2009; Shaw *et al.* 2023) for Neanderthal recolonization. This late Middle Palaeolithic archaeological record is associated with morphologically and technologically distinctive handaxes (White and Jacobi 2002). A key site belonging to this period is Lynford Quarry, Norfolk where a palaeochannel containing mammoth remains and associated late Middle Palaeolithic stone tools and debitage have been recovered (Boismier *et al.* 2012).

2.3.11 Climatically, MIS 3 was significantly colder than now but did not attain the glacial conditions of later or earlier glacial periods (e.g. MIS 6 or 2) (Pettitt and White 2012). For the Neanderthals that may have occupied the region at this time, surviving in the area that is now the southern North Sea during this period may have been subject to a variety of technological and cultural adaptations (White 2006).

2.3.12 In the early Upper Palaeolithic, at the end of the Late Pleistocene, Neanderthals were replaced in northern Europe by modern humans who, occupying and moving through what is now the southern North Sea, were present in Britain from around 34 Kya (Jacobi and Higham 2011; Bicket and Tizzard 2015). Archaeological evidence for this period consists of blade point/leaf point assemblages, thought to be associated with the final Neanderthal occupation of Britain, and a small number of findspots associated with Evolved Aurignacian and Gravettian lithic artefacts which were produced by modern humans (Jacobi and Higham 2011).

2.3.13 During the last glacial period, the Proposed Offshore Scheme will have been close to the maximum Devensian ice margin. At the maximum of the last glacial period, the environment within the southern North Sea was relatively poor for human colonisation, with humans absent from Britain during these peak cold conditions. However, there was increasing human exploitation after ~15 Kya. Humans at this time were hunting game, such as mammoth and deer, and evidence of these animals has been reported through marine aggregate dredging, and the associated reporting requirements (Bicket and Tizzard 2015).

2.3.14 The onshore archaeological record of later Upper Palaeolithic activity is marked by Creswellian/Final Magdalenian stone tool assemblages associated with the later Upper Palaeolithic recolonization of Britain by modern humans (Higham and Jacobi 2011), and offshore locations may provide unique and important context for coastal and lowland human activity during this period. For example, an antler harpoon was recovered by a trawler from the Leman and Ower Banks in the early 20th century: initially assumed to be Mesolithic, this was later radiocarbon dated to around 12,000 Kya (Housley 1991).

2.3.15 The Mesolithic period began in the early Holocene and at around 10 Kya sea levels were approximately 35 m below current levels (Shennan *et al.* 2018), sub-aerially exposing large parts of the southern North Sea and English Channel, making them suitable for human occupation. Archaeological and palaeoenvironmental material from this period has been reported from North Sea contexts for over a century (Godwin and Godwin 1933).

2.3.16 Between 8 and 5 Kya, much of the landscape was inundated by eustatically driven sea level change, and by 6 Kya sea level was only approximately 7 m below the present level (Shennan et al. 2018). Around this time, Britain became an island again (Coles 1998). Settlements at the time were often transitory and seasonal, and therefore leave little trace in the archaeological record. It is possible that the now-submerged environment within the Norfolk Vanguard and Norfolk Boreas sites, located 600 m west (Norfolk Vanguard West) and 400 m south-east (Norfolk Boreas) of the Proposed Offshore Scheme, was occupied up until the final marine transgression thought to have occurred around 8,000 Kya.

2.3.17 It is clear from numerous research and development-led investigations that postglacial marine transgression has not destroyed Pleistocene and Holocene palaeogeography by default. Areas of preserved palaeogeographic features do remain, and detailed reconstructions of palaeoenvironments and palaeogeography can be achieved for large parts of the North Sea basin (Tappin *et al.* 2011; Limpenny *et al.* 2011; Dix and Sturt, 2011).

2.3.18 Considerable attention has been paid to Mesolithic landscapes of the southern North Sea (Gaffney *et al.* 2007; Tappin *et al.* 2011, Geary *et al.* 2017) as these now-submerged palaeolandscapes provide key contextual evidence for recovered artefacts and a background landscape within which to place these human communities. Increasingly, a maritime perspective has developed for understanding the early prehistoric archaeological record, where coasts, estuaries and wetlands are key landscape elements (Ransley *et al.* 2013).

3 AIMS AND OBJECTIVES

3.1.1 The principal aim of this Stage 2 report is to determine the geoarchaeological and palaeoenvironmental potential of selected sub-samples recovered from the Proposed Offshore Scheme. This will be achieved by addressing the following objectives:

- Describe vibrocore sequences assigned medium and high priority status during the Stage 1 review;

- Model the character, extent and depth of deposits;
- Interpret the probable environments represented;
- Determine the importance of the deposits, with regard to their archaeological and palaeoenvironmental potential, and;
- Make recommendations for dating and palaeoenvironmental assessment as appropriate, with reference to key research questions and regional/national period specific and maritime research agendas.

4 METHODOLOGY

4.1 Coordinate system

4.1.1 All location information and figures are presented as projected coordinates in ETRS89 UTM Zone 31N Eastings and Northings.

4.1.2 The vertical reference level is given as metres below sea floor (mbsf) which assumes the top of the vibrocore is equal to the level of the sea floor. Location data for vibrocores recorded is presented in **Section 1.2** (**Table 1**).

4.2 Stage 2 geoarchaeological recording

4.2.1 Based on the results of the Stage 1 geoarchaeological review (Wessex Archaeology 2025a), a total of 41 vibrocores were recommended for Stage 2 geoarchaeological recording as they preserved deposits considered to have medium to high archaeological and palaeoenvironmental potential. The vibrocores selected for recording are outlined in **Table 1**.

4.2.2 Selected geotechnical vibrocores retained by the geotechnical contractor (Next Geosolutions) during the initial survey were split and recorded on the vessel prior to being delivered to Wessex Archaeology. However, as a series of core samples selected to be retained for geoarchaeological recording were discarded during geotechnical testing, a second geotechnical survey was undertaken in December 2024 to reacquire purposive geotechnical vibrocores for Stage 2 geoarchaeological recording. These targeted core samples were delivered to Wessex Archaeology unsplit. A full list of the vibrocores reacquired is presented in **Table 1**.

4.2.3 At Wessex Archaeology, all sub-samples were photographed and described in detail including information such as:

- Depth;
- Texture;
- Composition;
- Colour;
- Inclusions;
- Structure (bedding etc.); and,

- Contacts between deposits (where visible).

4.2.4 Interpretations were made regarding the probable depositional environments and Formation processes of the sampled deposits. The data is presented in **Appendix 2**.

4.2.5 Deposits recovered in vibrocores were interpreted in terms of their geoarchaeological potential. Of greatest geoarchaeological potential are sediments from former terrestrial depositional environments, as well as certain features or inclusions of possible archaeological and palaeoenvironmental interest, specifically:

- Peat layers;
- Deposits containing other organic material such as wood fragments, roots, dark organic staining etc.;
- Clay or silt deposits, especially those containing laminated features such as lacustrine varves (seasonally deposited sediment layers found in lake environments) or tidal rhythmites (sediment layers reflecting response to periodic tidal cycles, and demonstrating a directing marine influence in the sediment cycle);
- Inorganic fossils (such as molluscs);
- Concentrations of charcoal;
- Individual artefacts such as pieces of flint or pottery (though finding these within core samples is rare), and;
- Any other feature thought to indicate a terrestrial depositional environment.

4.2.6 All vibrocores were sealed, clearly labelled with core ID, depth and assigned series and sample numbers, and stored in plastic casing also labelled with the appropriate core information.

4.3 Deposit modelling

4.3.1 The results from the Stage 1 review of geotechnical logs and geotechnical recording of selected sub-samples were used to produce a deposit model using RockWorks v23 outlining the character, extent and depth of key deposits within the Proposed Offshore Scheme (Historic England 2020).

4.3.2 The outputs from the deposit modelling were largely dependent on the resolution and density of the data available. Given the relatively large distance (>700 m) between data points, two-dimensional cross sections were considered the most accurate method of representing the deposits present within the Proposed Offshore Scheme.

4.3.3 A total of three cross sections (‘transects’) were produced for the Proposed Offshore Scheme, focussing on areas where deposits of high archaeological and/or geoarchaeological potential (i.e. peats) are located. The locations of cross sections are presented alongside the deposit models (**Figures 4-6**).

5 RESULTS

5.1 Introduction

5.1.1 Stage 2 geoarchaeological recording was undertaken on the 41 vibrocores that were requested following the Stage 1 review of geotechnical logs (Wessex Archaeology 2025a). A selection of vibrocores were assigned medium priority status as they comprised deposits interpreted as the Yarmouth Roads Formation (Unit 1; five vibrocores), possible organic deposits associated with the Eem Formation (Unit 2; 11 vibrocores), Upper Brown Bank Formation (Unit 4b; eight vibrocores), Fluvial sands and gravels and alluvial sands (Unit 5; nine vibrocores) and organic interbedded (Unit 6b; 23 vibrocores). Three vibrocores were identified as containing peat assigned a high priority status. Two of these vibrocores (VC_005 and VC_128) contained *in situ* peat deposits (Unit 6a), however in VC_006 pockets of peat were also identified. The peat in VC_006 is located within sediments tentatively interpreted as the Yarmouth Roads Formation.

5.2 Stage 2 recording

Yarmouth Roads Formation (Unit 1)

5.2.1 A total of five vibrocores (Geoarch_VC_006, Geoarch_VC_009, Geoarch_VC_013, Geoarch_VC_017 and Geoarch_VC_177) were recommended for Stage 2 geoarchaeological recording due to the presence of grey sands, interpreted as possible alluvial deposits associated with the Yarmouth Roads Formation. These deposits were assigned a medium priority status.

5.2.2 Vibrocore VC_006 was recommended for Stage 2 recording as it comprised pockets of peats within grey sands which could correlate to the Yarmouth Roads Formation. The sequence in Geoarch_VC_006 was lithologically similar to that in VC_006, however contained two beds of well-decomposed peat between 3.33-3.43 m and 3.47-3.60 m separated by a thin (0.04 m) unit of structureless gravelly sand. These peat deposits represent waterlogged conditions in a semi-terrestrial landscape with the intercepting gravelly sands suggested to represent an episode of high-energy deposition (e.g. storm event). The peat is underlain by greenish grey sands with occasional laminae and plant material. Vertical rooting was also exhibited and coupled with the absence of shell fragments, may suggest deposition occurred in a semi-terrestrial environment (e.g. floodplain or marginal setting).

5.2.3 Geoarch_VC_009, Geoarch_VC_013 and Geoarch_VC_177 are located in the nearshore and recovered light grey sands with silty clay laminae and few pockets of lithified silt, characteristic of the Yarmouth Roads Formation. However, these sediments stratigraphically underly dark red sands reassigned to the Crag Formations. Based on lithology alone, it is difficult to differentiate between the Yarmouth Roads and Crag Formations given these deposits were laid down in broadly similar depositional environments. Despite this, the deposits in these vibrocores show similar lithological characteristics to the Crag Formations. As the formation is unclear, these sediments are collectively interpreted as Undifferentiated Crag Formations.

5.2.4 A thick sequence (3.51 m) of light greenish grey sand with few clay laminae and shell fragments was recorded underlying seabed sediments in Geoarch_VC_017. The laminae within this deposit are described as wavey and sub-horizontal and coupled with the presence of shells, indicate deposition within a tidally influenced low-energy waterlain environment. These deposits are therefore interpreted as estuarine to shallow marine deposits of the Yarmouth Roads Formation.

5.2.5 A series of vibrocores were also reinterpreted as the Yarmouth Roads Formation during the Stage 2 recording. These deposits generally contained abundant shell and showed characteristics of marine sediments considered to be of low geoarchaeological potential. However, in VC_209, silty fine to medium sands entirely absent of shell were recorded underlying seabed sediments between 0.69 mbsf and 5.80 mbsf. This thick sequence of sand also comprised frequent laminae and partings of clayey silt containing organic fragments including fibrous plant material, possibly indicative of deposition in a semi-terrestrial or marginal low-energy setting.

5.2.6 These reinterpretations highlight the difficulty of both assigning units to geological formations and determining the depositional history of deposits in an area such as the southern North Sea where formations of very different age can show little variation in lithology.

Eem Formation (Unit 2)

5.2.7 A series of vibrocores (VC_154, VC_166, VC_167, VC_168, VC_169, VC_170, VC_172, VC_173, Geoarch_VC_138, Geoarch_VC_140 and Geoarch_VC_152) containing deposits interpreted as the Eem Formation were recommended for Stage 2 recording on the basis that they were identified as comprising upper bedded organics possibly capturing the development of a semi-terrestrial landscape following the last interglacial (MIS 5e).

5.2.8 These deposits were collectively described as fine to coarse sands with common to many stiff laminae and beds of reddish-brown clay. The shell content varied in these deposits, however, was typically abundant with many to very many fragmented shells. During recording, the uppermost deposits were described as entirely minerogenic with no organic sediments or fragments observed. The lack of evidence for a preserved landsurface indicates that these sequences were deposited under fully marine conditions and are considered to be of low geoarchaeological priority.

Upper Brown Bank (Unit 4b)

5.2.9 Seven vibrocores comprising deposits interpreted as possible upper estuarine to intertidal deposits of the Upper Brown Bank Formation were recommended for Stage 2 geoarchaeological recording, including VC_073, VC_075, VC_095, VC_209, Geoarch_VC_106, Geoarch_VC_109, Geoarch_VC_111 and Geoarch_VC_128.

5.2.10 In VC_073, no thick clay units associated with the Upper Brown Bank Formation were recorded. Instead, a thick sequence of grey fine to medium sands with few thick beds of clay was observed overlying structureless sands interpreted as marine sediments associated with the Yarmouth Roads Formation between 3.29 mbsf and 4.70 mbsf. Between 1.00 mbsf and 3.29 mbsf, these sands contain many thin laminae of slightly organic silt with gravel-sized (<19mm) fragments of plant remains recorded between 1.00 mbsf and 1.53 mbsf. The presence of organic laminae and absence of shells indicates deposition may have occurred in a low-energy fluvial or floodplain environment. Furthermore, this deposit is characteristic of the Yarmouth Roads Formation and has therefore also been reinterpreted.

5.2.11 The laminated sands recorded in VC_095 between 0.98 and 1.47 mbsf stratigraphically overly grey clay of the Upper Brown Bank and were recommended for Stage 2 geoarchaeological recording based on the potential presence of organic laminae. Nonetheless, these laminations were observed as minerogenic. The deposit was also yellowish brown in colouration and shows a clear upper contact to the overlying seabed sediments. This deposit is therefore reinterpreted as representing modern marine sediments.

5.2.12 In Geoarch_VC_106, a thin unit of grey medium sand with few shell fragments and thick wavey laminae of clay was recorded between 1.20 mbsf and 1.80 mbsf. This unit stratigraphically overlies a thick sequence of firm sandy clay, interpreted as the Upper Brown Bank Formation. The clear lower boundary of this unit indicates that this deposit does not represent a later erosive phase of marine transgression but could immediately post-date the underlying estuarine clays. This is reinforced by the grey colouration, indicative of anaerobic conditions, and presence of laminae and shell fragments, characteristic of the Upper Brown Bank Formation. However, this later unit is higher in energy and is thus interpreted as estuarine to intertidal deposits possibly associated with the Upper Brown Bank Formation.

5.2.13 Similar sequences of grey sand stratigraphically overlying firm clay of the Upper Brown Bank were observed in Geoarch_VC_109, Geoarch_VC_111 and Geoarch_VC_128. These units comprised few shells and laminae, although are generally structureless in Geoarch_VC_111. Despite this, these deposits are also interpreted to represent later estuarine to intertidal sediments which post-date the clays of the Upper Brown Bank Formation. No organic fragments or units are associated with these sediments.

Fluvial sands and gravels and alluvial sands (Unit 5)

5.2.14 A total of nine vibrocores located in the nearshore area and interpreted as representing possible fluvial to alluvial or floodplain sediments were selected for Stage 2 geoarchaeological recording.

5.2.15 In Geoarch_VC_002, Geoarch_VC_003, Geoarch_VC_007, Geoarch_VC_013, Geoarch_VC_177 and Geoarch_VC_178, thick sequences of oxidised reddish to orangish brown laminated sands were recorded overlying grey sands, interpreted during the initial Stage 1 review as possible fluvial deposits overlying marine sediments of the Yarmouth Roads Formation. These sands show characteristics of low-energy fluvial or floodplain deposits, such as the bedded structure, absence or low quantity of shell and presence of iron pan concretions indicative of drying and exposure. However, during the Stage 2 recording, no significant change in lithology was observed between the upper orange sands and lower grey sands previously interpreted as the Yarmouth Roads. This change in colouration is unique to the Red Crag Formation which typically comprises uppermost oxidised deposits which transition to these grey unoxidized sediments. Although the depositional history of these deposits is uncertain, they are tentatively reinterpreted as Undifferentiated Crag Formations.

5.2.16 Dark red sands equivalent to those described in **Section 5.2.15** were not observed in Geoarch_VC_180 and were instead characterised as slightly greenish grey medium to coarse sand with many fragmented and whole shells, indicative of deposition in a marine environment. These sediments are similar in lithology to the lower grey sands described above and are therefore likely shallow marine deposits associated with the Crag Formations. However, this is unclear based on lithology alone.

5.2.17 Mid yellowish brown to reddish brown gravelly sand with beds of fine to medium shelly sands were recorded between 1.65 mbsf and 5.34 mbsf in Geoarch_VC_202. The clast lithology is described as subangular to well-rounded flint with some quartz and is characteristic of marine gravels. Below are laminated sands with many shells, also indicative of deposition in a shallow marine to marine environment. These deposits are tentatively interpreted as representing deposits of the Crag Formations.

Peat (Unit 6a)

5.2.18 Two vibrocores (VC_005 and VC_128) were identified in the Stage 1 review as containing *in situ* peat deposits, with pockets of peat recorded in VC_006. Vibrocores VC_006 and VC_128 were reacquired during the second geotechnical survey (Geoarch_VC_006 and Geoarch_VC_128, respectively).

5.2.19 A single core length (4.00-4.60 m) for VC_005 was delivered for geoarchaeological recording. A peat deposit was recovered between 4.51 and 4.60 mbsf and described as strongly decomposed amorphous humified peat. As the core sediments are very dry, the peat has a blocky structure. Although slightly disturbed, the peat is still suitable for radiocarbon dating.

5.2.20 In Geoarch_VC_128, peat described as very dark brown, pseudo fibrous becoming amorphous with depth and containing fragments of wood, was recovered between 0.95 mbsf and 1.22 mbsf. Stratigraphically, this peat is overlain by seabed sediments and is underlain by estuarine to intertidal sediments tentatively interpreted as the Upper Brown Bank Formation.

5.2.21 During the Stage 1 review, geotechnical log VC_006 was noted as comprising pockets of peat between 3.20 mbsf and 3.50 mbsf. Despite this, during the reacquisition of this vibrocore (Geoarch_VC_006), two units of *in situ* peat were recovered between 3.33 mbsf and 3.43 mbsf (upper peat) and 3.47 mbsf and 3.60 mbsf (lower peat). These peats are separated by a gravelly sand, representing a possible storm event. The peats are lithologically homogeneous and are described as reddish-black, well-decomposed peat. The lower contacts of these deposits are sharp and suggest a degree of erosivity.

5.2.22 Organic interbedded deposits identified in VC_111 were also recommended for geoarchaeological recording following the Stage 1 review. However, a peat deposit was recovered from reacquired vibrocore Geoarch_VC_111. The unit is characterised as reddish brown amorphous clayey peat with few fragmented shells at the upper boundary. The peat is stratigraphically located between seabed sediments and possible upper estuarine to intertidal deposits of the Upper Brown Bank Formation (see **Section 5.2.11**).

Organic Interbedded (Unit 6b)

5.2.23 A series of vibrocores identified as containing potential upper organic units, beds or laminae, defined as ‘interbedded organic’ deposits during the Stage 1 review, were recommended for Stage 2 recording in order to ground-truth interpretations.

5.2.24 The geotechnical logs for four vibrocores located in the nearshore (VC_003, VC_009, VC_013 and VC_001_A) noted the presence of these upper organic deposits and were requested for Stage 2 geoarchaeological recording. However, during recording these vibrocores were collectively observed as containing stiff interbedded clays and sands reinterpreted as the Westkapelle Ground Formation. These deposits were entirely minerogenic in nature with no organic units recorded.

5.2.25 Soft slightly reddish-brown clay was recorded in two vibrocores in the nearshore (Geoarch_VC_177 and Geoarch_VC_178). Based on the photographs, these units had potential to contain organic fragments and beds with geoarchaeological potential, nonetheless were described as minerogenic during the recording stage. During the geotechnical log review, VC_180 was identified as containing organic clay, however Geoarch_VC_180 recovered minerogenic slightly gravelly silty fine to medium sand. The soft fine-grained nature of these deposits suggest that deposition likely occurred in a low-energy alluvial environment.

5.2.26 A representative selection of vibrocores were selected for Stage 2 geoarchaeological recording to assess their potential to contain upper organic deposits (VC_007, VC_088, VC_114, VC_120, VC_031, VC_060, VC_102, VC_106, VC_109 and VC_130). The photographs taken of these vibrocores comprised thick upper beds of dark brown-black sands with the potential to be organic in nature or contain *in situ* organic fragments. However, no organic deposits were observed during Stage 2 recording. The lower part of these deposits occasionally contained laminations, possibly representing shallow marine conditions progressing into a fully marine environment; however, both are considered to have low geoarchaeological potential and are collectively interpreted as modern seabed sediments.

5.2.27 The depositional history of the organic interbedded unit in VC_005 was undetermined considering a single core length (4.00-4.60 m) was received for geoarchaeological recording. The sediments in this core had also lost their water content meaning lithology was difficult to determine.

5.2.28 In Geoarch_VC_202, sand with laminae of clay transitioning to clayey sand is recorded between 0.25 mbsf and 1.65 mbsf and is suggested to represent a low-energy alluvial sequence. Between 0.85 mbsf and 1.45 mbsf, many fragmented shells are observed and demonstrate increasing marine conditions. Although black sediments were recorded, alongside a single wood fragment at 1.60 m, these sediments are not considered to be organic. The woody inclusions represent detrital material reworked into the upper part of the sequence. The deposits between 0.25 mbsf and 1.65 mbsf are thus likely to be alluvial in nature.

5.3 Deposit modelling

5.3.1 A total of three transects were created to show the stratigraphic relationship between deposits within the Proposed Offshore Scheme, with a focus on illustrating peats of high geoarchaeological and archaeological potential (**Figures 4-6**).

5.3.2 Transect 1 is located within the nearshore area and comprises six vibrocores (**Figure 4**). To the south-west, three vibrocores contain thick sequences of red laminated sands interpreted as the Crag Formations. In Geoarch_VC_178, this deposit outcrops at seabed although is overlain by interbedded sand and clay in Geoarch_VC_202 and Geoarch_VC_177. The surface elevation of this interbedded sand and clay unit is slightly higher in Geoarch_VC_202 (-13.45 m) relative to that in Geoarch_VC_177 (-14.70 m). To the north-east, a similar sequence of Crag Formation deposits overlain by interbedded sands and clays is observed in Geoarch_VC_180. This interbedded unit exhibits a comparatively lower elevation (-21.23 m) and as such, may be different in age and deposition to equivalent deposits in the south-west. To the far north-east of Transect 1, possible deposits of the Yarmouth Roads Formation are recorded and contain beds of peats. Based on interpreted SBP data, these peat deposits form part of a continuous seismic layer. The upper surface of the peat is recorded at -28.53 m in VC_005 and -26.93 m in Geoarch_VC_006.

5.3.3 Transect 2 (**Figure 5**) and Transect 3 (**Figure 6**) are located in the offshore area of the Proposed Offshore Scheme and both comprise four vibrocores. In both the transects, the lower stratigraphy comprises sub-units of the Brown Bank Formation. The Brown Bank Formation deposits are collectively overlain by either modern seabed sediments or interbedded sands and clays. However, in Geoarch_VC_111 (Transect 2) and Geoarch_VC_128 (Transect 3), upper deposits of the Brown Bank Formation are stratigraphically overlain by thin beds of peat. In Geoarch_VC_111, the peat deposit is recorded between -35.98 m and -36.11 m, whereas the peat in Geoarch_VC_128 is

observed between -32.37 m and -32.64 m. The peats are overlain by modern seabed sediments. Both Geoarch_VC_111 and Geoarch_VC_128 are mapped within high amplitude reflectors, indicative of possible organic sediments (Wessex Archaeology 2025b).

6 DISCUSSION

6.1 Introduction

6.1.1 The results from the geotechnical vibrocores in the Proposed Offshore Scheme are broadly consistent with the expected stratigraphy in this area of the southern North Sea. Reinterpretations have however been proposed based on both the Stage 2 geoarchaeological recording and sub-bottom profiler interpretations (Wessex Archaeology 2025b) and highlights the importance of ground-truthing initial interpretations to determine the geoarchaeological potential of deposits. As such, the shallow stratigraphy for the Proposed Offshore Scheme has been updated to include deposits observed during Stage 2 geoarchaeological recording and units identified based on geophysical datasets as discussed in the Marine Archaeological Technical Report (Wessex Archaeology 2025b; **Table 4**).

Table 4 Updated shallow stratigraphy within the Proposed Offshore Scheme

Unit	WA Unit	Geophysical description	Sediment description	Formation	Epoch
8	Seabed sediment	Generally acoustically unstructured/chaotic, ranging in thickness from a thin veneer to mobile sand ripples and sand waves up to a few metres high.	Fine to coarse sand with shell fragments.	Seabed sediment	Modern/Late Holocene
7	Possible dunes/banks	Small features within seabed sediment characterised by a well-defined upper reflector and steeply dipping internal reflectors.	n/a	Transgression	Mid-Holocene
6d	Head	Not definitively identified in the geophysical data.	Soft to firm slightly sandy and gravelly clay.	Pre-transgression terrestrial	Early to mid-Holocene
6c	Interbedded sand and clay	Characterised nearshore by very densely packed, sub-horizontal internal reflectors and a distinct, low relief basal reflector. Not definitively identified offshore.	Olive to reddish brown silty sand with clay beds.		Early Holocene (pre-transgression)
6b	Peat	Generally discontinuous horizontal high amplitude reflector. Beneath sand waves offshore and early Holocene deposits nearshore.	Dark brown peat.		Early Holocene to Cromerian (MIS>13-1)
6a	Fluvial sands and gravels/alluvial/ channels	Distinct channel features with erosive bases and fills generally characterised by parallel internal reflectors.	n/a		
5c	Estuarine to intertidal sands	Distinct areas of parallel internal reflectors, can be present within channels,	Gravelly fine to coarse sands with shell fragments and	Upper Brown Bank Formation	Early to Mid-Devensian (MIS 5d-3)

Unit	WA Unit	Geophysical description	Sediment description	Formation	Epoch
		form banks, or be a blanket deposit. Difficult to definitively distinguish between the geoarchaeological sub-units.	thin beds and laminae of silts and clays.		
5b	Estuarine alluvium		High strength greenish grey sandy silty clay and clayey silt.	Upper Brown Bank Formation	
5a	Intertidal to shallow marine		Greenish grey fine to coarse occasionally gravelly sand with occasional faint laminae.	Lower Brown Bank Formation	Early Devensian (MIS 5e-5d)
4	Marine to shallow marine	Extensive generally acoustically transparent unit with faint horizontal internal reflectors.	Dense brown sands with frequent shell fragments. Frequently overlain by organic silt/sand.	Eem Formation	Ipswichian Interglacial (MIS 5e)
3	Grey sands	Extensive deposit that is acoustically transparent/unstructured in some areas, and in others exhibits faint internal reflectors/structures.	Light greenish grey fine to medium silty sand and clayey sand with thin beds of stiff clay.	Yarmouth Roads Formation	Cromerian (>MIS 13)
2	Stiff clays	Area of faint to distinct dipping parallel reflectors, with a poorly defined basal reflector.	Stiff silty clay and clayey silt.	Westkapelle Ground Formation	Early Pleistocene
1	Red/grey sands	Acoustically transparent with little or no internal features and a strong upper bounding reflector.	Various lithologies of silty sand and gravel.	Undifferentiated Crag Formations	Pliocene to Early Pleistocene

6.2 Undifferentiated Crag Formations

6.2.1 A series of deposits interpreted as possible fluvial sands and gravels and alluvial sands during the Stage 1 review are reinterpreted here as undifferentiated Crag Group Formations, following geoarchaeological recording. These deposits were initially interpreted as overlying grey sands of the Yarmouth Roads Formation, however based on the geoarchaeological recording are reinterpreted as 'Undifferentiated Crag Formations'.

6.2.2 Based on modern geography, it was suggested that these oxidised laminated sands and gravelly sands may represent an offshore continuation of the palaeo-Blythe, Bytham or other unidentified channel in the nearshore area. Fluvial sediments of the Bytham have been recorded at Pakefield, located c. 18 km to the north of the proposed Landfall at Walberswick, where this river system once drained into the southern North Sea (Hardaker and Rose 2021). The distribution and extent of deposits of the palaeo-Bytham is however uncertain, with the potential for equivalent fluvial sediments to be preserved in the nearshore off the Suffolk coastline. The laminated sands recorded differed lithologically from the coarse-grained sands and gravels typically associated with the Bytham stratigraphy (Lewis *et al.* 2021). In addition, interpreted SBP data indicates that deposits associated with the Crag Formations outcrop at seabed or below a veneer of seabed sediments in the nearshore (Wessex Archaeology 2025b). As such, these deposits could represent sediments of the Crag Formations as opposed to fluvial deposits. Most deposits

within the Crag Group pre-date the earliest known occupation of Britian (Stoker *et al.* 2011) and would therefore have low archaeological potential. However, the Crag Formations may contain terrestrial sediments; the Cromer Forest Bed, for instance, outcrops on top of and within the Wroxham Crag and contains internationally significant archaeological and palaeoenvironmental records.

6.2.3 The excavation of five boreholes and 11 test pits to a maximum depth of 3.50 m was undertaken onshore at the proposed Landfall by Geotechnics in 2024. The test pits comprised topsoil overlying yellowish brown very dense sand with pockets of clay. This lower unit is lithologically similar to the dark orange laminated sands recovered in the nearshore area and is also observed in all five boreholes. However, in BH02, BH03, and BH04, there is a transition to grey dense sands with many shells. This transition was recorded at a broadly similar elevation in all three boreholes (19.00 m in BH02, 23.00 m in BH03 and 18.00 m in BH04) and could represent estuarine to shallow marine sediments of the Wroxham Crag Formation, which stratigraphically overlies the Red Crag Formation. Equivalent shell-rich deposits were not definitively identified in any of the nearshore or offshore vibrocores. However, given it is difficult to differentiate between the Crag Formations based on lithology alone, they are interpreted as 'Undifferentiated Crag Formations'.

6.3 Westkapelle Ground Formation

6.3.1 In the nearshore, a series of deposits comprising sands and clays were interpreted as organic interbedded based on their potential to contain upper organic sediments. Nonetheless, during geoarchaeological recording these deposits were defined as stiff interbedded minerogenic clays and sands and reinterpreted as the Westkapelle Ground Formation (e.g. in VC_001_A). This was reinforced by historic BGS mapping and interpreted SBP data in the nearshore (Wessex Archaeology 2025b). The Westkapelle Ground Formation is considered to have low archaeological potential and therefore no further works are recommended for these deposits.

6.4 Yarmouth Roads Formation

6.4.1 Grey sands with laminae and shells were recovered in vibrocores across the Proposed Offshore Scheme and correlate to Lower to Middle Pleistocene deltaic sediments of the Yarmouth Roads Formation (MIS >13).

6.4.2 Offshore, these deposits are typically shell-rich and represent deposition in a shallow marine setting with low archaeological and geoarchaeological potential. However, in Geoarch_VC_073 organic laminae with plant material were recorded and may represent low-energy fluvial deposits or banks/bar features within channels forming hotspots for human occupation. To determine the age and depositional history of this deposit, palaeoenvironmental assessment and scientific dating is recommended.

6.4.3 In the nearshore, a sequence of grey sands with beds of clay and peat was recorded in Geoarch_VC_006. Based on BGS mapping, the Yarmouth Roads Formation is largely restricted to the offshore region of the southern North Sea off the Norfolk and Suffolk coastlines. Understanding of this formation in the nearshore is however uncertain, with sediments expected to be, at least partially, contemporaneous with the Wroxham Crag Formation (1.8 to >0.6 Mya; Cameron *et al.* 1992). Channels corresponding to the Cromer Forest-bed Formation (CF-bF) which contain units with internationally significant archaeological and palaeoenvironmental records, have also been recorded between (Pakefield; Parfitt *et al.* 2005 and Lee *et al.* 2006) or cut into (Happisburgh 1; Lewis *et al.* 2019) deposits of the Wroxham Crag. At Pakefield, shallow marine to estuarine silts of the

Wroxham Crag are stratigraphically overlain by floodplain sediments, which include a 'rootlet bed', suggested to represent the CF-bF (Parfitt *et al.* 2005). In Geoarch_VC_006, a similar lower sequence of grey sands with plant fragments and vertical rooting was recovered. However, the "rootlet bed" at Pakefield is overlain by two peats separated by a thin bed of gravelly sand. Pre-Anglian organic and peat deposits are particularly rare in the southern North Sea and may provide important information on vegetation and climate change during the late Cromerian. Based on lithostratigraphy, it is possible that this sequence may also be broadly contemporary with that documented at Pakefield and as such, could preserve a similar rich archaeological and palaeoenvironmental record.

6.4.4 The depositional history and relative age of the nearshore peats in VC_005 and Geoarch_VC_006 is uncertain, however. The interpreted SBP data suggests that they represent a continuous layer. It is unclear in the geophysical data if these sediments represent Cromerian age or younger units, which again highlights the requirement for further geoarchaeological assessment to determine their likely age and the environment in which they were deposited.

6.5 Eem Formation

6.5.1 During the Stage 1 review, a series of vibrocores comprising brown shelly sands were recovered towards the offshore extent of the Proposed Offshore Scheme and interpreted as marine deposits laid down in the Ipswichian interglacial (MIS 5e). These marine sediments are correlated to the Eem Formation (Stoker *et al.* 2011) and are of low geoarchaeological significance. However, a selection of vibrocores were noted as presenting possible upper organic deposits, which may represent evidence of a developing terrestrial landscape immediately following the Ipswichian highstand. Despite this, no organic deposits or material were identified during the Stage 2 recording, with deposits described as entirely minerogenic. These marine deposits are therefore collectively assigned a low priority status with no further geoarchaeological works required.

6.6 Upper Brown Bank

6.6.1 Greenish-grey laminated sands characteristic of deposition in a lower energy rhythmic waterlain estuarine to intertidal environment were recorded stratigraphically overlying stiff, interbedded clays of the Upper Brown Bank Formation, These sands often show a clear lower boundary with the underlying clays, and therefore may represent marginal sediments immediately post-dating the clay sequences of the Upper Brown Bank. This deposit has not been widely discussed in the literature and therefore its depositional history, relative age and geoarchaeological and/or archaeological potential is unclear.

6.6.2 Interestingly in Norfolk Vanguard (NV; East and West) and Norfolk Boreas Offshore Windfarms, located approximately 1.80 km and 1 km respectively from the Proposed Offshore Scheme, a unit defined as 'Undifferentiated' was identified based on the interpreted geophysical and geotechnical data as overlying the Upper Brown Bank Formation (Wessex Archaeology 2019a; 2019b). These deposits are lithologically similar (i.e. laminated sands with shell) to the sediments interpreted as the 'Upper Brown Bank' during the initial review of vibrocores from the Proposed Offshore Scheme. In the Vanguard/Boreas area, these deposits were suggested to represent either intertidal or channel deposits (Wessex Archaeology 2019a, 2019b). These sand deposits were not definitively identified in the geophysical assessment for the Proposed Offshore Scheme and therefore it is uncertain if these sediments identified are contemporaneous with those identified in the adjacent offshore windfarms (Wessex Archaeology 2019a; 2019b). Further investigation is required to determine their taphonomy and archaeological potential.

6.7 Peat

6.7.1 In the Proposed Offshore Scheme, four vibrocores (VC_005, Geoarch_VC_006, Geoarch_VC_111 and Geoarch_VC_128) are identified as containing peat deposits, considered to be of high potential for preserving material for radiocarbon dating, along with a range of palaeoenvironmental remains (e.g. pollen, plant macrofossils) suitable for reconstructing past landscape and environmental change. The peats in VC_005 and Geoarch_VC_006 are discussed in 6.4.3.

6.7.2 Two peat deposits characterised as amorphous clayey peat (Geoarch_VC_111) and pseudo-fibrous to amorphous peat with wood fragments (Geoarch_VC_128) are located in the offshore area of the Proposed Offshore Scheme. These peat units stratigraphically overly sediments correlated to the Brown Bank Formation and therefore are expected to post-date the late Devensian (MIS 3). In NV East, NV West and Norfolk Boreas Offshore Windfarm sites, Pleistocene sediments are overlain by terrestrial peats identical to those recovered during the geotechnical investigation (Wessex Archaeology 2019a; 2019b). Radiocarbon dating of peat deposits from the Norfolk Boreas site indicate peat development commenced at the start of the Early Holocene at 9992 ± 51 BP (UBA-38190; 11710-11260 cal. BP) and continued for a period of up to ~700 years. It is therefore possible that these peats also preserve a range of palaeoenvironmental evidence informing on landscape change in the southern North Sea.

6.8 Interbedded sand and clay

6.8.1 Across the Proposed Offshore Scheme, upper organic interbedded sediments interpreted as representing deposition in a low-energy waterlain environment (e.g. fluvial channel, intertidal or estuarine) were recorded during the Stage 1 review. A series of units were therefore requested for further geoarchaeological investigation. However, during geoarchaeological recording, no organic deposits were identified, with all sediments described as minerogenic slightly clayey sand, and sand with clay beds and laminations. Based on SBP data, in the nearshore these sediments are characterised by densely packed, sub-horizontal internal reflectors, indicative of fine-grained deposition. The sediments are therefore re-assigned a medium priority status given their absence of organics and are collectively defined as ‘Interbedded sand and clay’. The depositional history and age of these deposits is unclear, although based on the interpreted SBP geophysical data may be associated with palaeochannels or cut and fill features (Wessex Archaeology 2025b).

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

7.1.1 The Quaternary stratigraphy present within the Proposed Offshore Scheme, based on deposits recovered from vibrocore and units identified based on interpreted SBP geophysical data, is presented in **Table 4**. Deposits interpreted as Peat are collectively assigned a high priority status. Sediments defined as Interbedded Sand and Clay, the Upper Brown Bank Formation and Yarmouth Roads Formation are considered to have medium geoarchaeological priority.

7.1.2 No further geoarchaeological works are recommended for deposits assigned a low geoarchaeological potential, including the Undifferentiated Crag Formation, Westkapelle Ground Formation, Eem Formation, Lower and Upper Brown Bank Formation, Head and Seabed Sediments.

7.1.3 Recommendations for Stage 3 palaeoenvironmental assessment are outlined below and presented in **Table 5**.

7.2 Yarmouth Roads Formation

7.2.1 The distribution, formation history and age of deposits correlated to the Yarmouth Roads Formation are complex and largely unresolved, however these deposits appear to have been deposited in a range of environments from fluvial, intertidal to estuarine, and shallow marine, during the Early Pleistocene prior to the Anglian glaciation (MIS 12). Of archaeological and geoarchaeological interest are deposits associated with fluvial or floodplain environments. Geoarch_VC_073 offshore contained sands with organic laminations and plant material which may indicate warmer climatic conditions. To understand the relative age and depositional mode of this deposit, it is recommended that a series of sub-samples are taken to assess the preservation potential of foraminifera and ostracods. It is also recommended that a selection of sub-samples are acquired to establish if plant macrofossils, pollen and non-pollen palynomorphs (NPPs), which have been identified as useful indicators of changes in salinity in Pleistocene deposits (e.g. Wessex Archaeology 2024), are preserved.

7.2.2 Deposits tentatively correlated to the Yarmouth Roads were also identified in Geoarch_VC_006 in the nearshore. The Yarmouth Roads Formation is thought to contain units that are broadly contemporary with terrestrial deposits belonging to the CF-bF recorded on the foreshore north of the proposed Landfall at Pakefield, which have produced internationally significant Lower Palaeolithic archaeology and palaeoenvironmental evidence (Parfitt et al. 2005; Parfitt 2008). To determine the depositional history of this sequence, it is recommended that a selection of sub-samples from the sands and clay bed overlying the peats between 0.44 mbsf and 3.33 mbsf), as well as the sands underlying the peats between 3.60 mbsf and 5.80 mbsf, are taken to determine if foraminifera and ostracods are preserved. As diatoms are better preserved in silts and clays, it is recommended that a couple of sub-samples are acquired from the clay bed recovered between 2.69 mbsf and 3.25 mbsf.

7.3 Upper Brown Bank Formation

7.3.1 The spatial distribution, formation history and age of sediments representing the Brown Bank Formation are largely unresolved, particularly with regard to the upper deposits associated with the termination of this shallow lagoon embayment. Based on geoarchaeological recording, it is possible these sediments represent deposition in an estuarine to intertidal setting, reflecting increasing depositional energy in response to the regression of this feature. Without a clear understanding of the depositional history, the archaeological importance of this unit is poorly understood. To understand the archaeological potential of this unit and to develop an absolute chronology, it is recommended that the top and bottom of the sand unit recorded between 1.61-1.90 mbsf in Geoarch_VC_111 are dated using optical simulated luminsence (OSL) techniques. It is also recommended that a small number of sub-samples are assessed to establish if foraminifera and ostracods are preserved to determine changes in salinity content and climate conditions.

7.4 Peat

7.4.1 Peat was recovered in four vibrocores from the Proposed Offshore Scheme (VC_005, Geoarch_VC_006, Geoarch_VC_111 and Geoarch_VC_128). The peats in Geoarch_VC_111 and Geoarch_VC_128 were located further offshore and based on stratigraphy and the age of peat deposits in the wider area (Wessex Archaeology 2019a; 2019b), are expected to date from the Late Glacial to Early Holocene. To establish a

chronology, it is recommended that a sub-sample is taken from the top and bottom of the peat in Geoarch_VC_128. It is also recommended that a single bulk sub-sample is taken for radiocarbon dating from Geoarch_VC_111. To assess palaeoenvironmental change, a series of sub-samples from Geoarch_VC_111 and Geoarch_VC_128 are recommended for pollen and plant macrofossil assessment.

7.4.2 There is greater uncertainty regarding the age of the peat deposits recovered in the nearshore in VC_005 and Geoarch_VC_006. These peats are within grey sands characteristic of the Yarmouth Roads Formation and may be broadly contemporaneous with CF-bF channel deposits identified at Pakefield (Cromerian; >MIS 13), from which internationally significant archaeology has been recovered (Parfitt et al. 2005). Based on interpreted SBP data, it is evident that the peat in VC_005 and Geoarch_VC_006 form a continuous layer and are therefore expected to be similar in age. However, it is unclear based on the seismic data if these deposits form part of an Early Holocene or older depositional feature. To determine the relative age of the nearshore peat, it is therefore recommended that a sub-sample from the top and bottom of each peat bed in Geoarch_VC_128 is taken for radiocarbon dating. As the peat in VC_005 is slightly disturbed, it is recommended that a single bulk sample is taken for radiocarbon dating.

7.5 Interbedded sand and clay

A series of deposits interpreted as 'Organic Interbedded' during the Stage 1 review (Wessex Archaeology 2025a) were reinterpreted as 'Interbedded Sand and Clay' during the Stage 2 geoarchaeological recording due to the absence of organics. The depositional history of these deposits in the nearshore is unclear although appear to be alluvial in nature. To determine if these sediments represent deposition in an intertidal, estuarine or fluvial environment, it is recommended that a series of sub-samples are taken from Geoarch_VC_202 to assess the preservation potential of foraminifera and ostracods. Vibrocore Geoarch_VC_202 is targeted as it is located on the edge of a palaeochannel mapped based on interpreted SBP data (Feature 75006; Wessex Archaeology 2025b).

Table 5 Recommendations for Stage 3 palaeoenvironmental assessment of vibrocores from the Proposed Offshore Scheme

ID	Unit	C14 dating	OSL dating	Plant macros	Pollen	Diatoms	Foraminifera & ostracods
Geoarch_VC_006	Yarmouth Roads (0.44-3.33m)					2	4
Geoarch_VC_006	Yarmouth Roads (3.60-5.80m)						6
VC_073	Yarmouth Roads			2	4 x pollen 4 x NPPs		6
Geoarch_VC_111	Upper Brown Bank		2				3
VC_005	Peat	1		1	2		
Geoarch_VC_006	Peat (3.33-3.43m)	2		2	4		
Geoarch_VC_006	Peat (3.47-3.60m)	2		2	4		
Geoarch_VC_111	Peat (1.48-1.61m)	1		2	4		
Geoarch_VC_128	Peat (0.95-1.22m)	2		2	6		

ID	Unit	C14 dating	OSL dating	Plant macros	Pollen	Diatoms	Foraminifera & ostracods
Geoarch_VC_202	Interbedded sand and clay						4
TOTAL		**8**	**2**	**11**	**28**	**2**	**23**

7.6 Research questions

7.6.1 A series of research questions are posed to underpin the recommended Stage 3 palaeoenvironmental assessment, taking into account the prehistoric research management framework for the North Sea (NSPRMF 2023), the national maritime research framework (Ransley *et al.* 2013) and the national research and conservation framework for the British Palaeolithic (Historic England 2008).

7.6.2 Specific research questions include:

- What is the relative age and depositional history of the nearshore and offshore Yarmouth Roads Formation deposits?
- What is the depositional history of the ?Upper Brown Bank Formation unit?
- What is the age and vegetation history of the Peat deposits?
- Do the peats in nearshore vibrocores VC_005 and Geoarch_VC_006 date to the Cromerian (>MIS 13) or a later period of exposure and warming?

7.6.3 These questions will address the following research themes:

- What climatic, landscape and environmental changes occurred and how did these impact on the region? (E2; NSPRMF 2023)
- Where are former land surfaces with the potential to be associated with minimally disturbed and *in situ* archaeology? (F3; NSPRMF 2023)
- How did vegetation change in response to climatic and environmental changes? (E2.1; NSPRMF 2023)
- What were the sea-level changes (recorded as sea-level index points) and at what timescale? (E2.3; NSPRMF 2023)
- How did climate, landscapes and environments change across and between archaeological periods in the region? (E4; NSPRMF 2023)
- Exploring environmental change and its impact over the Pleistocene/Holocene transition (English Heritage 2008).

7.7 Palaeoenvironmental assessment methods

7.7.1 Palaeoenvironmental assessment will involve a suite of complementary techniques, comprising, pollen, diatoms, foraminifera and ostracods, supported by the optically stimulated luminescence dating of suitable deposits. Multiple techniques are typically assessed in accordance with Historic England guidelines on good practice in environmental

archaeology (Campbell *et al.* 2011), geoarchaeology (Canti and Corcoran 2015), and dating the Pleistocene (Grant and Marshall 2025), providing a comprehensive understanding of the depositional and environmental context of the sediments.

Pollen analysis

7.7.2 Pollen is one of the principal techniques used in environmental archaeology to investigate past vegetation environments and the impact of human communities on the landscape, the latter often evident as distinct phases of woodland clearance or specific land-use strategies (e.g. cereal cultivation, creation of pastures or meadows). Pollen is best preserved in waterlogged organic and oxygen-free sediment, such as peat, where the pollen grains are most representative of the surrounding vegetation at the time of deposition. Marine/riverine sediments are not ideal for pollen assessment as the grains may be transported over long distances or suspended in the water column for significant periods of time.

Diatoms, foraminifera and ostracods

7.7.3 Diatoms (unicellular algae), foraminifera (marine protozoa) and ostracods (bivalve Crustacea) occur in a wide range of marine and semi-terrestrial environments (e.g. saltmarsh) and provide important comparative indicators on past coastal and riverine change. Assessment of sediments at transitions can help to distinguish evidence for sea level, coastal and riverine change, including, the influence of storm/high tide events on semi-terrestrial environments (perhaps visible as fine organic/mineral banding in sediments).

Radiocarbon dating

7.7.4 Radiocarbon dating is an established technique used for determining the date of a range of organic materials. AMS (Accelerator Mass Spectrometry) dating of slices of peat, or of short-lived material (seeds, twigs) recovered from the peat, will provide a secure chronological context for these deposits and the palaeoenvironmental assessment recommended on select boreholes. Where thick peats are present AMS dates from the top and base of the peats are recommended, whereas one date will suffice for thin and relatively short-lived peats.

Optically-stimulated luminescence (OSL) dating

7.7.5 Luminescence dating is an established technique for determining the burial age of sediments and can provide a chronology for deposits that lack organic material or are older than the maximum age range of radiocarbon dating. The dating of quartz (OSL) is most commonly used in geoarchaeological contexts and is preferred for deposits with a higher sand content such as those laid down in aeolian and fluvial environments. Luminescence dating is also used to obtain ages for alluvial deposits which contain a sufficient quantity of sand. Where clay is more dominant in alluvial sequences, a larger sample of the deposit is required. Sampling direct from a sedimentary unit is preferred, however intact vibrocore and borehole sequences can be sampled for luminescence dating in the laboratory if the samples have been retrieved and stored appropriately and the sediments shielded from light is available (Grant and Marshall 2025).

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APPENDICES

Appendix 1 – Location of targeted geoarchaeological vibrocores

ID	Easting	Northing	Water depth (m)
Geoarch_VC_006	416751.42	5800231.56	23.60
Geoarch_VC_007	417513.82	5800852.29	18.56
Geoarch_VC_009	418706.82	5802617.01	21.70
Geoarch_VC_013	422200.57	5803529.57	25.09
Geoarch_VC_017	426383.02	5803437.4	31.98
Geoarch_VC_031	439054.49	5806211.63	42.69
Geoarch_VC_031_A	439057.6	5806214.13	42.69
Geoarch_VC_060	456894.66	5823862.6	47.89
Geoarch_VC_063	458806.32	5826166.33	50.31
Geoarch_VC_063_A	458806.96	5826170.48	50.65
Geoarch_VC_102	471912.87	5860114.12	36.20
Geoarch_VC_106	471570.6	5864073.54	37.18
Geoarch_VC_109	473132.95	5866276.75	35.05
Geoarch_VC_111	473110.33	5868271.34	34.50
Geoarch_VC_118	473232.5	5875264.88	32.71
Geoarch_VC_128	481088.89	5880572.78	31.42
Geoarch_VC_130	482913.94	5881381.7	31.14
Geoarch_VC_138	486074.48	5887696.08	28.66
Geoarch_VC_140	486467.1	5888918.12	27.80
Geoarch_VC_152	494196.13	5897983.06	29.24
Geoarch_VC_177	410681.72	5796099.64	14.50
Geoarch_VC_178	411533.37	5796442.8	14.90
Geoarch_VC_180	414454.47	5797743.16	21.00
Geoarch_VC_202	410143.16	5795907.88	13.20

Appendix 2 – Stage 2 geoarchaeological recording

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
Geoarch_VC_202	0.00	0.25	No recovery	N/A	Reacquired
Geoarch_VC_202	0.25	0.85	Light brown to dark grey, silty SAND, fine to medium sand, few to common thickly laminated (20mm), clay concentration increases, few fine to medium shell inclusions. Sharp to 102.	Interbedded sand and clay	Reacquired
Geoarch_VC_202	0.85	1.45	Dark grey slightly silty SAND, sand is fine to medium many shell inclusions (25-1mm). Gradual to 103. 1.00-1.08 - No recovery	Interbedded sand and clay	Reacquired
Geoarch_VC_202	1.45	1.65	Dark brown to black slightly clayey fine to medium SAND with singular wooded fragment (30mm). Gradual to 104	Interbedded sand and clay	Reacquired
Geoarch_VC_202	1.65	4.65	Dark reddish brown gravelly SAND, sand medium to coarse gravel fine to coarse (<65mm), sub angular to rounded. matrix supported, sharp sub-horizontal contact to 105. Sand becomes increasingly coarser and lighter in colour throughout this unit	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_202	4.65	4.81	Light grey to grey slightly silty SAND, sand is fine to medium	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_202	4.81	5.34	Light brown very gravelly SAND, sand is coarse, gravel is fine to coarse. sub-angular to rounded sharp contact to 107.	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_202	5.34	6	Light reddish brown to grey very slightly silty SAND, sand is fine to medium, many shell inclusions (<8mm). very few pockets of higher silt/clay content, thickly laminated and closely spaced. Basal sediments coarser grained, very many shell inclusions with no silt content.	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_177	0	0.2	No recovery	N/A	Reacquired
Geoarch_VC_177	0.2	0.80	Dark reddish brown slightly clayey SAND, very few clasts, medium to cobble sized (<75mm) sub rounded, matrix supported, diffuse to 802.	Interbedded sand and clay	Reacquired
Geoarch_VC_177	0.80	2.18	Reddish orange very slightly silty SAND, sand fine to medium, common grey thinly laminated to thinly bedded intermittently spaced clay laminations (3mm), gradual contact to 803	Undifferentiated Crag Formations	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
Geoarch_VC_177	2.18	4.80	Light grey fine to coarse sand, thickly laminated widely spaced clay incursions, 100mm pockets of finer grained sand. gradual to 804	Undifferentiated Crag Formations	
Geoarch_VC_177	4.80	5.80	Light to dark grey SAND, sand is fine to coarse, common shell inclusions, fine to medium (<20mm). Few flint clasts, coarse sub angular.	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	0.00	1.50	Brown SAND, fine to medium, widely spaced pockets of dark black clay. Upper half of unit contains few fine to medium sized shells (<7mm). Lower half, broken thickly laminated closely spaced clay. Sharp to 1502	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	1.50	1.61	Reddish grey, slightly sandy moderately soft CLAY. Sharp to 1503	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	1.61	2.44	Light brownish orange medium SAND. Gradual to 1504	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	2.44	2.57	Reddish brown to grey SAND, sand is medium, common (<6mm) extremely closely spaced (<20mm) thin laminae of clay. Sharp to 1505	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	2.57	3.18	Orange mottled light grey fine to medium SAND. Sharp to 150	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	3.18	3.26	Dark red very slightly clayey fine to medium SAND. Iron pan with reddish concretions. Sharp to 1507	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	3.26	3.70	Reddish orange to light grey fine to medium SAND. Common broken clay laminations, thinly to thickly laminated, medium spaced. Diffuse to 1508	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	3.70	4.28	Grey to reddish orange fine to medium SAND. Diffuse to 1509	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	4.28	4.92	Reddish pink to grey clayey SAND, sand fine to medium, many laminations, thinly to thickly laminated, extremely to very closely spaced. Sharp to 1510	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	4.92	5.14	Reddish grey slightly sandy CLAY, sand is fine, moderately soft	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	5.14	5.45	Light reddish brown slightly clayey fine SAND. Unclear contact to 1512	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	5.45	5.74	Reddish to orangish brown fine to medium SAND. Gradual to 1513	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_178	5.74	6.00	Reddish pink to grey clayey SAND, sand fine to medium,	Undifferentiated Crag Formations	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			many laminations, thinly to thickly laminated, extremely to very closely spaced		
VC_001_A	0.00	1.00	Not recorded	N/A	Retained
VC_001_A	1.00	2.21	Grey slightly gravelly fine to coarse SAND with very many fine sand-sized to medium gravel-sized (1-18mm) whole and fragmented shells. Abrupt lower contact.	Westkapelle Ground Formation	Retained
VC_001_A	2.21	3.90	Dark grey to mid greyish brown interbedded firm silty CLAY and fine to medium SAND with many thin to thick horizontal and wavey laminae (<20mm) of silty clay.	Westkapelle Ground Formation	Retained
Geoarch_VC_180	0.00	0.23	Dark brownish mottled blackish grey slightly silty fine to medium SAND. Common extremely closely spaced thick laminae to very thin beds (10-25mm) horizontal to sub-horizontal of soft silty clay. Thin bed of medium to coarse sand with many coarse sand-sized to medium gravel-sized (2-15mm) fragmented and whole shells. Irregular sharp lower contact.	Seabed sediment	Reacquired
Geoarch_VC_180	0.23	1.14	Dark brownish grey slightly gravelly slightly clayey fine to medium SAND. Gravel is medium to coarse (12-50mm) subrounded flint clasts. Structureless. Few coarse sand-sized to fine gravel-sized (<10mm) fragmented and whole shells. Sharp broken lower contact.	Interbedded sand and clay	Reacquired
Geoarch_VC_180	1.14	1.55	Light reddish brown to light greenish grey slightly gravelly medium to coarse SAND. Gravel is fine to coarse (2-30mm) subrounded to subangular flint and quartzite clasts. Common coarse sand-sized to medium gravel-sized (<17mm) shell fragments. Structureless. Sharp irregular lower contact.	?Undifferentiated Crag Formations	Reacquired
Geoarch_VC_180	1.55	5.50	Light greenish grey medium SAND with common to many coarse sand-sized to coarse gravel-sized (<20mm) shell fragments. Structureless. Few thick laminae (<10mm) of silty fine sand and coarse sand from 2.37m and between 5.00-5.27m. Few coarse (<45mm) subrounded flint.	?Undifferentiated Crag Formations	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
VC_002_A	1.00	1.65	Dark orangish brown fine to coarse SAND with few coarse (24mm) subrounded clasts of lithified clay and few thin laminae of light grey silty clay between 1.48-1.64m. Sharp convex lower contact.	?Westkapelle Ground Formation	Retained
VC_002_A	1.65	1.78	Dark grey fine to coarse SAND with few partings of silty clay. Sharp sub horizontal lower contact.	Westkapelle Ground Formation	Retained
VC_002_A	1.78	2.09	Dark brownish grey firm silty CLAY with very many coarse sand-sized to coarse gravel-sized (<32mm) pockets and partings of silty fine to coarse sand.	Westkapelle Ground Formation	Retained
VC_003	0.00	0.27	Mid orangish brown medium to coarse SAND with common coarse gravel-sized pockets of firm silty clay and many fine to coarse sand-sized (0.10-2.00mm) shell fragments. Sharp lower contact.	Seabed sediment	Retained
VC_003	0.27	1.46	Mid greyish brown fine to coarse SAND with very many fine sand to medium gravel-sized (<7mm) shell fragments and many thin to thick (5-200mm) partings and pockets of blackish brown silty fine to medium sand and very soft sandy silty clay (minerogenic). Common medium (12mm) subrounded flint gravel at lower contact. Sub-horizontal abrupt lower contact.	?Westkapelle Ground Formation	Retained
VC_003	1.46	2.80	Mid orangish brown fine to coarse becoming fine to medium SAND with thin to thick laminae (10mm) of dark orange fine to medium sand and few fine gravel-sized (<5mm) pockets of grey clay. Inverse grading.	Undifferentiated Crag Formations	Retained
VC_005	4.00	4.06	Mid brown slightly gravelly slightly clayey fine to coarse SAND with many fine gravel-sized (<6mm) shell fragments. Gravel is few fine to medium (4-15mm) subangular to subrounded flint. Clear lower contact.	?Yarmouth Roads	Retained
VC_005	4.06	4.19	Mid greyish brown fine to coarse SAND with many coarse sand-sized to fine gravel-sized (1-4mm) shell fragments. Sharp horizontal lower contact.	?Yarmouth Roads	Retained
VC_005	4.19	4.28	Mid brownish grey thinly to thickly interlaminated (5-24mm)	?Yarmouth Roads	Retained

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			fine to medium SAND and mid brown firm occasionally sandy silty CLAY with few coarse sand-sized (<2mm) shell fragments. Sharp sub-horizontal lower contact.		
VC_005	4.28	4.37	Mid grey gravelly fine to coarse SAND with few medium to coarse sand-sized (<1mm) shell fragments. Gravel is fine to medium (2-20mm) subangular to subrounded flint clasts. Structureless. Sharp lower contact.	?Yarmouth Roads	Retained
VC_005	4.37	4.51	Mid grey fine to medium silty SAND with few medium sand-sized (<1mm) shell fragments and many thick laminae and to thin beds (6-22mm) of dark brownish black very strongly decomposed peat. Sharp lower contact.	?Yarmouth Roads	Retained
VC_005	4.51	4.60	Dark brownish black very strongly decomposed amorphous humified PEAT.	Peat	Retained
Geoarch_VC_006	0.00	0.44	Light yellowish brown gravelly SAND. Sand is fine to coarse. Gravel is fine to coarse (2-55mm) subangular (30%) to subrounded (70%) flint clasts. Common coarse sand-sized to medium gravel-sized fragmented and whole shells (<22mm). Sharp irregular lower contact.	Seabed sediment	Reacquired
Geoarch_VC_006	0.44	2.69	Light grey slightly gravelly SAND. Sand is fine to coarse. Gravel is few medium to coarse (23-40mm) subrounded (40%) to subangular (60%) flint and quartzite clasts. Moderately sorted. Few fine black organic fragments and thin partings between 1.27-1.45m. Few to common fine gravel-sized (<6mm) fragmented and whole shells. Abrupt horizontal lower contact.	?Yarmouth Roads	Reacquired
Geoarch_VC_006	2.69	3.25	Light grey firm silty CLAY with few fine sand-sized (<1mm) shell fragments. Diffuse broken lower contact.	?Yarmouth Roads	Reacquired
Geoarch_VC_006	3.25	3.33	Light grey very shelly SAND. Sand is fine to coarse. Very many medium sand-sized to coarse gravel-sized (2-48mm) fragmented and whole shells including oysters. Sharp sub-horizontal (erosive) lower contact.	?Yarmouth Roads	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
Geoarch_VC_006	3.33	3.43	Dark reddish black well decomposed PEAT. Sharp lower contact.	Peat	Reacquired
Geoarch_VC_006	3.43	3.47	Light greyish brown gravelly SAND. Sand is fine to medium. Gravel is medium to coarse (8-30mm) subangular to rounded flint and quartzite clasts. Poorly sorted and structureless. Sharp sub-horizontal lower contact.	?Yarmouth Roads	Reacquired
Geoarch_VC_006	3.47	3.60	Dark reddish blackish brown well decomposed PEAT. Sharp horizontal lower contact.	Peat	Reacquired
Geoarch_VC_006	3.60	5.00	Mid greenish grey fine to medium SAND with few coarse sand-sized (<2mm) pockets of clay and fine plant fragments. Few fine sand-sized (<1mm) shell fragments. Large pocket of slightly clayey fine to medium sand between 4.80-4.97mm. Lower contact is unclear.	?Yarmouth Roads	Reacquired
Geoarch_VC_006	5.00	5.80	Light grey fine to medium SAND. Common extremely closely spaced thin sub-horizontal laminae (<3mm) of fine sand between 5.05-5.26m. Few vertical organic fragments (?rooting). Few thin to thick horizontal and slightly wavey laminae (6-12mm) of dark brown firm silty clay from 5.38m.	?Yarmouth Roads	Reacquired
Geoarch_VC_007	0.00	0.08	Void	N/A	Reacquired
Geoarch_VC_007	0.08	0.47	Mid orangish brown slightly gravelly SAND. Sand is fine to coarse. Gravel is occasional (<10%) subrounded flint clasts. Occasional fine to coarse gravel-sized (5-28mm) shell fragments including mussels. Clear lower contact.	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_007	0.47	3.40	Mid orangish brown mottled light grey fine to coarse SAND with few pockets of black minerogenic sand. Thin (<4mm) sub-horizontal sandy clay laminae at 0.75m and wavey laminae between 3.00-3.40m. Occasional thick faint laminae and thin to thick laminae of medium to coarse sand. Sharp sub-horizontal lower contact.	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_007	3.40	4.04	Dark reddish to brownish orange fine to coarse SAND with extremely closely spaced thin (<3mm) slightly wavey laminae. Iron pan with dark brown lithified	Undifferentiated Crag Formations	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			sand between 3.40-3.44m. Sharp sub-horizontal lower contact.		
Geoarch_VC_007	4.04	5.40	Light grey fine to medium SAND with few pockets of lithified silt and clay	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_009	0.00	0.10	Void	N/A	Reacquired
Geoarch_VC_009	0.10	2.71	Light greyish brown fine to coarse SAND with few thin laminae (<2mm) and very thin beds (<25mm) between 2.61-2.71m of black minerogenic sandy clay. Sharp lower contact.	Westkapelle Ground Formation	Reacquired
Geoarch_VC_009	2.71	4.38	Light orangish brown medium to coarse SAND with thin to thick laminae (2-7mm) of clay becoming extremely closely spaced between 2.94-3.00m. Few coarse (<43mm) subangular flint clasts at 2.73m. Thin (<3mm) iron pan at 2.71m. Sharp horizontal lower contact.	?Undifferentiated Crag Formations	Reacquired
Geoarch_VC_009	4.38	5.60	Mid to light grey medium to coarse SAND with occasional thin to thick (<7mm) sub-horizontal laminae of silty clay. Few medium gravel-sized clasts of lithified silt.	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_013	0.00	0.20	Mid greyish brown gravelly SAND. Sand is fine to coarse. Gravel is fine to coarse (2-30mm) subrounded (80%) to subangular (20%) flint clasts. Structureless. Many coarse sand-sized to medium gravel-sized (<20mm) shell fragments. Sharp broken lower contact.	Seabed sediment	Reacquired
Geoarch_VC_013	0.20	0.39	Dark blackish brown very silty CLAY with few very thin beds (22mm) of clayey silt. Common coarse sand-sized shell fragments and medium to coarse gravel-sized (<40mm) oyster shells. Sharp sub-horizontal lower contact.	Westkapelle Ground Formation	Reacquired
Geoarch_VC_013	0.39	0.50	Dark blackish brown very silty fine to medium SAND with few fine gravel-sized (<4mm) shell fragments. Clear irregular lower contact.	Westkapelle Ground Formation	Reacquired
Geoarch_VC_013	0.50	1.23	Dark greyish brown slightly gravelly SAND. Sand is fine to medium. Gravel is common fine to coarse (2-25mm) subangular (70%) to subrounded (30%) flint and few quartzite clasts. Structureless. Few spongy plant	Westkapelle Ground Formation	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			fragments (c. 5cm) between 0.58-0.68m.		
Geoarch_VC_013	1.23	2.00	Black to light reddish brown to grey slightly silty SAND with many thin beds (20-90mm) of grey clay. Few sub rounded to sub angular medium gravel sized clasts (<12mm) of flint. Unclear lower contact.	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_013	2.00	2.73	Dark greenish grey to black slightly silty clayey SAND, fine to medium sand. Clear lower contact.	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_013	2.73	4.00	Light grey very slightly silty fine to medium SAND with common sub rounded to sub angular fine to coarse flint clasts (<50mm). Sharp contact to 6208	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_013	4.00	4.35	Light grey matrix supported sandy GRAVEL. Sand is fine to medium. Gravel is fine to coarse (7mm-35mm) rounded (40%) to sub angular (60%) flint (95%) and mudstone (5%). Sharp contact to 6209	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_013	4.35	4.60	Light brownish grey very slightly silty fine to medium SAND. Clear lower contact	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_013	4.60	5.00	Dark greenish grey slightly silty sandy matrix supported GRAVEL. Sand is fine to coarse. Gravel is fine to coarse (<60mm) rounded (60%) to sub angular (40%) flint clasts.	Undifferentiated Crag Formations	Reacquired
Geoarch_VC_017	0.00	0.29	Light yellowish brown fine to coarse SAND with common coarse sand-sized to fine gravel-sized (<4mm) shell fragments. Sharp irregular lower contact.	Seabed sediment	Reacquired
Geoarch_VC_017	0.29	0.49	Mid brownish grey slightly gravelly SAND. Sand is fine to medium. Gravel is common fine to coarse (4-22mm) subangular flint clasts between 0.29-0.34m. Thin (5mm) wavey laminae of slightly clayey silt at 0.30m and few fine gravel-sized pockets of clay. Common medium sand-sized to fine gravel-sized (<6mm) shell fragments. Clear broken lower contact.	?Yarmouth Roads	Reacquired
Geoarch_VC_017	0.49	3.37	Light grey fine to coarse SAND with few to common coarse sand-sized to fine gravel-sized (<5mm) shell fragments with few medium gravel-sized (<20mm)	?Yarmouth Roads	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			shell fragments. Few sub-horizontal thin (2mm) laminae of fine sand and clay. Clear lower contact.		
Geoarch_VC_017	3.37	3.80	Dark grey very silty fine to medium SAND with few medium sand-sized (<1mm) shell fragments.	?Yarmouth Roads	Reacquired
Geoarch_VC_031	0.00	0.29	Brown slightly silty clayey SAND, sand is fine to coarse, shells common (22-7m), broken and unbroken, contact to 7402 is moderately sharp	Seabed sediment	Reacquired
Geoarch_VC_031	0.29	0.70	light brown coarse SAND, many shell inclusions (35-4mm), broken and unbroken, singular 5-10mm slightly organic SILT lamination, horizontally bedded. Sharp to 7403	Seabed sediment	Reacquired
Geoarch_VC_031	0.70	0.90	Dark grey sandy silty CLAY, sand is medium, alternating laminations of clay and sand, thickly laminated to thinly bedded, very to closely spaced, clay member become thicker lower down.	Westkapelle Ground Formation	Reacquired
Geoarch_VC_031A	0.00	0.40	Light brown SAND, medium to coarse, common shell inclusions fine to coarse (<17mm), broken and unbroken. Courser sand lower in unit. Sharp to 7602	Seabed sediment	Reacquired
Geoarch_VC_031A	0.40	0.54	Brown to black sandy SILT, silt is medium to fine. very few broken shell inclusions (<7mm). Gradual to 7603	Seabed sediment	Reacquired
Geoarch_VC_031A	0.54	0.99	Light brown SAND, sand is course, singular sub horizontal silty CLAY lamination (5-10mm), common shell inclusions, broken and unbroken (25-5mm), sharp to	Seabed sediment	Reacquired
Geoarch_VC_031A	0.99	1.07	Very dark grey slightly silty CLAY, very few shell inclusions (<20mm). diffuse to 7605	Yarmouth Roads	Reacquired
Geoarch_VC_031A	1.07	5.60	Light brown to grey very slightly silty SAND, sand is to fine to medium, singular silty CLAY lamination (3.81-3.86m), very few medium flint clasts (19mm), sub angular, low sphericity. Lower contact unclear	Yarmouth Roads	Reacquired
VC_209	0.00	0.40	Light yellowish brown fine to coarse SAND with common fine gravel-sized (<6mm) shell fragments and few thick parting (<20mm) of black slightly organic	Seabed sediment	Retained

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			slightly clayey fine sand. Sharp irregular lower contact.		
VC_209	0.40	0.69	Mid greyish brown becoming dark blackish brown slightly organic slightly clayey gravelly SAND. Sand is fine to coarse. Gravel is fine to medium (2-18mm) subrounded flint. Structureless. Many fine to coarse gravel-sized (2-32mm) whole and fragmented shells. Clear lower contact.	?Seabed sediment	Retained
VC_209	0.69	5.80	Mid grey silty fine to medium SAND with common horizontal and sub-horizontal thin laminae and partings (<3mm) to very thin beds (<30mm) of mid brown silt and clayey silt with few fine gravel-sized (3-6mm) organic fragments. Common coarse sand-sized to fine gravel-sized (2-5mm) pockets of plant material.	Yarmouth Roads	Retained
Geoarch_VC_060	0.00	0.78	Brown SAND, sand is course, few shell inclusions (<15mm), unbroken, two thickly laminated closely spaced laminae (silty CLAY). sharp to 602.	Seabed sediment	Reacquired
Geoarch_VC_060	0.78	1.00	Dark grey slightly sandy gravelly CLAY, sand is medium, gravel is fine to coarse, flint clasts, angular to sub angular, low sphericity, moderately sorted. Very many shells (fine to coarse - 30-4mm), broken and unbroken. bioturbated. clast and shell supported, sharp to 603	Upper Brown Bank	Reacquired
Geoarch_VC_060	1.00	2.25	Dark brownish grey slightly silty CLAY, structured, many laminae of increased clay concentration. thinly to thickly bedded extremely closely to closely spaced.	Upper Brown Bank	Reacquired
Geoarch_VC_060	2.25	2.53	Dark grey sandy silty CLAY, structureless, common shell incursions, (18-3mm), diffuse to 605	Upper Brown Bank	Reacquired
Geoarch_VC_060	2.53	4.03	Grey to brown slightly silty SAND, sand is fine to medium, massive sedimentation until 4.07. 4.07 - increase in shell concentration with increasing grain size of sand- very many shell inclusions, (35-04mm). Very sharp to 606	Upper Brown Bank	Reacquired
Geoarch_VC_060	4.03	4.64	Firm brown slightly sandy CLAY, clay considerably dry, common fine to medium flint clasts,	Upper Brown Bank	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			rounded to sub rounded, moderate sphericity. Gradual to 607		
Geoarch_VC_060	4.64	5.90	Grey to light brown slightly silty SAND, sand is fine to medium, thinly to laminated to thinly bedded, very widely spaced clay laminae, lower contact unknown.	Yarmouth Roads	Reacquired
Geoarch_VC_063A	0.00	1.76	Mid greyish brown fine to coarse SAND with common thin laminae to very thin beds (3-28mm) of dark brownish black minerogenic (?possible organic) silty clay and common (<50mm) fragmented and whole shells. Common fine subrounded flint gravel clasts between 1.54-1.76m. Abrupt sub-horizontal lower contact.	?Seabed sediment	Reacquired
Geoarch_VC_063A	1.76	2.40	Light brown medium to coarse SAND with common faint thin laminae (<3mm) sub-horizontal fine sand. Many coarse sand-sized (1-2mm) shell fragments. Single coarse (60mm) subrounded flint gravel at 2.36m. Clear smooth lower contact.	?Seabed sediment	Reacquired
Geoarch_VC_063A	2.40	4.20	Light brownish grey to greyish brown fine to medium SAND with few coarse sand-sized clay fragments.	Yarmouth Roads	Reacquired
VC_073	0.00	0.36	Mid orange brown fine to coarse SAND with singular coarse gravel-sized (35mm) marine shell fragment and very rare medium gravel-sized (10mm) shell fragments. Sharp sub-horizontal lower boundary.	Seabed sediment	Retained
VC_073	0.60	0.61	Dark grey silty fine to medium SAND with singular sub-horizontal thick lamination of silt between 0.46-0.47m. Abrupt horizontal lower contact.	Seabed sediment	Retained
VC_073	0.61	0.88	Soft dark brownish grey thickly laminated slightly clayey SILT with common fine sand-sized shell fragments. Laminae is horizontal fine to medium sand. Sub-horizontal very thin bed of slightly gravelly (fine to medium subangular flint) fine to coarse sand between 0.85-0.88m. Sharp sub-horizontal lower contact.	?Yarmouth Roads	Retained
VC_073	0.88	1.00	Soft dark brownish grey mottled dark blackish brown very silty CLAY with common medium (10mm) partings of fine to medium silty sand, fine sand-sized shell fragments and few	?Yarmouth Roads	Retained

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			fine gravel-sized (<4mm) pockets of black minerogenic silt		
VC_073	1.00	1.53	Light grey thickly becoming thinly laminated silty fine to medium SAND. Laminae is dark brownish grey fine sand with rare oxidized orange mottles and few laminar medium gravel-sized (19mm) organic plant fragments. Sharp lower contact.	?Yarmouth Roads	Retained
VC_073	1.53	2.30	Mid grey fine SAND with few horizontal medium-spaced thin laminae of slightly organic silt and fine sand and few faint sub-horizontal thin laminae. Clear lower contact.	?Yarmouth Roads	Retained
VC_073	2.30	3.00	Mid grey fine SAND with few horizontal medium-spaced thin laminae of slightly organic silt and fine sand and few faint sub-horizontal thin laminae. Clear lower contact.	?Yarmouth Roads	Retained
VC_073	3.00	3.29	Soft dark brownish grey very silty CLAY with thin to thick laminae (2-7mm) of fine sand with few fine sand-sized shell fragments. Sharp sub-horizontal lower contact.	?Yarmouth Roads	Retained
VC_073	3.29	3.41	Mid brownish grey slightly clayey slightly gravelly SAND with many coarse sand-sized to fine gravel-sized (<5mm) shell fragments. Sand is fine to coarse. Gravel is fine to medium (2-14mm) subangular to subrounded flint. Sharp sub-horizontal lower contact.	?Yarmouth Roads	Retained
VC_073	3.41	4.70	Mid brownish grey fine to medium SAND with few thin laminae (2mm) of black slightly organic medium sand.	Yarmouth Roads	Retained
VC_075	0.00	0.12	Dark greyish brown clayey gravelly SAND. Sand is fine to coarse. Gravel is fine to medium (2-16mm) subangular flint. Structureless. Many fine gravel-sized (<6mm) shell fragments. Sharp disturbed lower contact.	Seabed sediment	Retained
VC_075	0.12	0.41	Soft mid to dark brown slightly sandy silty CLAY. Sand is fine to coarse. Common fine gravel-sized (2-6mm) shell fragments. Common thin laminae of dark blackish brown slightly organic silt. Clear lower contact.	Upper Brown Bank	Retained

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
VC_075	0.41	0.61	Dark greyish brown mottled orangish brown slightly organic gravelly SAND. Gravel is fine to coarse (<45mm) subangular to subrounded flint. Many fine coarse gravel-sized (<26mm) whole and fragmented shell. Sharp sub-horizontal lower contact.	?Upper Brown Bank	Retained
VC_075	0.61	1.82	Dark grey slightly clayey silty fine to medium SAND with very many pockets and partings of silty and sandy clay and few fine gravel-sized (<4mm) organic fragments. Sharp sub-horizontal lower contact.	?Upper Brown Bank	Retained
VC_075	1.82	3.82	Dark grey fine to medium SAND with many thinly to thickly laminated (1-20mm) horizontal and sub-horizontal (wavey) clayey silt. Few laminae contain fine gravel-sized (<3mm) organic fragments. Thick laminae and thin beds of organics at 3.54m. Clear lower contact.	Yarmouth Roads	Retained
VC_075	3.82	4.11	Dark greyish brown slightly clayey silty fine to medium SAND with few coarse sand-sized (<2mm) organic fragments. Sharp sub-horizontal lower contact.	Yarmouth Roads	Retained
VC_075	4.11	5.12	Dark grey fine to medium SAND with common thick laminae (18mm) of clayey silt and few very thin to thin beds of dark brown stiff clay between 4.82-4.84m and 5.00-5.10m. Thin bed (22mm) of organic material at 4.60m. Few medium gravel-sized (8-16mm) clasts of lithified clay between 4.90-4.98m. Sharp sub-horizontal (wavey) lower contact.	Yarmouth Roads	Retained
VC_075	5.12	5.60	Mid grey fine to medium SAND with few coarse sand-sized (<2mm) pockets of dark greyish brown clay. Well sorted. Structureless.	Yarmouth Roads	Retained
VC_088	0.00	0.93	Light yellowish brown fine to coarse SAND with very many fine sand-sized to coarse gravel-sized (1-32mm) shell fragments. Structureless. Sharp horizontal lower contact.	Seabed sediment	Retained
VC_088	0.93	1.00	Mid grey fine to medium SAND with few coarse sand-sized (<2mm) organic fragments. Lower contact is unclear.	?Upper Brown Bank	Retained
VC_088	1.00	1.61	Void	N/A	Retained

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
VC_088	1.61	2.40	Dark grey firm silty CLAY with common thin laminae (2-4mm) of black slightly organic silt, many fine to medium gravel-sized pockets of fine sand and sandy clay and few organic fragments (e.g. plant stems). Lower contact is unclear.	Upper Brown Bank	Retained
VC_088	2.40	2.84	Void		Retained
VC_088	2.84	3.00	Dark grey firm silty CLAY with common fine gravel-sized (<10mm) pockets of fine sand. Lower contact is unclear.	Upper Brown Bank	Retained
VC_088	3.00	3.70	Void		Retained
VC_088	3.70	5.95	Dark grey firm silty CLAY with few medium gravel-sized (8mm) shell fragments, many thick laminae (8-14mm) and medium gravel-sized pockets of slightly clayey silty fine sand and few fine sand-sized (<2mm) organic fragments.	Upper Brown Bank	Retained
VC_095	0.00	0.98	Mid yellowish brown fine to coarse SAND. Common medium sand-sized to medium gravel-sized (<14mm) shell fragments becoming many fine to coarse gravel-sized (<22mm) shell fragments and whole shells between 0.78-0.98mm. Clear lower contact.	Seabed sediment	Retained
VC_095	0.98	1.47	Mid brownish grey fine to medium SAND with few coarse sand-sized shell fragments (<2mm). Very thin extremely closely spaced black minerogenic laminae between 1.32-1.35m. Faint thin laminae (1-3mm) between 1.36-1.43m. Sharp horizontal lower contact.	Seabed sediment	Retained
VC_095	1.47	5.80	Dark grey soft to firm CLAY. Many thin laminae and partings (<4mm) of dark brown to black silt and fine sand becoming common at 4.34m. Common medium sand-sized pockets (<2mm) of black organic fragments. Common coarse gravel-sized (<20mm) pockets of silt. Thin bed of silty fine sand between 3.41-3.46m. Few fine gravel-sized (2-4mm) shell fragments.	Upper Brown Bank	Retained
Geoarch_VC_130	0.00	0.40	Brown to black silty SAND, sand is fine to medium. few shell inclusions (<10mm), broken. sharp to 1302	Seabed sediment	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
Geoarch_VC_130	0.40	0.57	Brown shelly SAND, sand is medium to fine, alternating laminations of clay to sandy SHELLS (10-2mm, broken). Clay laminae is thickly laminated, closely spaced	Seabed sediment	Reacquired
Geoarch_VC_130	0.57	1.00	Brown to black silty SAND, sand is fine to medium, few shell inclusions (<10mm), broken. sharp to 1304	Seabed sediment	Reacquired
Geoarch_VC_130	1.00	1.88	Brown slightly silty SAND, sand is fine to medium, few shell inclusions, (<10mm), broken and unbroken, irregular and broken red clay laminae, thinly to thickly aminated, closely spaced. diffuse to 13005	Seabed sediment	Reacquired
Geoarch_VC_130	1.88	3.50	Grey SAND, fine to medium, few shell inclusions (singular layer), <10mm, broken. Very frequent sub to horizontal bedding. lower section of unit -sub vertical bedding. Gradual lower contact to 13006	?Upper Brown Bank	Reacquired
Geoarch_VC_130	3.50	4.15	Brown medium to coarse SAND, many shell inclusions (<3mm) broken. Gradual to 13007	?Upper Brown Bank	Reacquired
Geoarch_VC_130	4.15	4.80	Dark grey slightly sandy CLAY, sand is fine. Sand lamination (until 4.42) - thinly bedded, closely spaced clay laminations (until end of unit) - thinly laminated, extremely closely spaced. Gradual to 13008	Upper Brown Bank	Reacquired
Geoarch_VC_130	4.80	5.70	Dark grey very slightly sandy CLAY, sand is fine, slight black mottling otherwise structureless.	Upper Brown Bank	Reacquired
Geoarch_VC_102	0.00	1.64	Light orangish brown fine to coarse SAND with rare thin to thick laminae (<20mm) of black slightly clayey sandy silt and fine to medium gravel-sized (3-12mm) shell fragments and whole shells. Irregular abrupt lower contact.	Seabed sediment	Reacquired
Geoarch_VC_102	1.64	2.07	Light to mid grey very silty fine to medium SAND with common coarse sand-sized to fine gravel-sized (<4mm) shell fragments and rare pockets of slightly clayey silt. Diffuse lower contact.	Upper Brown Bank	Reacquired
Geoarch_VC_102	2.07	5.60	Mid to dark grey slightly clayey becoming clayey SILT. Common coarse gravel-sized (<30mm) pockets of fine to medium sand and thin laminae and lenses (<12mm) of silty clay from	Upper Brown Bank	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			3.97mm. Few coarse sand-sized fragments of organic material. Few medium sand-sized (<2mm) shell fragments.		
Geoarch_VC_138	0.00	1.45	Brown medium SAND, common shell inclusions broken and unbroken (15-4mm). Moderately abrupt to 13802	Seabed sediment	Reacquired
Geoarch_VC_138	1.45	2.50	Brown to black very slightly silty clayey SAND, sand is medium, silty CLAY laminations, thickly laminated closely spaced. common shell inclusions, broken (<6mm). Sharp 13803	Seabed sediment	Reacquired
Geoarch_VC_138	2.50	5.00	Brown to grey slightly silty SAND, sand is fine to medium, common red clay laminations, thinly laminated to thinly bedded, extremely to closely spaced, common shell inclusions, broken and unbroken (<10mm). Abrupt. to 13804	Eem Formation	Reacquired
Geoarch_VC_138	5.00	5.45	Light creamy brown SAND, sand is course, shell inclusions many (4-60mm), broken and unbroken, mostly unbroken, lower contact gradational and then abrupt.	Eem Formation	Reacquired
Geoarch_VC_138	5.45	5.80	Dark grey slightly silty SAND, sand is fine to medium, horizontal to sub horizontal cross bedding (many).	Eem Formation	Reacquired
Geoarch_VC_140	0.00	1.42	Yellowish brown shelly SAND. broken laminations, common to few shell inclusions, fine (<6mm), broken. Silt content increases throughout unit. Gradual to 14002	Seabed sediment	Reacquired
Geoarch_VC_140	1.42	2.61	Brown to black slightly silty SAND, sand is fine to medium, few irregular and broken thinly laminated widely spaced clay laminae, common shell inclusions (30-6mm), broken and unbroken. Diffuse to 14003	Seabed sediment	Reacquired
Geoarch_VC_140	2.61	4.68	Brown slightly silty SAND, sand is fine to medium, common. red clay laminations thinly to thickly laminated, extremely closely to closely spaced. common to many shell inclusions (6-50), broken and unbroken. Gradual to 14004	Eem Formation	Reacquired
Geoarch_VC_140	4.68	5.80	common to many shell inclusions, mostly unbroken (35-4mm).	?Yarmouth Roads	Reacquired
Geoarch_VC_106	0.00	0.60	Brown SAND, sand is fine to medium, gradual lower contact.	Seabed sediment	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
Geoarch_VC_106	0.60	1.20	Black to brown silty SAND, sand is fine to medium, few shell inclusions(<5mm) broken. sharp to 14003	Seabed sediment	Reacquired
Geoarch_VC_106	1.20	1.80	Grey SAND, sand is medium, few shell inclusions (<30mm), few to common thick laminae of wavey clay, few coarse gravel clasts (22mm), sub angular, moderately low sphericity, flint. clear to 14004	?Upper Brown Bank	Reacquired
Geoarch_VC_106	1.80	2.00	Dark Brown sandy silty CLAY, structureless, common fine gravel clasts ,(<10mm), sub angular, matrix supported, common similar sized shell inclusions, unbroken. Lower contact unclear	Upper Brown Bank	Reacquired
Geoarch_VC_106	2.00	2.64	Dark greenish grey silty CLAY, very many thinly laminated, extremely closely spaced, clay laminae. diffuse lower contact	Upper Brown Bank	Reacquired
Geoarch_VC_106	2.64	3.10	Greenish grey silty CLAY, largely structureless with mottling present. Contact to 14008 is sharp	Upper Brown Bank	Reacquired
Geoarch_VC_106	3.10	4.00	Brown to grey silty CLAY, somewhat structured with mottling similar to laminations. lower contact unclear	Upper Brown Bank	Reacquired
Geoarch_VC_106	4.00	5.50	Brownish grey CLAY, massive, very slight mottling. (firm)	Upper Brown Bank	Reacquired
Geoarch_VC_109	0.00	1.00	Brown SAND, sand is medium to coarse, common shell inclusions (30-5mm), unbroken and broken. Clay concentration decreases throughout. Diffuse to 14702.	Seabed sediment	Reacquired
Geoarch_VC_109	1.00	2.78	Light brownish grey SAND, sand is fine to coarse. cross bedding present. Sharp to 14703.	?Upper Brown Bank	Reacquired
Geoarch_VC_109	2.78	5.50	Dark brownish grey sandy CLAY, mottling common. massive/structureless.	Upper Brown Bank	Reacquired
Geoarch_VC_111	0.00	1.00	Brown to dark grey slightly silty SAND, sand is medium. common shell (25-3mm) broken and unbroken, gradual lower contact to 15402	Seabed sediment	Reacquired
Geoarch_VC_111	1.00	1.48	Brown to grey SAND, sand is fine, horizontal to sub horizontally bedded clay laminations. thinly to thickly laminated, extremely closely to closely spaced. Sharp to 15403	?Seabed sediment	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
Geoarch_VC_111	1.48	1.61	Dark reddish brown amorphous clayey PEAT, few detrital fragments. shell inclusions many (start of unit), fine grained. broken. Gradual to 15404 with higher clay concentration.	Peat	Reacquired
Geoarch_VC_111	1.61	1.90	Grey silty SAND, fine to medium, structureless. Sharp to 15405	?Upper Brown Bank	Reacquired
Geoarch_VC_111	1.90	2.20	Moderately firm brownish grey CLAY, structureless other than slight mottling. Gradual to 15406.	Upper Brown Bank	Reacquired
Geoarch_VC_111	2.20	3.00	Moderately soft grey/silver silty CLAY, structureless. Gradual to 15407	Upper Brown Bank	Reacquired
Geoarch_VC_111	3.00	5.30	Moderately soft to moderately firm brownish grey CLAY, structureless other than slight mottling.	Upper Brown Bank	Reacquired
VC_114	0.00	0.75	Mid orangish brown fine to coarse SAND with common fine to coarse gravel-sized (2-14mm) shell fragments. Structureless. Diffuse irregular lower contact.	Seabed sediment	Retained
VC_114	0.75	1.38	Light greyish brown to mid brownish grey fine to medium SAND. Common coarse gravel-sized pockets and partings of clay. Few coarse sand-sized to medium gravel-sized (<12mm) shell fragments.	?Upper Brown Bank	Retained
VC_114	1.38	3.00	Dark grey soft to firm CLAY with many coarse gravel-sized pockets (<50mm) of fine to medium sand. Few fine to coarse gravel-sized (3-18mm) shell fragments. Few thin laminae (2-4mm) of orangish iron-stained silt. Few black mottles with organic material.	Upper Brown Bank	Retained
Geoarch_VC_118	0.00	1.55	Brown to black silty clayey SAND, sand is fine to medium, common shell inclusions(50-4mm), broken and unbroken. clay laminae, thickly laminated to thinly bedded, very widely spaced (i.e., irregular). Diffuse to 16502	Seabed sediment	Reacquired
Geoarch_VC_118	1.55	2.55	Brown to grey slightly silty SAND, sand is fine to medium. Sharp to 16503	?Upper Brown Bank	Reacquired
Geoarch_VC_118	2.55	4.00	Dark grey slightly silty sandy CLAY, structure unclear, black mottling present. Medium sand laminae containing common shells present (fine), thickly laminated to thinly bedded, closely to very widely spaced (laminae thicker towards lower	Upper Brown Bank	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			end of unit) sharp to 16504		
Geoarch_VC_118	4.00	5.05	Dark brownish grey CLAY, structureless, very firm.	Upper Brown Bank	Reacquired
VC_120	0.00	1.00	Mid brown mottled black fine to medium SAND with common fine to coarse gravel-sized (4-26mm) pockets of silty clay. Common medium sand-sized to fine gravel-sized (<6mm) shell fragments becoming many between 0.37-0.42m. Unclear lower contact.	Seabed sediment	Retained
VC_120	1.00	3.15	Light yellowish to greyish brown fine to medium SAND with few thin to thick laminae (4-10mm) of mid brown silty clay and few very thin beds (<35mm) of coarse sand with very many coarse sand-sized to fine gravel-sized (1-4mm) shell fragments. Few fine gravel-sized (<3mm) shell fragments. Thick laminae (8mm) of organic sand with fine fibrous material at 3.03m. Abrupt irregular lower contact.	Seabed sediment	Retained
VC_120	3.15	3.69	Firm dark grey mottled orangish brown silty CLAY with common medium to coarse gravel-sized (<22mm) pockets of fine to medium sand. Few fine to coarse sand-sized (<2mm) shell fragments. Iron mottling throughout. Abrupt sub-horizontal slightly irregular lower contact.	Upper Brown Bank	Retained
VC_120	3.69	5.00	Stiff dark greyish brown clayey SILT with common thin beds (20-75mm) of fine to medium silty SAND. Common thin laminae (2-6mm) of black silt. Few medium to coarse sand-sized (<2mm) shell fragments.	Upper Brown Bank	Retained
Geoarch_VC_128	0.00	0.90	Light brown to dark grey silty medium SAND common banding, thin silty clay horizontal laminae (5mm) with broken laminae (~15mm), common course gravel to course sand sized shell inclusions, diffuse lower boundary	Seabed sediment	Reacquired
Geoarch_VC_128	0.90	0.95	Dark grey to dark reddish brown, slight clayey silty fine to medium SAND, course sand to find gravel sized shells. Sharp lower contact	Seabed sediment	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
Geoarch_VC_128	0.95	1.00	Dark brown woody pseudo fibrous structured peat common plant fragments wood fragment inclusion (30mm). Lower contact unclear.	Peat	Reacquired
Geoarch_VC_128	1.00	1.22	Very dark brown pseudo fibrous to amorphous structureless peat with few plant fragments clear lower contact, increasing silt concentration	Peat	Reacquired
Geoarch_VC_128	1.22	1.33	Light brownish grey structureless silty fine SAND. Sharp lower contact	?Upper Brown Bank	Reacquired
Geoarch_VC_128	1.33	2.04	Slightly greenish grey soft structureless CLAY. slight mottling (33-37cm) few organic fragments alongside shell fragments	Upper Brown Bank	Reacquired
Geoarch_VC_128	2.04	2.18	Mid grey fine to medium SAND. Structureless. Common coarse gravel-sized (<20mm) pockets of grey silty clay. Single clast of coarse (28mm) subrounded flint. Many medium sand-sized to fine gravel-sized (<6mm) shell fragments. Clear broken lower contact.	Lower Brown Bank	Reacquired
Geoarch_VC_128	2.18	2.58	Greyish brown to brownish grey medium to coarse SAND with thin beds of coarse sand with very many coarse sand-sized to coarse gravel-sized (<25mm) fragmented and whole shells. Sharp sub-horizontal lower contact.	Lower Brown Bank	Reacquired
Geoarch_VC_128	2.58	3.35	Light brownish grey to mid grey fine to medium SAND. Structureless. Common medium sand-sized to coarse gravel-sized (<35mm) shell fragments. Irregular abrupt lower contact.	Lower Brown Bank	Reacquired
Geoarch_VC_128	3.35	5.40	Light brown to grey medium to coarse SAND with dark brownish grey faint banding. Very many coarse sand-sized to coarse gravel-sized (<55mm) shell fragments and whole shells.	Lower Brown Bank	Reacquired
Geoarch_VC_152	0.00	0.75	Brown SAND, medium, thickly laminated widely spaced clay laminae. common shell inclusions (25-05mm). broken and unbroken. Diffuse to 20502	Seabed sediment	Reacquired
Geoarch_VC_152	0.75	4.50	Dark grey to brown slightly silty SAND, sand is fine to medium, common thickly laminated to thinly bedded closely spaced clay laminations, few shell inclusions	Eem Formation	Reacquired

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
			(<5mm), broken. Diffuse to 20503		
Geoarch_VC_152	4.50	5.60	Dark greyish brown silty SAND, sand is fine to medium, common shell inclusions (<10mm). broken and unbroken	Eem Formation	Reacquired
VC_154	0.00	4.70	Mid brown fine to medium SAND with common thin to thick laminae and partings (<12mm) of soft slightly reddish brown silty clay. Many becoming few coarse sand-sized to coarse gravel-sized (2-25mm) shell fragments and whole shell.	Eem Formation	Retained
VC_166	0.00	4.40	Mid brown fine to coarse SAND with common fine to coarse sand-sized (<2mm) shell fragments and few coarse sand-sized pockets (<35mm) of dark brown fine to medium sand between 0.24-0.50m.	Eem Formation	Retained
VC_167	0.00	4.00	Mid brown fine to medium SAND with few thin laminae (<3mm) of clay and common coarse sand-sized to fine gravel-sized (1-6mm) shell fragments and few medium gravel-sized (<16mm) pockets of blackish brown sand.	Eem Formation	Retained
VC_168	0.00	4.00	Mid brown fine to medium SAND with common medium sand-sized to fine gravel-sized (<3mm) shell fragments. Many fine to medium gravel-sized (2-8mm) shell fragments between 1.37-1.63m. Diffuse lower contact.	Eem Formation	Retained
VC_168	4.00	4.40	Mid brown clayey fine to medium SAND with few coarse sand-sized (<2mm) shell fragments and fine gravel-sized (6mm) whole shells. Structureless.	Eem Formation	Retained
VC_169	0.00	3.80	Light greyish brown to mid brownish grey fine to medium SAND. Structureless. Many medium sand-sized to coarse gravel-sized (1-45mm) shell fragments and whole shell to 1.46m. Common medium sand-sized to medium gravel-sized (<9mm) shell fragments between 1.46-3.80m. Clear irregular lower contact.	Eem Formation	Retained
VC_169	3.80	4.00	Mid brownish grey slightly clayey fine to medium SAND. Structureless. Common medium sand-sized to medium gravel-sized (<9mm) shell fragments.	Eem Formation	Retained

ID	Depth from (m)	Depth to (m)	Description	Interpretation/ Unit	Recovery
VC_170	0.00	3.26	Mid brown fine to medium SAND with few becoming many coarse sand-sized to coarse gravel-sized (2-30mm) shell fragments. Structureless. Medium gravel-sized pocket (10mm) of peat at 2.76m. Clear irregular lower contact.	Eem Formation	Retained
VC_170	3.26	3.80	Mid brown slightly clayey fine to coarse SAND with common coarse sand-sized to medium gravel-sized (<9mm) shell fragments. Structureless.	Eem Formation	Retained
VC_172	0.00	4.40	Mid brown fine to medium SAND with very many coarse sand-sized to medium gravel-sized (1-8mm) shell fragments.	Eem Formation	Retained
VC_173	0.00	4.50	Mid brown fine to medium SAND with few becoming many coarse sand-sized and medium gravel-sized (1-24mm) shell fragments. Structureless.	Eem Formation	Retained

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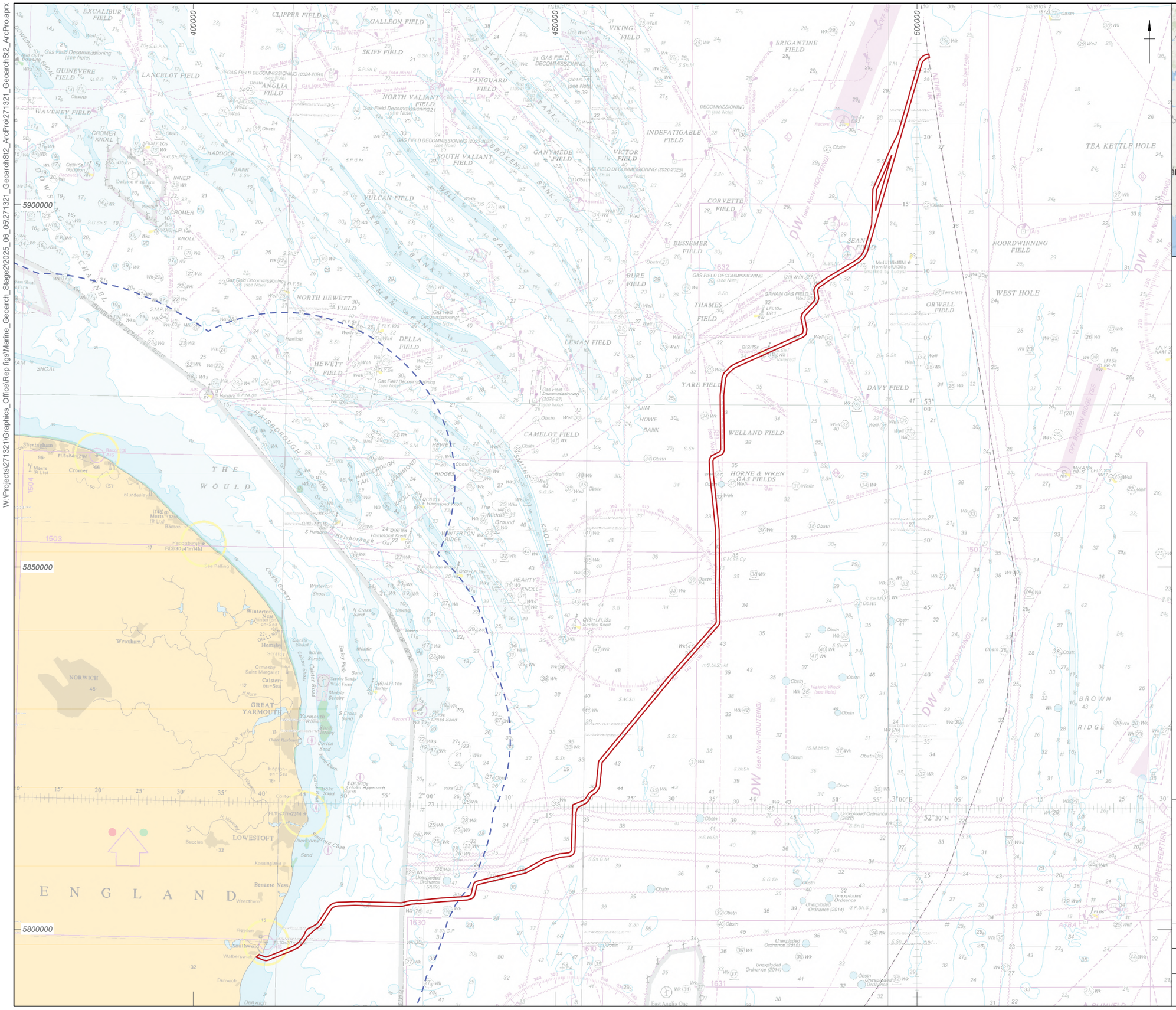

Coordinate system: ETRS 1989 UTM Zone 31N

Date: 21/07/2025	Created by: KJF	
Scale: 1:500,000 at A3	Revision: 0	

Figure 1: Location of proposed Offshore Scheme

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B1387

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VC_177
VC_202

Norwich
Great Yarmouth

Proposed Offshore Scheme Draft Order Limits
English Territorial Waters
Priority
High
Medium

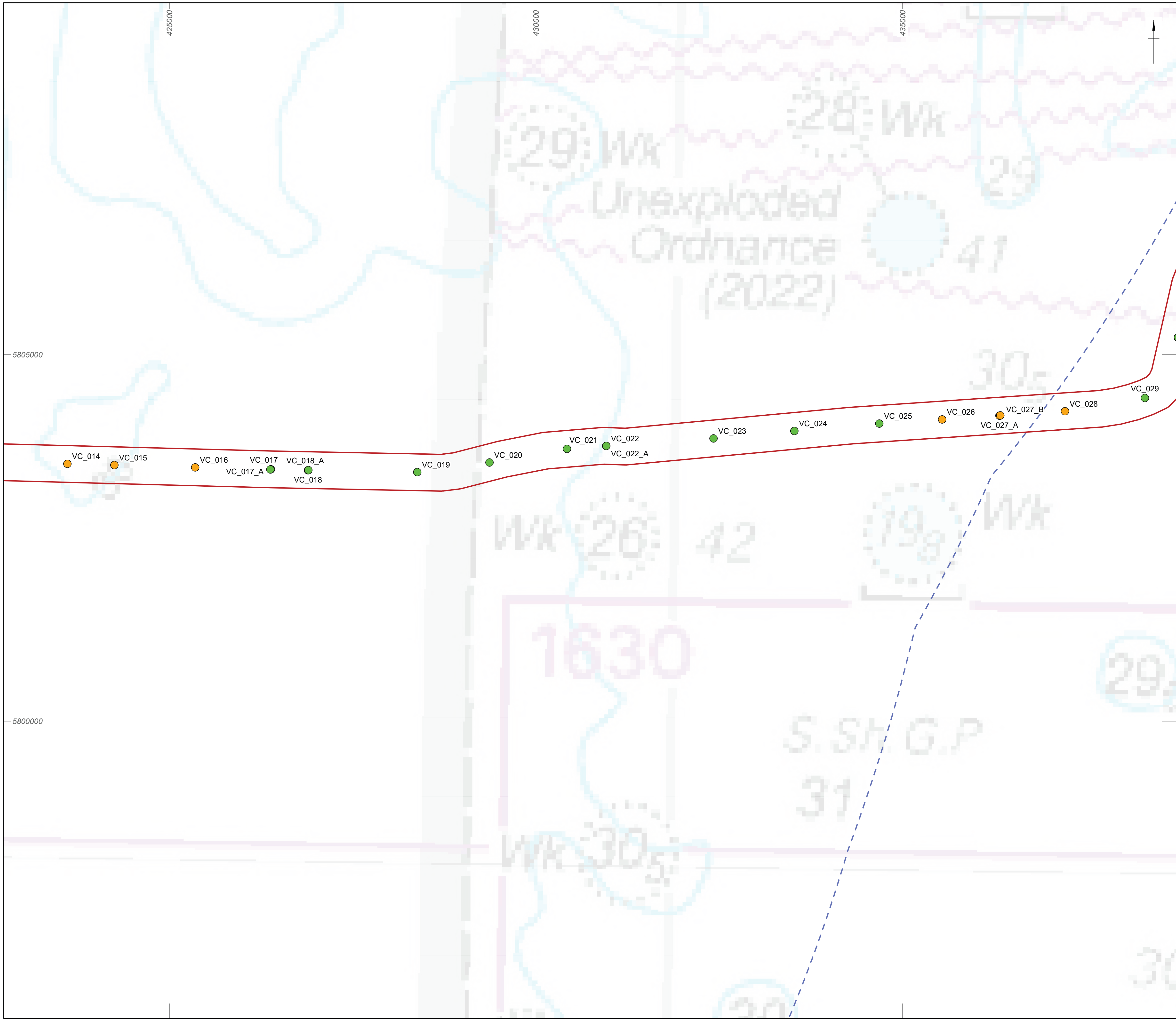
0
2.5 km

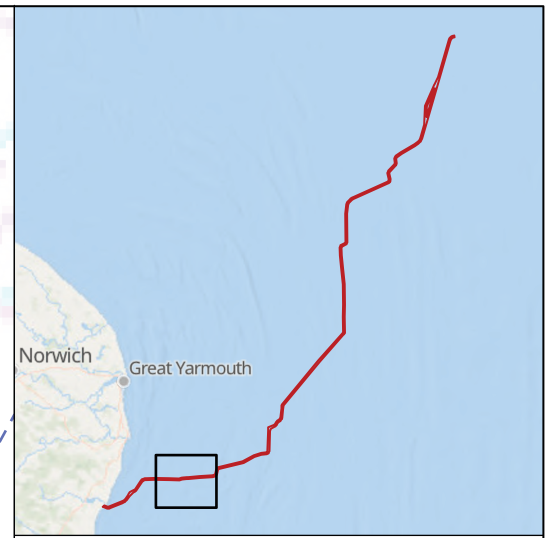
Date: 21/07/2025 | Created by: KJF

Scale: 1:50,000 at A3 | Revision: 0

Figure 2a: Location of vibrocores and geoarchaeological priority (based on Stage 1)

W:\Projects\271321\Graphics_Office\Rep figs\Marine_Geoarch_Stage2\2025_06_05\271321_GeoarchSt2_ArcPro\271321_GeoarchSt2_ArcPro.aprx





Proposed Offshore Scheme Draft Order Limits
English Territorial Waters
Priority
Medium
Low

0 2.5 km

Coordinate system: ETRS 1989 UTM Zone 31N

Date: 21/07/2025	Created by: KJF
Scale: 1:50,000 at A3	Revision: 0

Figure 2b: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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VC_048

VC_047

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VC_040

VC_039

VC_038

VC_037

VC_036_B

VC_036_A

VC_035

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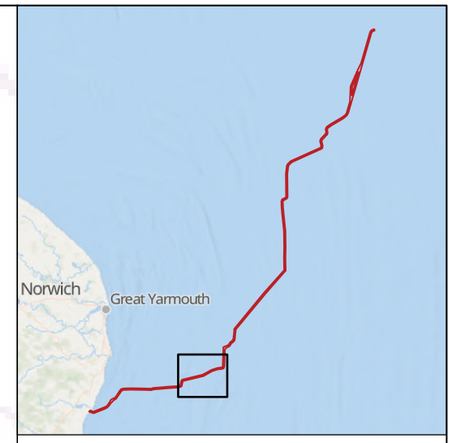

Proposed Offshore Scheme Draft Order Limits

English Territorial Waters

Priority

Medium

Low

0 2.5 km

Date: 21/07/2025 | Created by: KJF

Scale: 1:50,000 at A3 | Revision: 0

Figure 2c: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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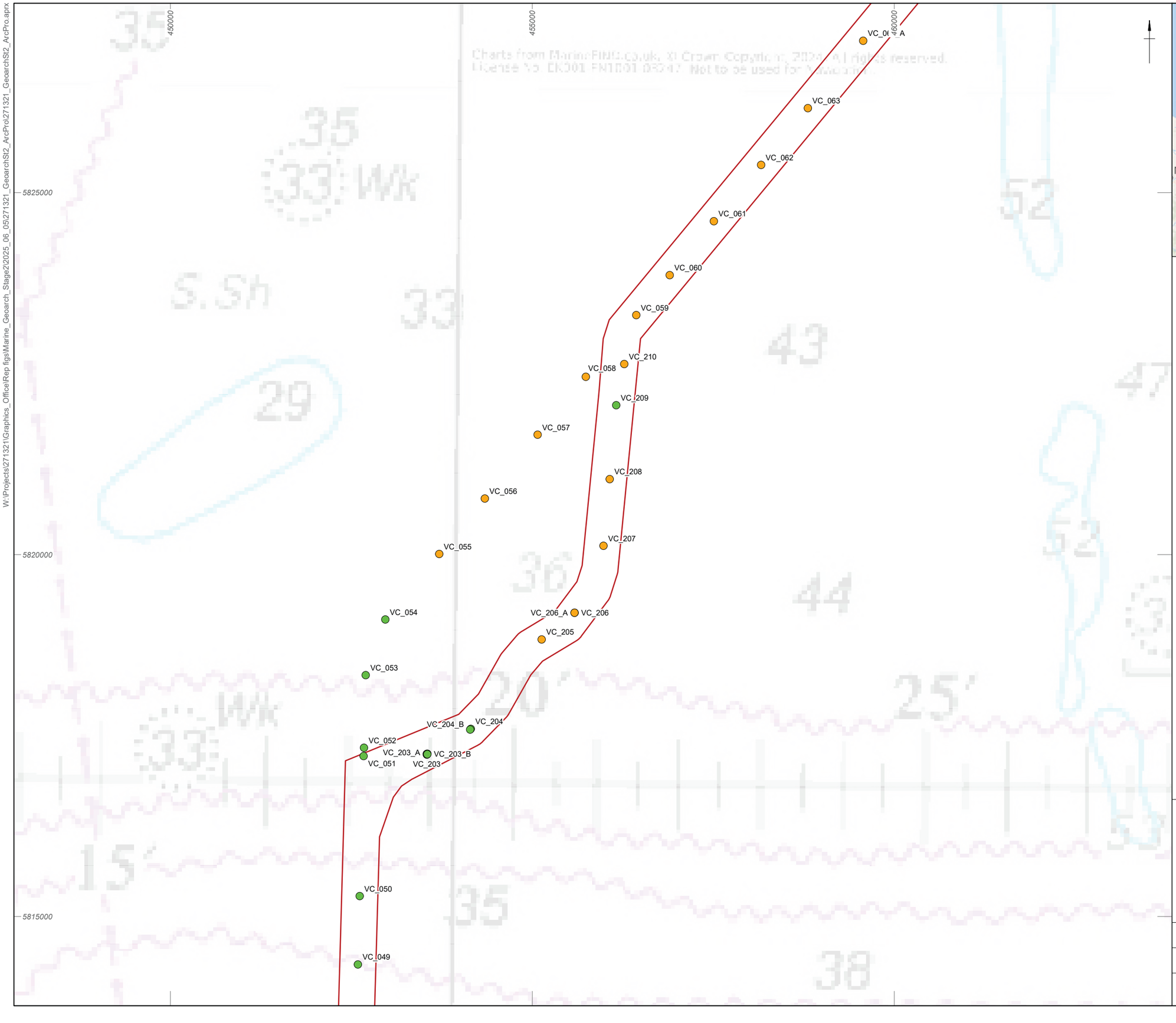

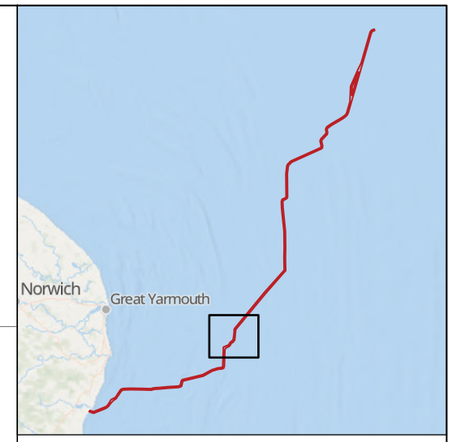

Proposed Offshore Scheme Draft Order Limits

Priority

- Medium
- Low

0 2.5 km

Coordinate system: ETRS 1989 UTM Zone 31N

Date: 21/07/2025	Created by: KJF	
Scale: 1:50,000 at A3	Revision: 0	

Figure 2d: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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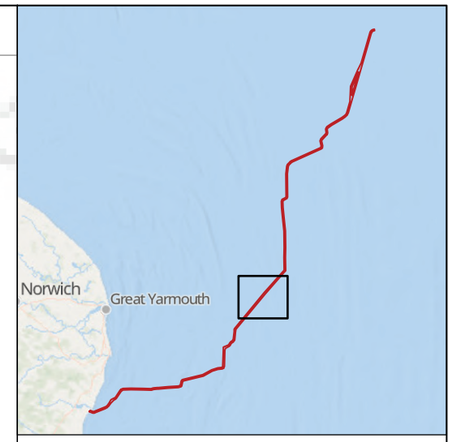

Proposed Offshore Scheme Draft Order Limits

Priority

- Medium
- Low

0 2.5 km

Date: 21/07/2025 | Created by: KJF

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Figure 2e: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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VC_085

VC_084

VC_083

VC_082

VC_081

Norwich

Great Yarmouth

Proposed Offshore Scheme Draft Order Limits

Priority

Medium

Low

0

2.5 km

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Figure 2f: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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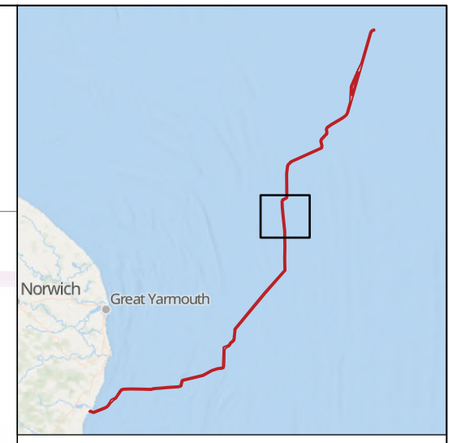

Proposed Offshore Scheme Draft Order Limits

Priority

Medium

0 2.5 km

Date: 21/07/2025 | Created by: KJF

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Figure 2g: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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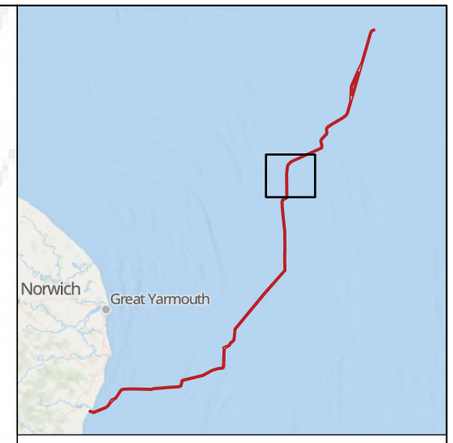
VC_111

VC_110

VC_109

YARE FIELD

WELLAND FIELD



Proposed Offshore Scheme Draft Order Limits

Priority

Medium

0 2.5 km

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Figure 2h: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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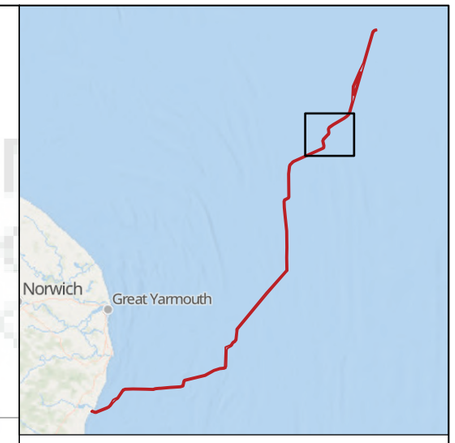
GAWAIN GAS FIELD



Proposed Offshore Scheme Draft Order Limits

Priority
- High
- Medium
- Low

0 2.5 km

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Figure 2i: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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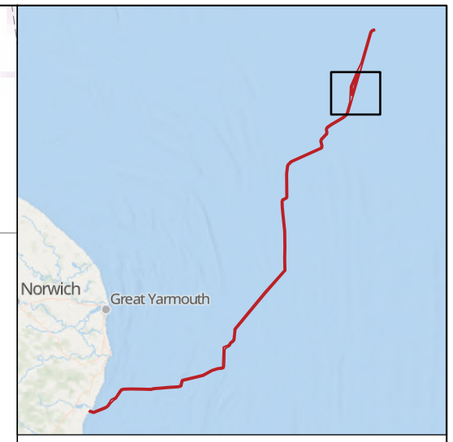

Proposed Offshore Scheme Draft Order Limits
EEZ limit

Priority
Medium
Low

0 2.5 km

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Figure 2j: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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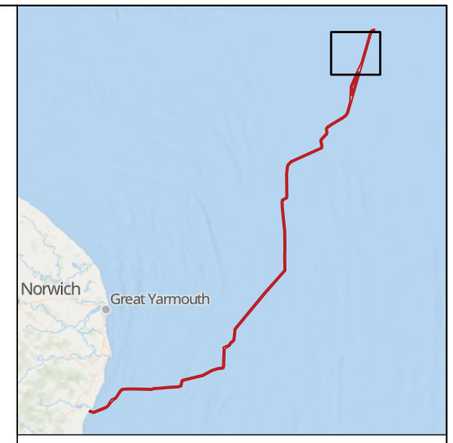

Proposed Offshore Scheme Draft Order Limits
EEZ limit
Priority
Medium
Low

0 2.5 km

Coordinate system: ETRS 1989 UTM Zone 31N
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Figure 2k: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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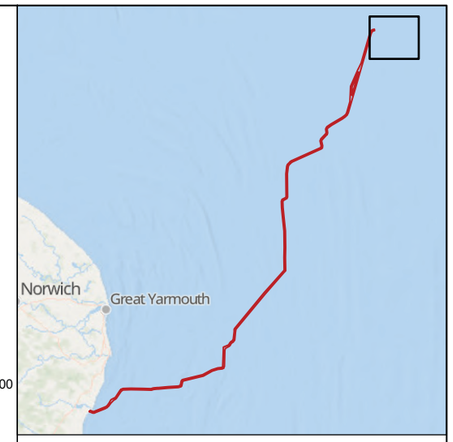

Proposed Offshore Scheme Draft Order Limits

EEZ limit

Priority

Medium

Low

0 2.5 km

Date: 21/07/2025 | Created by: KJF

Scale: 1:50,000 at A3 | Revision: 0

Figure 2l: Location of vibrocores and geoarchaeological priority (based on Stage 1)

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Geoarch_VC_177
Geoarch_VC_202
Norwich
Great Yarmouth
Proposed Offshore Scheme Draft Order Limits
English Territorial Waters
Vibrocores recorded during Stage 2
0
2.5 km

Date: 21/07/2025 | Created by: KJF
Scale: 1:50,000 at A3 | Revision: 0

Figure 3a: Location of vibrocores recorded during Stage 2

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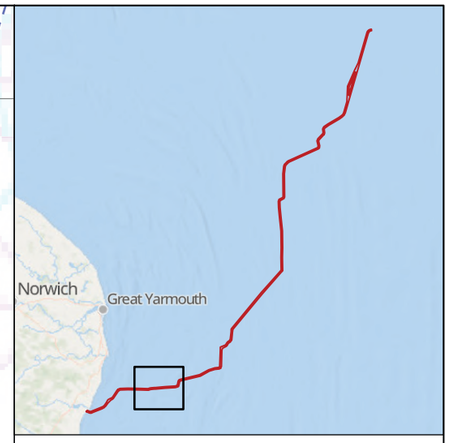

Proposed Offshore Scheme Draft Order Limits

English Territorial Waters

Vibrocores recorded during Stage 2

0 2.5 km

Coordinate system: ETRS 1989 UTM Zone 31N

Date: 21/07/2025 | Created by: KJF

Scale: 1:50,000 at A3 | Revision: 0

Figure 3b: Location of vibrocores recorded during Stage 2

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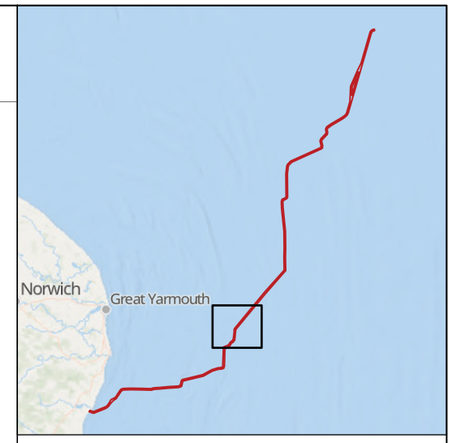

Proposed Offshore Scheme Draft Order Limits

Vibrocores recorded during Stage 2

0 2.5 km

Coordinate system: ETRS 1989 UTM Zone 31N

Date: 21/07/2025	Created by: KJF
Scale: 1:50,000 at A3	Revision: 0

Figure 3c: Location of vibrocores recorded during Stage 2

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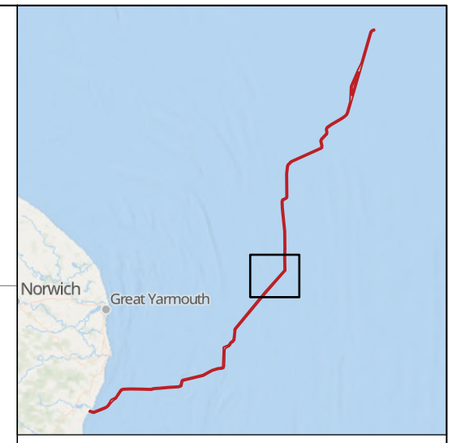

Proposed Offshore Scheme Draft Order Limits

Vibrocores recorded during Stage 2

0 2.5 km

Date: 21/07/2025	Created by: KJF
Scale: 1:50,000 at A3	Revision: 0

Figure 3d: Location of vibrocores recorded during Stage 2

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Geoarch_VC_102

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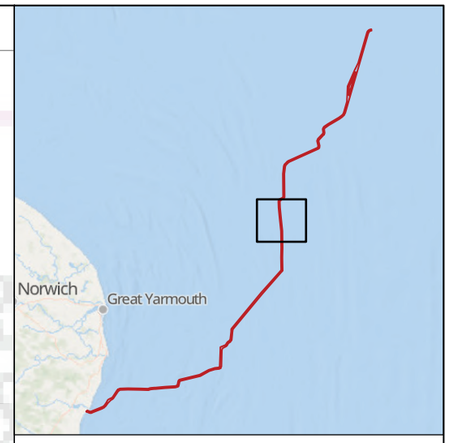

Proposed Offshore Scheme Draft Order Limits

Vibrocores recorded during Stage 2

0 2.5 km

Date: 21/07/2025	Created by: KJF
Scale: 1:50,000 at A3	Revision: 0

Figure 3e: Location of vibrocores recorded during Stage 2

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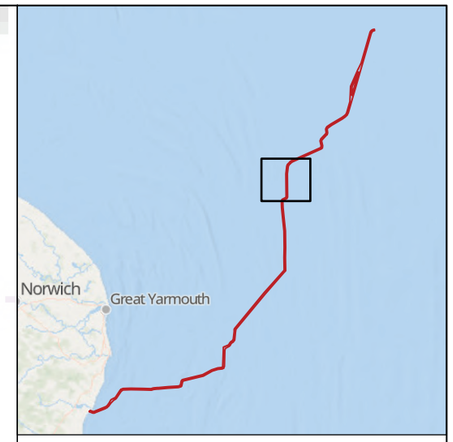


Proposed Offshore Scheme Draft Order Limits

Vibrocores recorded during Stage 2

0 2.5 km

Date: 21/07/2025 | Created by: KJF

Scale: 1:50,000 at A3 | Revision: 0

Figure 3f: Location of vibrocores recorded during Stage 2

W:\Projects\271321\Graphics_Office\Rep figs\Marine_Geoarch_Stage2\2025_06_05\271321_GeoarchSt2_ArcPro\271321_GeoarchSt2_ArcPro.aprx

480000

485000

490000

5890000

5885000

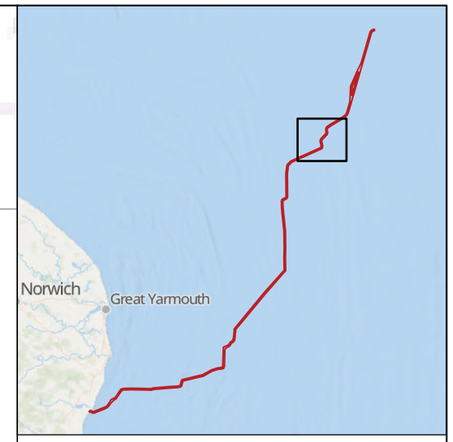
5880000

Geoarch_VC_140

Geoarch_VC_138

Geoarch_VC_130

Geoarch_VC_128



Proposed Offshore Scheme Draft Order Limits

Vibrocores recorded during Stage 2

0 2.5 km

Date: 21/07/2025 | Created by: KJF

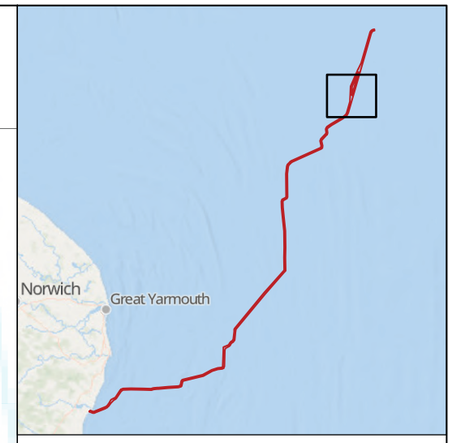
Scale: 1:50,000 at A3 | Revision: 0

Figure 3g: Location of vibrocores recorded during Stage 2

W:\Projects\271321\Graphics_Office\Rep figs\Marine_Geoarch_Stage2\2025_06_05\271321_GeoarchSt2_ArcPro\271321_GeoarchSt2_ArcPro.aprx

490000
495000
500000
5905000
5900000
5895000

VC_154
Geoarch_VC_152



Proposed Offshore Scheme Draft Order Limits
Vibrocores recorded during Stage 2

0 2.5 km

Date: 21/07/2025	Created by: KJF
Scale: 1:50,000 at A3	Revision: 0

Figure 3h: Location of vibrocores recorded during Stage 2

W:\Projects\271321\Graphics_Office\Rep figs\Marine_Geoarch_Stage2\2025_06_05\271321_GeoarchSt2_ArcPro\271321_GeoarchSt2_ArcPro.aprx

495000

500000

505000

5920000

5915000

5910000

VC_173

VC_172

VC_170

VC_169

VC_168

VC_167

VC_166

Norwich

Great Yarmouth

Proposed Offshore Scheme Draft Order Limits

EEZ limit

Vibrocores recorded during Stage 2

0

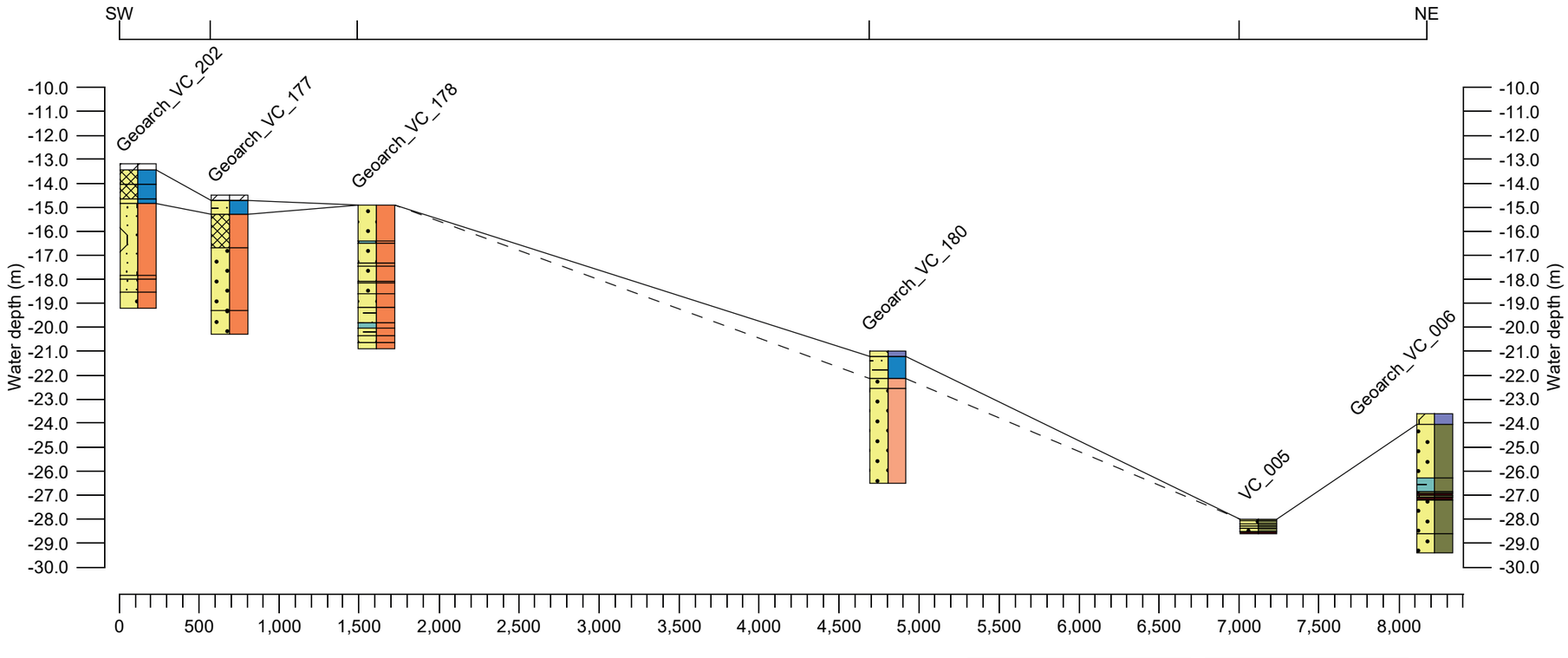
2.5 km

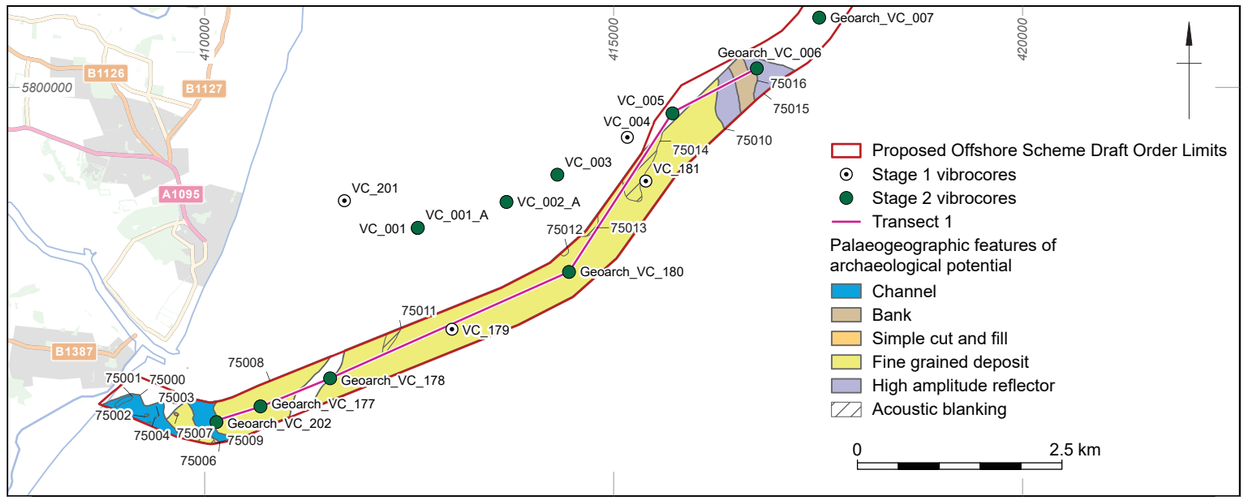
Date: 21/07/2025 | Created by: KJF

Scale: 1:50,000 at A3 | Revision: 0

Figure 3i: Location of vibrocores recorded during Stage 2

W:\Projects\271321\Graphics_Office\Rep figs\Marine_Geoarch_Stage2\2025_06_05





Stratigraphy

- N/A
- ?Seabed sediments
- Seabed sediments
- Interbedded sand and clay
- Peat
- ?Upper Brown Bank
- Upper Brown Bank
- Lower Brown Bank
- ?Yarmouth Roads
- ?Red Crag
- Red Crag

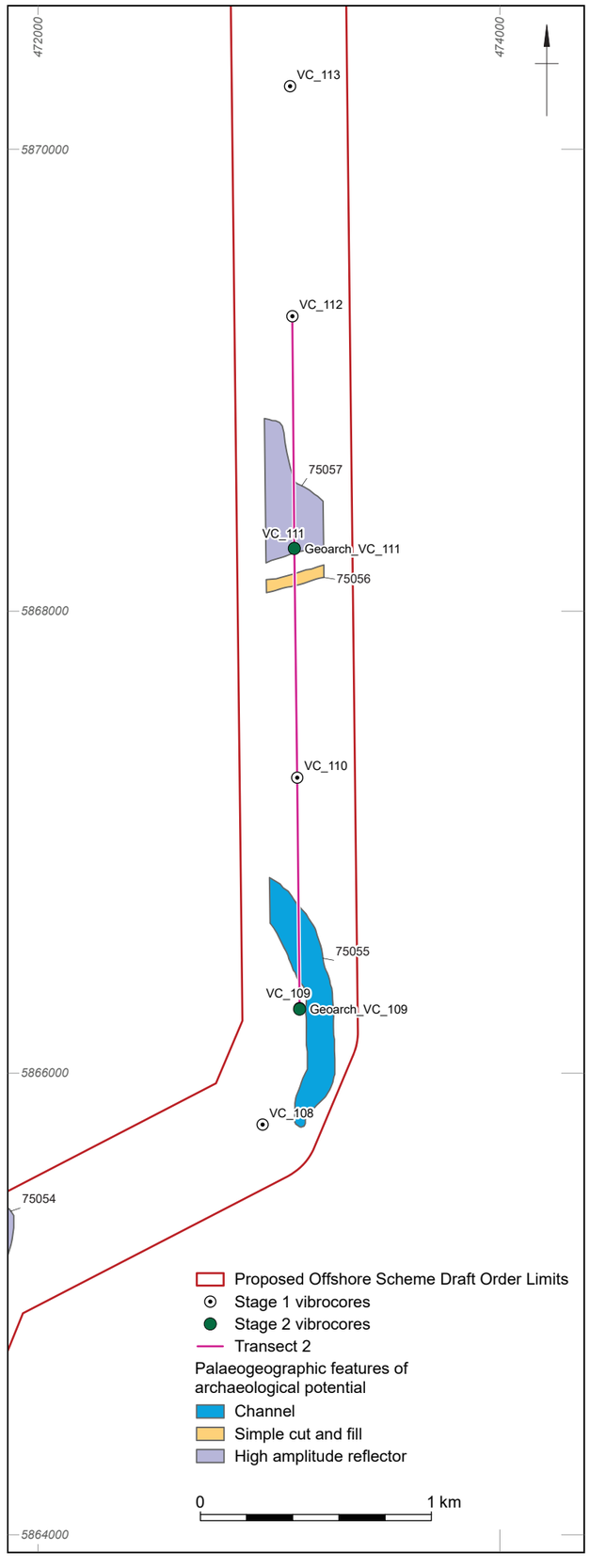
Lithology

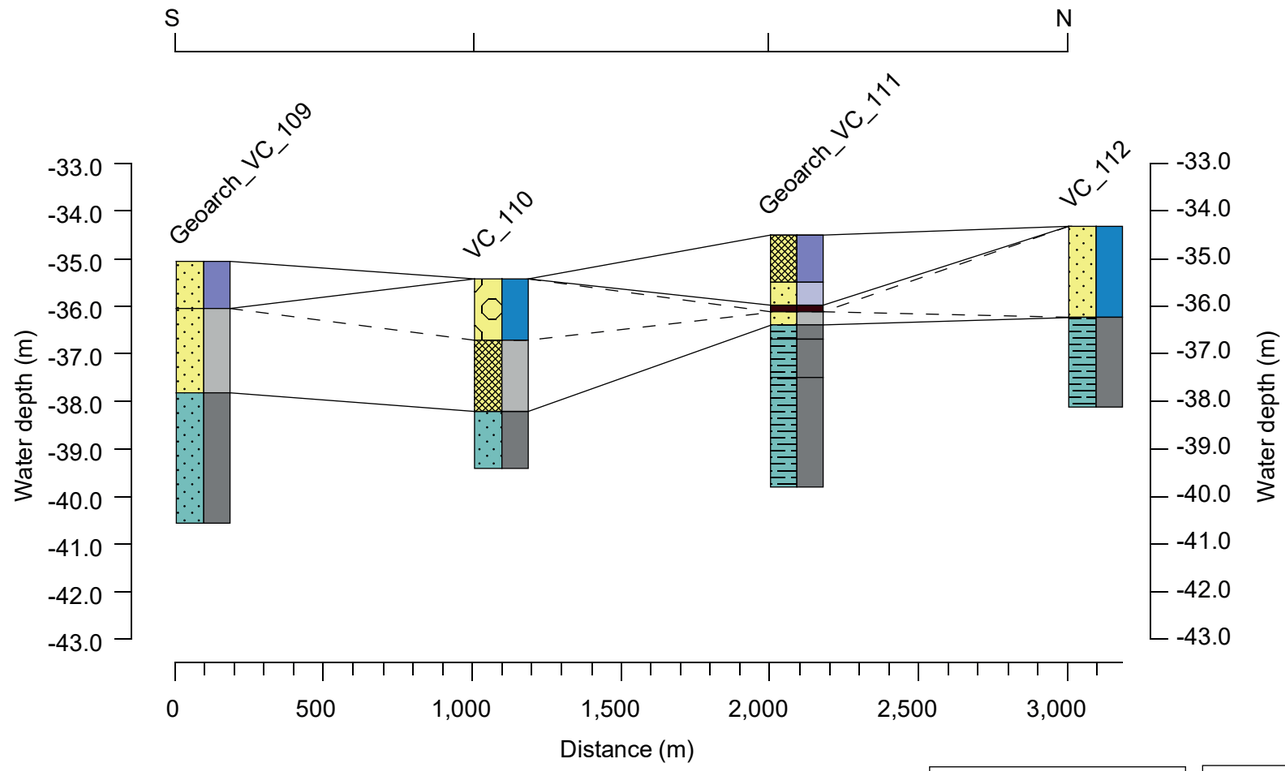
- N/A
- Clay
- Sandy clay
- Silty clay
- Clayey sand
- Gravelly sand
- Sand
- Silty sand
- Peat

Date: 21/07/2025	Created by: KJF	Revision: 1	Scale: Inset 1:75,000 at A3

Figure 4. Transect 1 with palaeogeographic features of archaeological potential

W:\Projects\271321\Graphics_Office\Rep figs\Marine_Geoarch_Stage2\2025_06_05





Stratigraphy

- N/A
- ?Seabed sediments
- Seabed sediments
- Interbedded sand and clay
- Peat
- ?Upper Brown Bank
- Upper Brown Bank
- Lower Brown Bank
- ?Yarmouth Roads
- ?Red Crag
- Red Crag

Lithology

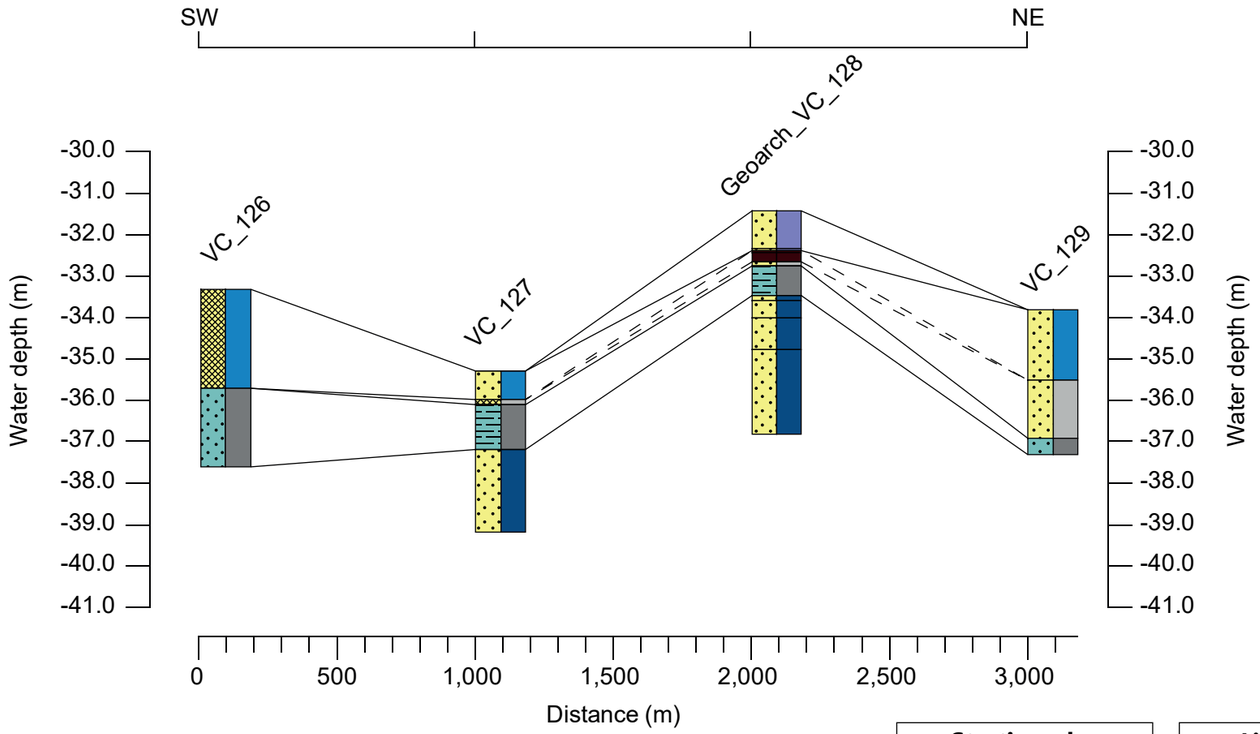
- N/A
- Clay
- Sandy clay
- Silty clay
- Clayey sand
- Gravelly sand
- Sand
- Silty sand
- Peat

Coordinate system: ETRS 1989 UTM Zone 31N.

Date: 21/07/2025	Created by: KJF	Revision: 1	Scale: Inset 1:25,000 at A3

Figure 5. Transect 2 with palaeogeographic features of archaeological potential

W:\Projects\271321\Graphics_Office\Rep figs\Marine_Geoarch_Stage2\2025_06_05

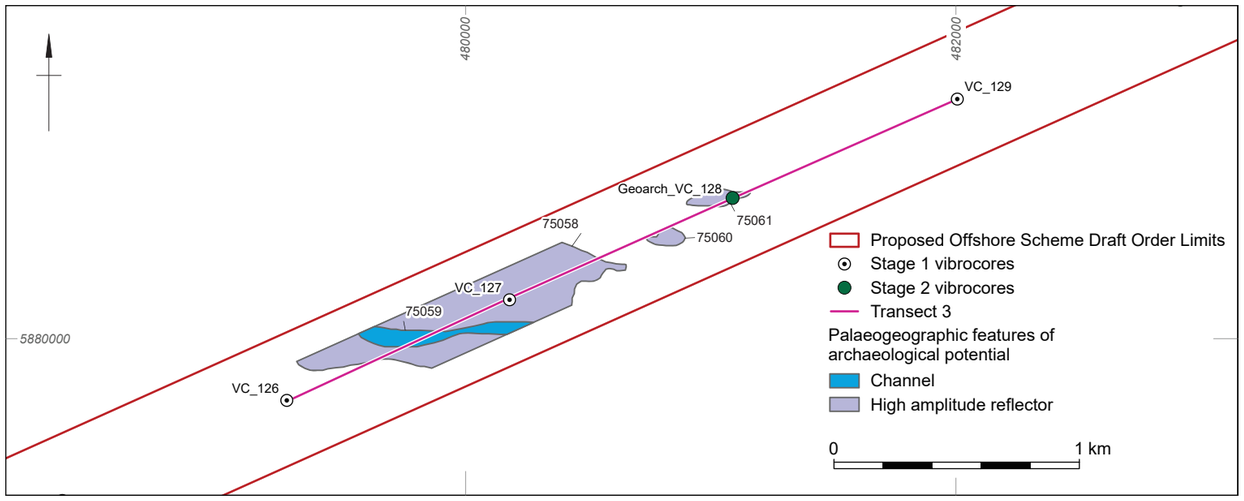


Stratigraphy

- N/A
- ?Seabed sediments
- Seabed sediments
- Interbedded sand and clay
- Peat
- ?Upper Brown Bank
- Upper Brown Bank
- Lower Brown Bank
- ?Yarmouth Roads
- ?Red Crag
- Red Crag

Lithology

- N/A
- Clay
- Sandy clay
- Silty clay
- Clayey sand
- Gravelly sand
- Sand
- Silty sand
- Peat



Date: 21/07/2025	Created by: KJF	Revision: 1	Scale: Inset 1:25,000 at A3

Figure 6. Transect 3 with palaeogeographic features of archaeological potential

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