



Palaeo-Yare Catchment

Geoarchaeological Assessment
of Marine Aggregates Licence Areas 511, 512, 513/1 and 513/2

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Summary

Wessex Archaeology was commissioned by Cemex UK Marine Ltd. to undertake a geoarchaeological assessment of vibrocores from Marine Aggregate Licence Area 511, Area 512, Area 513/1 and 513/2 located in the southern North Sea, offshore of Great Yarmouth. This work follows on from the Palaeo-Yare Catchment Assessment undertaken by Wessex Archaeology (2013a) and supports the Palaeo-Yare catchment 5-year monitoring review (Wessex Archaeology 2020).

The principal aim of this work is to review deposit extent, survival and archaeological potential within each Marine Aggregate Licence Area, considering new archaeological finds and any dredging activity, inferred from Electronic Monitoring System (EMS) data, that has occurred since the date of the last review (2016). The results will be compared to the legacy deposit model constructed by Wessex Archaeology (2013a), making updates where necessary. Any changes to the deposit model will be reflected in the Operational Sampling Groups and Thresholds for each licence area.

Vibrocore logs, core photographs and the results from particle size distribution analysis from 71 locations were reviewed, and the deposits recovered interpreted with reference to the Palaeo-Yare stratigraphic framework defined by Wessex Archaeology (2013a): Unit 1 (Westkapelle Ground Formation); Unit 2 (Yarmouth Roads Formation); Unit 3a (Palaeo-Yare palaeochannel infill); Unit 3b (Palaeo-Yare floodplain sediments); Unit 4 (Brown Bank Formation); Unit 5 (Early Weichselian estuarine sediments); Unit 6 (Early Weichselian glaciofluvial sediments); Unit 7 (Holocene transgressive sediments), and; Unit 8 (surficial seabed sediments).

In Area 511, Unit 2 and Unit 3b are preserved, overlain by Unit 8 (surficial sediments). A large Early Holocene channel (Channel B) runs through Area 511, cutting into Unit 3b deposits below. The results of the vibrocore review agreed with the legacy deposit model and no changes were required. Archaeological discoveries show the potential to recover Lower to Upper Palaeolithic lithics and faunal remains. The finds in this area form a mixed assemblage suggesting reworking, most likely by fluvial processes associated with Channel B.

Deposits in Area 512 belong to Unit 2 and Unit 3b, and no changes were made to their extent based on the vibrocore review. Operational sampling in Area 512 targets Unit 3b, and numerous faunal remains and a single Lower Palaeolithic lithic were recovered highlighting the high archaeological potential of Unit 3b.

Unit 3b is most extensive in Area 513/2, with isolated patches of Unit 2 and Unit 4 also preserved. Again, the vibrocore data agree with the legacy deposit model and no changes were made. Archaeological finds in Area 513/1 originate from Unit 3b and comprise worked flint and mammal bone fragments.

Area 513/2 preserves Unit 2, Unit 3b and Unit 4 and the results from the vibrocore review agree with the legacy deposit model. Dredging activity in Area 513/2 is low and there have been no operational sampling events. As a result, no Palaeolithic finds have been recorded. However, drawing from the archaeological potential of Unit 3b in other licence areas, there is potential to preserve archaeology.

No changes were made to the extent and survival of deposits. Therefore, no changes have been made to the Operational Sampling Groups or Thresholds. The vibrocore data assessed here were consistent with the legacy deposit model increasing confidence in the original interpretation. To support ongoing operational sampling monitoring visits, it is recommended the data sheets for each licence area are updated on a yearly basis to include new operational sampling events, any new finds and EMS data for the last year.



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Palaeo-Yare Catchment

Geoarchaeological Assessment of Marine Aggregate Licence Areas 511, 512, 513/1 and 513/2

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology have been commissioned by Cemex UK Marine Limited to undertake a marine geoarchaeological assessment of deposits from the submerged Palaeo-Yare within Marine Aggregate Licence Areas 511, 512, 513/1 and 513/2. The results will be used to inform decisions relating the management of future marine aggregate dredging activity. This work will build upon the regional-scale Palaeo-Yare Catchment Assessment undertaken by Wessex Archaeology (2013a) and supports the Palaeo-Yare catchment 5-year monitoring review (Wessex Archaeology 2020).

1.2 Study Area

1.2.1 The study area is located in the southern North Sea, between 10 km and 30 km east of Lowestoft, UK, and comprises Marine Aggregate Licence Areas 511, 512, 513/1 and 513/2 (**Figure 1**). These licence areas are located within the offshore reaches of the Palaeo-Yare valley (**Figure 2**) which comprises key deposits from which a large number of Palaeolithic artefacts and faunal remains have been recovered.

2 BACKGROUND

2.1 Summary of previous works

2.1.1 Archaeological works in the region of the East Coast Marine Aggregate Licence Areas have been ongoing since 2007 and continue in the present day with the delivery of the operational sampling monitoring programme (Wessex Archaeology 2020) (**Table 1**). Much of the work was commissioned after the discovery of a rich Middle Palaeolithic assemblage in Area 240 which lies directly adjacent to Area 511. Therefore, selected archaeological works undertaken in Area 240 are considered here as their findings are relevant to Area 511, Area 512, Area 513/1 and Area 513/2.

Table 1 Summary of previous geoarchaeological works in East Coast Marine Aggregate Licence Areas

Year	Report	Reference
2011	Seabed Prehistory: Site Evaluation Techniques (Area 240) Synthesis	Wessex Archaeology (2011)
2011	East Coast Regional Environmental Characterisation	Limpenny (2011)
2013	Palaeo-Yare Catchment Assessment Technical Report (83740.04)	Wessex Archaeology (2013a)
2013	Palaeo-Yare Catchment Assessment Addendum Short-term Licence Areas	Wessex Archaeology (2013b)
2015	Palaeo-Yare Operational Sampling conducted under the short-term licencing provisional Written Scheme of Investigation: Interpretive Report.	Wessex Archaeology (2015)
2016	Marine Licence L/2014/00028 (Areas 511, 512, 513/1 and 513/2): Palaeo-Yare Monitoring Method Statements	Wessex Archaeology (2016)

Year	Report	Reference
2016	Written Scheme of Investigations Early Prehistoric Material in the Norfolk Block of the Anglian Region	Fjordr (2016)
2020	Paleo-Yare Catchment Monitoring: Interpretative Report Five Year Review of Operational Sampling: January 2015 to December 2019	Wessex Archaeology (2020)

- 2.1.2 In 2007/2008, 88 Palaeolithic artefacts, including handaxes, flakes and cores as well as a series of bones (woolly mammoth, woolly rhino, bison, reindeer and horse) were discovered by Mr Jan Meulmeester in stockpiles of gravel at the SBV Vlissingen (Flushing) Wharf. The finds were identified from stockpiles and reject piles between the 7th December 2007 to the 18th March 2008, dredged from the dredging Licence Area 240 between the 7th December 2007 and 5th February 2008. The fresh condition of some of the handaxes indicated that they came from relatively undisturbed deposits.
- 2.1.3 The discovery of the finds was reported to English Heritage and through the BMAPA *Protocol for Reporting Finds of Archaeological Importance* (BMAPA and English Heritage 2005). The place where the finds were dredged was relatively discrete, dredged specifically for aggregates for SBV Flushing. The correlation between the inspected stockpiles and the source of the aggregate, confirmed by the correspondence between the dates of his visits and the dates of aggregate dredging in Area 240, means that the provenance of the artefacts is secure. Moreover, a review of trackplots of dredging for the relevant dates has established the extent of a quite limited geographical area within which the artefacts are most likely to have been recovered.
- 2.1.4 Once the finds were reported, HAML, the licensee, stopped dredging in the immediate area and voluntarily implemented a rectangular exclusion zone based on dredger trackplots in accordance with the BMAPA *Protocol for Reporting Finds of Archaeological Interest*.
- 2.1.5 An assessment of the flint assemblage was carried out by Dr Dimitri De Loecker of the University of Leiden (De Loecker 2011). The assemblage comprised a total of 33 handaxes, 47 complete and fragmented flakes and flake tools, and eight cores.
- 2.1.6 The condition and quality of the flint artefacts show that the material originates from several contexts. However, it is likely that some of the flint artefacts were dredged from undisturbed deposits. Generally, accumulated evidence of early human activity (a palimpsest) is suggested (De Loecker 2011). The flint raw material used is homogenous in character and was sourced from exposed gravel bar river deposits (De Loecker 2011).
- 2.1.7 The assessment of the 33 handaxes revealed that the assemblage is homogenous and show a considerable amount of workmanship. The handaxes are of cordiform or sub-cordiform type and can be described as Acheulean or as Mousterian of Acheulean Tradition (De Loecker 2011).
- 2.1.8 The faunal remains were assessed by Mr Jan Glimmerveen in Holland. Initial radiocarbon dating of a number of bones returned dates of between 31,000 and 43,000 BP and approximately 70 % of the bones recovered have been attributed to this date. The remaining 30 % are heavily fossilised and at the time it was estimated that the majority were thought to be older than 500 ka (J. Glimmerveen, pers. com. 21/07/2010).
- 2.1.9 Between October 2008 and March 2011 Wessex Archaeology undertook a multi-disciplinary project (*Seabed Prehistory: Site Evaluation Techniques (Area 240)*) with the aim of improving the future management of the potential effects of aggregate dredging on the marine historic environment by developing techniques to evaluate the source of prehistoric

artefactual material discovered in the East Coast region. The project included the acquisition and interpretation of geophysical data, geotechnical data, seabed sampling, vibrocoreing, palaeoenvironmental assessment, analysis and dating (Wessex Archaeology 2011).

- 2.1.10 During the seabed sampling phase of the *Seabed Prehistory* project a further 11 worked flakes were recovered from the southern half of the exclusion zone. The worked flint were recovered using a clamshell grab with samples acquired from 31 locations along three transects. A total of 19 tons of sediments were processed (sieved to 10 mm, with sub-samples sieved to 4 mm). Although the number of flints recovered was low due to the methodology, the recovery of worked flint indicated that there was potential for further artefacts and that the sediment containing artefacts had not been completely removed by dredging activities.
- 2.1.11 During June 2009, prior to the seabed sampling phase of the *Seabed Prehistory* project, a piece of worked flint was recovered from a clamshell grab sample during the East Coast Regional Environmental Characterisation survey (Limpenny et al. 2011). The grab targeted sediments within the voluntary exclusion zone and confirmed the potential for further artefacts to be found.
- 2.1.12 The flint artefacts are interpreted as being principally associated with a specific glaciofluvial sediment Unit 3b. Deposited during the Saalian (MIS 8/7), Unit 3b forms a floodplain deposit of Channel A (Wessex Archaeology 2011).
- 2.1.13 The flint artefacts from the original discovery and the flints recovered during clamshell grab sampling and during the monitoring of dredging activity are, henceforth, referred to as the Middle Palaeolithic Assemblage.
- 2.1.14 Given the distribution of artefactual material in Area 240 it was hypothesised that there would be potential in the wider region where there were remnants of Unit 3b deposits. This is supported by the small number of finds reported through the Marine Aggregate Industry *Protocol for Reporting Finds of Archaeological Interest*. Interpretation of the geology of Area 240 suggested that Unit 3b extended into adjacent licence areas, but it was not known how regionally extensive this unit was.
- 2.1.15 As such, the presence of the Middle Palaeolithic Assemblage in Area 240 and the association with specific deposits (Unit 3b) has implications not only for licencing of Area 240 but also licence areas within the wider East Coast region. This was acknowledged by the industry and the aggregate companies.
- 2.1.16 It was also acknowledged that the relationship between the apparently *in situ* archaeological material and the regional context of Unit 3b could not effectively be carried out on a licence by licence area basis and highlighted the need for a regional review to provide a better understanding of the prehistoric archaeological resource in the region in terms of its distribution, significance and the mitigation effects from dredging.
- 2.1.17 The Palaeo-Yare Catchment Assessment was undertaken in 2012/2013 with the aim of delineating the regional extent and survival of deposits from which a large number of flint artefacts and faunal remains have been recovered (Wessex Archaeology 2013a). This assessment provided a holistic review of the archaeological potential of surviving deposits in the onshore and offshore sections of the Palaeo-Yare, considering the catchment as a whole. The results were used to develop key hypothesis that could be tested through an

operational sampling programme as a means of managing and mitigating future marine dredging activities in the East Coast region.

2.1.18 As an addendum to the Palaeo-Yare catchment assessment, each of the Licence Areas was reviewed independently and a series of methodologies designed to meet the individual needs of each Licence Area according to the deposits preserved and archaeology recovered (Wessex Archaeology 2013b).

2.1.19 A series of hypotheses were developed as part of the Palaeo-Yare Catchment Assessment (Wessex Archaeology 2013a) in order to test the following conclusions, and to address remaining uncertainties;

- The Middle Palaeolithic Assemblage is mixed, *i.e.* contains artefacts of *in situ* and secondary context.
- The Middle Palaeolithic Assemblage is primarily associated with Unit 3b within Area 240.
- There is potential for Palaeolithic material in secondary context associated with Units 2, 3b, 4, 7, 8 and the bank structures (of unknown age).
- Natural processes throughout transgressions and regressions subsequent to deposition have not completely removed sediment units. With regards to the *in situ* elements of the Middle Palaeolithic assemblage, remnants of *in situ* Unit 3b sediments are present within the region.
- Extensive dredging of the region has not necessarily completely removed Unit 3b sediments within the area.
- There is potential for *in situ* archaeological material to be present elsewhere within the region where remnants of Unit 3b are located.
- Faunal remains and palaeoenvironmental material are likely to be sourced from Units 2, 3b, 4 and 7. These could be *in situ* or secondary context and may be located throughout the region.
- Uncertainties remain due to the data limitations used for the assessment and the degree of dredging undertaken since the geophysics data were acquired.

2.1.20 The hypotheses were later reviewed in 2016 and defined in a Written Scheme of Investigation (Fjodr 2016). These hypotheses, listed below, underpin an operational sampling programme that has been ongoing since 2012 (summarised in Wessex Archaeology 2015 and Wessex Archaeology 2020). The hypotheses predominantly focus on the proven potential for artefacts within the Palaeo-Yare floodplain deposits (Unit 3b), divided into five key groups relating to specific issues as outlined in **Table 2**.

Table 2 Summary of hypotheses (Fjodr 2016)

Activity	Description
Inhabitation	H1.1: Middle Palaeolithic material is recovered from units other than 3b H1.2 Some of the Middle Palaeolithic material recovered from Unit 3b is <i>in situ</i> H1.3 Late Upper Palaeolithic material is recovered from other places in addition to the vicinity of Channel B



Activity	Description
	<p>H1.4 Some Late Upper Palaeolithic material from the vicinity of Channel B is <i>in situ</i>.</p> <p>H1.5 Some <i>in situ</i> Lower Palaeolithic material is recovered from other units than Unit 3b.</p> <p>H1.6 Artefactual material appears to be <i>in situ</i> in areas other than Unit 3b and the vicinity of Channel B.</p> <p>H1.7 Prehistoric material is recovered for periods later than the Late Upper Palaeolithic.</p> <p>H1.8 Faunal remains appear to be in primary contexts.</p>
Choice and use of location	<p>H2.1: Middle Palaeolithic material is recovered from the floodplain of Channel A, not from Channel A.</p> <p>H2.2: Middle Palaeolithic material is recovered from outlying deposits of Unit 3b north and south of the floodplain.</p> <p>H2.3: Middle Palaeolithic material is clustered in relatively large quantities at discrete locations.</p> <p>H2.4 Middle Palaeolithic material is present in small quantities throughout Unit 3b deposits.</p>
Natural processes	<p>H3.1: Middle Palaeolithic material is recovered in areas where Unit 3b has been reworked by natural processes.</p> <p>H3.2: Middle Palaeolithic material is recovered where Unit 3b appears to be covered by major bank structures.</p>
Dredging History	<p>H4.1: Middle Palaeolithic material is recovered where dredging history indicates that a high level of dredging has taken place since the introduction of EMS (Electronic Monitoring System).</p> <p>H4.2: Middle Palaeolithic material is recovered where geophysical data indicates that a high level of dredging has taken place.</p>
Operation Sampling methods	<p>H5.1: Faunal and artefactual material is found at all wharves where Operational Sampling takes place.</p>

2.2 Legacy deposit model

- 2.2.1 A deposit model was constructed as part of the Palaeo-Yare Catchment Assessment (Wessex Archaeology 2013a) by integrating over 2,500 line km of sub-bottom profiler data from 22 surveys that occurred between 1989 and 2011, and geotechnical information from 1,171 vibrocore logs acquired between 1988 and 2011. This vast data set was used to define the stratigraphy of key deposits in the region and map their extent (**Table 3; Figure 2**).
- 2.2.2 Each stratigraphic unit was correlated to a geological epoch or sub-epoch using British nomenclature (e.g. Wolstonian). However, here we adopt North West European nomenclature to align with the internationally recognised formal time subdivision of the Quaternary Period (Cohen and Gibbard 2011). As a result, the terms Wolstonian and Devensian have been replaced with Saalian and Weichselian.
- 2.2.3 Eight stratigraphic units were identified, dating from the Late Pliocene/Early Pleistocene to the Holocene (**Table 3**). The area is dominated by two palaeochannel features: Channel A which is interpreted to have formed during the Late Anglian (~430 ka), and Channel B which is a younger, shallow channel that dates to the Early Holocene. Although these channels are of different ages, they both represent an offshore extension of the Palaeo-Yare river system (**Figure 2**).
- 2.2.4 The Palaeo-Yare valley developed at the end of the Anglian Glaciation ~430ka and has continued to develop through to the present day. During cooler periods when sea-levels were lower, sands and gravels were deposited and during warmer climatic periods, when the sea-level was higher, the lower reaches of the Palaeo-Yare valley was slowly inundated,

changing from fluvial, to estuarine and where sea-levels were high enough, shallow marine environments.

2.2.5 During these times of high sea level, the upper reaches of the Yare would have remained a river but with some tidal influence. The main phase of development of the floodplain occurred during the cooling period from MIS 9 interglacial to the MIS 8 glacial (~300 to ~250 ka) and the floodplain continued to develop during this cold phase. It is these sediments, classified as Unit 3b, from which the Middle Palaeolithic Assemblage was dredged in Area 240.

2.2.6 Assessment of the geophysics and geotechnical data indicate that Unit 3b sediments are regionally extensive and are associated with a wide floodplain deposit orientated east-west and 12 km wide (**Figure 2**). Although Unit 3b does not occur throughout the entire block of Marine Aggregate Licence Areas, its distribution does extend across a number of individual licence areas within the region. Generally, the floodplain deposits in the west and south are thinner than elsewhere (~2 m to 4 m thick). Within the channel and to the east the units are typically 2 m to 6 m thick.

Table 3 Lithostratigraphy of the offshore Palaeo-Yare catchment

Unit	Interpretation	Age	Description
8	Marine deposits associated with the last transgression in the Holocene	Holocene	Shelly, gravelly medium to coarse sand.
7	Basal fill of a shallow under-filled channel feature (equivocal to onshore lower Breydon Formation)	Early Holocene	Only observed to the northwest of Area 240 and also a small patch in the south western corner. It comprises a basal unit of peat approximately 0.2 m thick overlain by a unit of sandy or shelly clay. Infilling of Channel B.
6	Glaciofluvial alluvium	Possibly mid-Weichselian	Sandy gravel.
5	Possibly represents an estuarine or near coastal depositional environment	Unknown, possibly contemporary with unit 6	Slightly gravelly, slightly silty, fine to medium grained sand infilling depressions.
4	Brown Bank Formation	Early Weichselian	Unit 4 is a very distinctive unit generally associated with the buried channel feature in the north of Area 240 interpreted as the infilling of a cut sequence. It is comprised of fine-grained sediments (sands, silts and clays) deposited in a low-energy environment such as river or estuary.
3b	Reworked glaciofluvial outwash	Saalian	Unit 3b overlies Unit 3a in the channel and directly overlies Unit 2 throughout the central and western area. It is comprised of sands and gravels.
3a	Reworked glaciofluvial outwash	Saalian	A channel (Channel A) infill deposit that is associated with a channel feature probably cut into Unit 2 during the Late-Anglian glaciation. Unit 3a is the deepest, and oldest, fill primarily associated with the channel feature in the northeast and comprises gravel and sand.
2a/b	Yarmouth Roads Formation	Cromerian	Unit 2a generally comprises silty, gravelly, fine to coarse sands. Observed throughout the majority of Area 240 and generally overlies Unit 1. To the south of Area 240



Unit	Interpretation	Age	Description
			Unit 2b comprises silty sand with very frequent thin beds and laminae of firm to stiff clay and peaty organic clay.
1	Westkapelle Ground Formation	Pliocene/Early Pleistocene	The deepest unit and is observed across Area 240

3 AIMS AND OBJECTIVES

3.1.1 The principle aim of this project is to reappraise the regional extent and survival of key deposits from which known artefacts and faunal remains have been recovered. This will be achieved by building upon the Palaeo-Yare Catchment Assessment (Wessex Archaeology 2013a) and incorporating new geological, archaeological and dredging information, to inform and support decisions relating to the assessment and management of future marine aggregate operations.

3.1.2 Specific objectives are as follows:

- Update the existing deposit model (Wessex Archaeology 2013a) by incorporating new vibrocore data;
- Map changes in the extent and survival of key deposits taking into account any dredging activity that has occurred between 2016 and 2019;
- Update Operational Sampling Groups to reflect changes in deposit extent;
- Reappraise the archaeological potential of key deposits where necessary, based on the archaeological material recovered to date, and;
- Update datasheets for each Marine Aggregate Licence Area.

4 METHODS

4.1 Introduction

4.1.1 This report follows on from previous works as outlined in **Section 2.1** and includes a review of data acquired since the last review (Wessex Archaeology 2016) and the end of 2019, plus any additional data omitted from previous reviews.

4.2 Geotechnical vibrocore assessment

4.2.1 A total of 71 geotechnical vibrocore logs from 2 individual surveys undertaken between 2016 and 2018 were provided for review (CMS Geotech Ltd 2017; 2019). Of these, 45 were located within Licence Areas 511, 512, 513/1 and 513/2 (**Table 4**). Core photographs and the results of particle size distribution analysis were also provided to support the assessment.

Table 4 Vibrocore survey data located in licence areas

Area	Year	No. of VCs included in assessment	Reference
511	2016	21	CMS Geotech Ltd (2017)
512	2016	11	CMS Geotech Ltd (2017)
513/1	2016	8	CMS Geotech Ltd (2017)
513/2	2016	5	CMS Geotech Ltd (2017)

4.2.2 Each of the 71 geotechnical vibrocore logs were reviewed by a trained geoarchaeologist in order to establish the nature and depth of deposits recovered. Deposits were interpreted with reference to the stratigraphic framework defined in **Table 3** (Wessex Archaeology 2013a) while recognising the potential for encountering different/new formations that were not previously captured. The results of the geotechnical log review are presented in **Appendix 1**.

4.3 Updates to deposit model

4.3.1 The geotechnical vibrocore data was used to ground truth the legacy deposit model. For each licence area, a comparison was made between the previously mapped extent of each of the Units defined in **Table 3**, with the exception of Unit 8 (surficial sediments), and the Units recorded in the vibrocores (**Figures 4-7**). Instances where the vibrocore data disagreed from the legacy deposit model were investigated to determine if the deposit model required updating (**Tables 5-7**). The following considerations were taken into account before making any changes to the deposit model;

- Removal of deposits due to dredging activity;
- Length of vibrocore, relative to stratigraphy and depth of deposits;
- Proximity to boundaries considering the resolution and positional accuracy of the legacy deposit model, and;
- Localised variations.

4.3.2 The legacy deposit model was constructed using a variety of geotechnical and geophysical datasets acquired between 1989 and 2011. As a result, there is considerable variation in resolution (see Wessex Archaeology 2013a for full discussion). Line spacing of the geophysical data ranged from 100 m to 300 m. For the purpose of this assessment a buffer of 100 m (smallest line spacing) was applied to all boundaries as a margin of error.

4.4 Dredging history

4.4.1 When considering potential changes in the extent and depth of deposits across the licence areas, it is important to consider recent dredging activity to determine if a deposit has been removed or newly exposed due to dredging activity.

4.4.2 Information on dredging activity over the period of 2016-2019 was derived from Electronic Monitoring System (EMS) data for the East Coast region on a yearly basis from 2016-2019 (**Figure 8-11**). This data is amalgamated by the Crown Estate and BMAPA and underpins The Area Involved report series.

4.4.3 The EMS data was provided as a series of shapefiles showing dredge intensity gridded by 50 m cell size, defined as follows;

- Low: <15 minutes
- Medium: 15 minutes – 1 hour 15 minutes
- High: >1 hour 15 minutes

4.4.4 Dredging intensity as a measure of time dredged cannot be used to quantify volumetrically the amount of sediment removed. However, it can be used to qualitatively assess areas most likely impacted by dredging activity. The area dredged on a year by year basis was reviewed alongside the geotechnical data to establish if any changes in the deposits recorded may have occurred as a result dredging.

4.5 Known Archaeology

4.5.1 Finds reported through the BMAPA *Protocol for Reporting Finds of Archaeological Interest*, along with the results from operational sampling events were collated to provide a summary of archaeological discoveries for each of the licence areas. A full review of operational sampling results is given in Wessex Archaeology (2020).

5 RESULTS

5.1 Area 511

Vibrocore assessment

- 5.1.1 Unit 1 was not recorded in any of the vibrocores from Area 511, most likely due to Unit 1 being present at depths below 6 m (maximum penetration of vibrocore).
- 5.1.2 Unit 2 was recorded in all but three vibrocores (2016-VC-03A, 2016-VC-08A and 2016-VC-12) within Area 511 (**Figure 4**) and is proven to a depth of 5.34 meters below sea floor (mbsf) in 2016-VC-16. Unit 2 in Area 511 comprises silty sand often with laminations of silt and shell fragments. Unit 2 is typically buried below overlying deposits but can be exposed at seabed (e.g. 2016-VC-17).
- 5.1.3 Unit 3b overlies Unit 2 and was recovered in 15 vibrocores in Area 511 (2016-VC-14, 2016-VC-15, 2016-VC-16, 2016-VC-18 and 2016-VC-21) (**Figure 4**). Unit 3b comprises silty gravelly sand and silty sandy gravel. Unit 3b is often exposed at seabed and can reach thicknesses up to 5.2 m (2016-VC-16).
- 5.1.4 Unit 3a, Unit 4, Unit 5, Unit 6 and Unit 7 are not present within Area 511.
- 5.1.5 Unit 8 is the uppermost deposit in Area 511 and is present in 10 vibrocores. Unit 8 comprises silty gravelly sand with occasional shell fragments.

Updates to deposit model

- 5.1.6 The legacy deposit model suggests Unit 2 is present across Area 511, overlain by Unit 3b and Unit 8 in places with a small area of Unit 7 on the eastern margin of Channel B (**Figure 4**). The presence or absence of each Unit in the vibrocores was compared to the legacy deposit model and 6 conflicts were identified as outlined in (**5.2.6Table 6Table 5**) (**Figure 4**).

Table 5 Data conflicts Area 511

VC ID	Conflict	Description	Change extent	Justification
UNIT 2				
2016-VC-03A	Unit 2 absent in VC that lies in area mapped as Unit 2	VC comprises Unit 8	No	Unit 2 is likely present at a greater depth
2016-VC-08A		VC comprises Unit 3b	No	
2016-VC-12		VC comprises Unit 3b	No	
UNIT 3b				



VC ID	Conflict	Description	Change extent	Justification
2016-VC-03A	Unit 3b absent in VC that lies in area of Unit 3b	VC comprises Unit 8	No	Isolated core, not enough information to change deposit model
2016-VC-17		VC lies 7 m from boundary of Unit 3b	No	Within 100 m of boundary, error acceptable
2016-VC-15	Unit 3b present in an area where Unit 3b is mapped as absent	VC lies 466 m from boundary of Unit 3b	No	Isolated core, not enough information to change deposit model

- 5.1.7 Based on the assessment of vibrocore data, no changes to the extent of Unit 2 or Unit 3b within Area 511 were made.

Dredging history

- 5.1.8 EMS data for the years 2016-2019 shows dredging intensity in Area 511 ranged from low to high (**Figure 8**). For the years 2016, 2017 and 2018, dredging activity was focussed in the northern dredge sub-areas. In 2019, dredging continued in the north, but intensity was low, and dredging of the southern dredge areas (Fluorite and Emerald) commenced. Dredging in the north targets Unit 3b while dredging in the south targets Unit 2.
- 5.1.9 The vibrocores assessed here were acquired in 2016 and therefore predate the EMS data. Therefore, in areas of dredging, the thickness of Unit 3b is expected to be lower. However, given Unit 3b can be up to 2.5 m thick in this area, it is unlikely the deposit has been removed completely by dredging activity.

Known Archaeology

- 5.1.10 Several finds have been reported through the BMAPA *Protocol for Reporting Finds of Archaeological Interest* from Area 511. Three reports of faunal remains (**2176**, **2175** and **2163**), a wooden sleeper (**CEMEX_0600**), container twist lock (**CEMEX_0866**), aircraft fragment (**CEMEX_0867**), shaft housing (**CEMEX_0871**), aircraft components (**CEMEX_0914**), aircraft components, bollard, munition, shoes (**CEMEX_0915**), aircraft components (**CEMEX_0918**) and a collection of munitions (**CEMEX_0920**) were all reported up until December 2019. A further collection of bones and aircraft pieces (**CEMEX_0948**) were also reported however, whether these were recovered from Licence Area 511 or 512 is unknown. A sample of peat (**2164**) was also recoded through the protocol.
- 5.1.11 Six operational sampling events have been undertaken between February 2013 and December 2019.
- 5.1.12 During the operational sampling, six faunal recoveries (**2235**, **2236**, **2241**, **2242**, **2261** and **2262**) were reported amounting to fifteen individual bones, including red deer humerus and antler, bones from mammoth and sheep and a mammoth tooth. Three lithics were recovered including a Lower Palaeolithic flake (**2232**), a tertiary flake possibly Holocene age (**2233**), and a thermal flake in fresh condition and of Holocene age (**2234**). A possible flint blade core, two flint flakes and five potential flint flakes have been discovered during recent operational sampling (2017) as well as unidentified mineralised bone fragments and mammoth teeth fragments (2018).

5.2 Area 512

Vibrocore assessment

- 5.2.1 Unit 1 was not recorded in any of the vibrocores from Area 511, most likely due to Unit 1 being present at depths below 6 m (maximum penetration of vibrocore).

- 5.2.2 Unit 2 was recorded in all vibrocores with the exception of 2016-VC-25. Unit 2 in Area 512 is characterised by silty sand with shell fragments or gravel recorded occasionally. At two location (2016-VC-31 and 2016-VC23) Unit 2 comprises sandy silt. Unit 2 is not exposed at seabed but can be present at very shallow depths (0.05 m).
- 5.2.3 Unit 2 is overlain by Unit 3b in the north of Area 512 where it is recorded in five vibrocores (2016-VC-26, 2016-VC-23, 2016, VC-24, 2016-VC-25 and 2016-VC-28). Unit 3b comprises silty gravelly sand and silty sandy gravel locally (2016-VC-23). The thickness of Unit 3b ranges from 0.01 m at 2016-VC-23 to 3.40 m at 2016-VC-25. At each of the five locations, Unit 3b is exposed at seabed.
- 5.2.4 Unit 3a, Unit 4, Unit 5, Unit 6 and Unit 7 are not present within Area 512.
- 5.2.5 Unit 8 correlates to seabed sediments and is present in six vibrocores in Area 512 (2016-VC-27, 2016-VC-29, 2016-VC-30, 2016-VC-31, 2016-VC-32 and 2016-VC-33A). Unit 8 comprises silty gravelly sand with shell fragments.

Updates to deposit model

- 5.2.6 The legacy deposit model suggests Unit 2 is present across Area 512, overlain in the north by Unit 3b and Unit 8 in places (**Figure 5**). The presence or absence of each Unit in the vibrocores was compared to the legacy deposit model and 1 conflict was identified as outlined in (**Table 6**Table 6) (**Figure 5**).

Table 6 Data conflicts Area 512

VC ID	Conflict	Description	Change extent	Justification
UNIT 2				
2016-VC-025	Unit 2 absent in VC that lies in area mapped as Unit 2	VC comprises Unit 3b	No	Unit 2 is likely present at a greater depth

- 5.2.7 Based on the assessment of vibrocore data, no changes to the extent of Unit 2 within Area 512 were made.

Dredging history

- 5.2.8 EMS data for the years 2016-2019 indicate dredging intensity in Area 512 was typically low to medium, with some isolated high intensity dredging occurring in 2017 (**Figure 9**). In 2016, 2017 and 2018, dredging was limited to the northern parts of Area 512, targeting Unit 3b sediments. In 2019, dredging continued in the north but also occurred in the south where Unit 2 sediments are expected to be recovered.
- 5.2.9 The vibrocores reviewed were acquired in 2016 and therefore predate the EMS data. In areas of dredging, the thickness of Unit 3b is expected to be lower and given Unit 3b can be <0.5 m in places (2016-VC-23 and 2016-VC-24), there is a possibility Unit 3b has been removed locally.

Known Archaeology

- 5.2.10 Seven operational sampling events have been undertaken up until November 2019, targeting Unit 3b sediments.
- 5.2.11 Operational sampling was undertaken on the 13th and 14th March 2013 in sub-licence area Ilmenite (and partially in Kyanite). A single lithic was recovered and is a large scraper made

on a secondary flake and is possible Lower Palaeolithic age (**2237**). Further operational sampling was undertaken in December 2013 in sub-licence area Ilmenite with no recoveries. In April 2014 a pelvis fragment of a cow or deer (**2253**) was recovered from sub-licence area Ilmenite. In May 2015 a single piece of struck flint, a portion of a large blade was recovered (**2266**) from sub-licence area Ilmenite. The lithic was broken and somewhat worn, not in situ. Recent visits have produced possible auroch bone fragments (2016), unidentifiable bone fragments (2018), a section of sheep rib, two worked flint flakes and several possible worked flint flakes (2019).

- 5.2.12 Additionally, an alloy object with rivet holes and fabric (**CEMEX_0609**), aluminium fragment (**CEMEX_0743**), drogue parachute (**CEMEX_0770**), knife blade (**CEMEX_0789**), part of an anchor (**CEMEX_0904**) and hook (**CEMEX_0905**) have been reported through the Marine Aggregate Industry *Protocol for Reporting Finds of Archaeological Interest*. A further collection of bones and aircraft pieces (**CEMEX_0948**) and (**CEMEX_0951** and **CEMEX_0952**) were reported however, whether these were recovered from Licence 511 or 512 and 460 or 512 respectively is unknown.

5.3 Area 513/1

Vibrocore assessment

- 5.3.1 Unit 1 was not recovered in vibrocores, most likely due to Unit 1 being present at depths greater than the maximum penetration of the vibrocores (6 m).
- 5.3.2 Unit 2 was recovered in seven of the eight vibrocores recovered from Area 513/1 (**Figure 6**) and comprises silty sand with occasional shell fragments and thin beds of silt locally. Unit 2 may be present at seabed or in the shallow sub-surface below Unit 3b.
- 5.3.3 Unit 3b overlies Unit 2 and is present in six vibrocores (**Figure 6**). Unit 3b is characterised by silty gravelly sand and silty sandy gravel and is exposed at seabed at all six locations. The thickness of Unit 3b is typically >2.5 m.
- 5.3.4 Unit 3a, Unit 4, Unit 5, Unit 7 and Unit 8 were not recovered in vibrocores from Area 513/1.

Updates to deposit model

- 5.3.5 The legacy deposit model suggests Unit 2 is present across Area 513/1, overlain by Unit 3b which is present across all but the eastern corner of the licence area, and Unit 4 in the southern corner (**Figure 6**). The presence or absence of each Unit in the vibrocores was compared to the legacy deposit model and 3 conflicts were identified as outlined in (**5.2.6Table 6Table 7**) (**Figure 6**).

Table 7 Data conflicts Area 513/1

VC ID	Conflict	Description	Change extent	Justification
UNIT 2				
2016-VC-38	Unit 2 absent in VC that lies in area mapped as Unit 2	VC comprises Unit 3b	No	Unit 2 is likely present at a greater depth
Unit 3b				
2016-VC-35A	Unit 3b absent in VC that lies in area mapped as Unit 3b	VC comprises Unit 2	No	Isolated core, not enough information to change deposit model
2016-VC-41A				

- 5.3.6 Based on the assessment of vibrocore data, no changes to the extent of Unit 2, Unit 3b or Unit 4 within Area 513/1 were made.

Dredging history

- 5.3.7 Dredging in Area 513/1 over the years 2016-2019 ranged from medium to high intensity (**Figure 10**). In 2016, dredging was concentrated in the western part of Area 513/2, in subsequent years the entire licence area was dredged. Dredging activity targets Unit 3b.
- 5.3.8 The vibrocores reviewed here were acquired in 2016 and therefore predate the EMS data. Given the licence area has been dredged on a year by year basis and in places dredging intensity was high, it is expected the thickness of Unit 3b will be lower. However, complete removal of Unit 3b is not expected given the original thickness exceeds 2 m.

Known Archaeology

- 5.3.9 Six finds of archaeological interest have been reported through the Marine Aggregate Industry *Protocol for Reporting Finds of Archaeological Interest* and comprised a collection of worked flint, bone fragments and environmental remains (**2177 - 2181**), and various mammal bone fragments (**2182 - 2187, 2166 and 2265**).
- 5.3.10 Three operational sampling events have been undertaken in Area 513/1 targeting Unit 3b.
- 5.3.11 Operational sampling was undertaken on the 23rd and 24th April 2013 and numerous faunal remains were recovered (**2240**). The bones were highly abraded and mineralised and are thought to be of considerable age. Operational sampling undertaken in October 2014 recovered three fragments of bone, two unidentifiable mammal bone fragments and a mammal vertebra (**2254 - 2256**). Also, a Bi-polar core fragment was recovered (**2257**). In July 2017, a mineralised antler fragment was discovered along with 12 fragments of unidentified mineralised bones, and several fragments of wood not thought to be archaeologically significant.

5.4 Area 513/2

Vibrocore assessment

- 5.4.1 Unit 1 was not recovered in Area 513/2, most likely due to Unit 1 being present at depths greater than the maximum penetration of the vibrocores (6 m).
- 5.4.2 Unit 2 was recovered in three of the five vibrocores (2016-VC-43, 2016-VC44 and 2016-VC-45A) and comprises silty sand. At these three locations Unit 2 is exposed at seabed.
- 5.4.3 Unit 3b is recorded in two vibrocores (2016-VC-42 and 2016-VC-46) where it is characterised by silty gravelly sand, silty sandy gravel or sand and gravel. At the location of 2016-VC-42 Unit 3b is exposed at seabed, but at 2016-VC-46 Unit 3b is overlain by Unit 8. Unit 8 is only present at this location.
- 5.4.4 Unit 3a, Unit 4, Unit 5, Unit 6 and Unit 7 are not present in Area 513/2.

Updates to deposit model

- 5.4.5 The legacy deposit model suggests Unit 2 is present across Area 513/2, overlain by Unit 3b which is present within Channel A in the north, and as an isolated patch in the south (**Figure 7**). The presence or absence of each Unit in the vibrocores was compared to the legacy deposit model and 2 conflicts were identified as outlined in (**5.2.6Table 6Table 8**) (**Figure 7**).

Table 8 Data conflicts Area 513/2

VC ID	Conflict	Description	Change extent	Justification
UNIT 2				
2016-VC-42	Unit 2 absent in VC that lies in area mapped as Unit 2	VC comprises Unit 3b	No	Unit 2 is likely present at a greater depth
2016-VC46		VC comprises Unit 3b and Unit 8	No	
Unit 4				
2016-VC-42	Unit 4 absent in VC that lies in area mapped as Unit 4	VC comprises Unit 3b	No	Isolated core, not enough information to change deposit model

5.4.6 Based on the assessment of vibrocore data, no changes to the extent of Unit 2 within Area 513/2 were made.

Dredging history

5.4.7 EMS data indicate Area 513/2 was not dredged over the period 2016-2018 (**Figure 11**). Dredging did occur in 2019 but it was restricted to a single track in the centre of the licence area and was low intensity. Due to minimal dredging, no changes in the extent or survival of deposits is anticipated.

Known Archaeology

5.4.8 No operational sampling has been undertaken in Area 513/2.

5.4.9 However, a single fragment of bone (**2165**) and shell case (**CEMEX_0855**) has been reported through the Marine Aggregate Industry *Protocol for Reporting Finds of Archaeological Interest*. A further bullet (**CEMEX_0854**) was also reported, however, whether this was recovered from Licence Area 513/2 or 458 is unknown.

6 DISCUSSION

6.1 Early Pleistocene (2.58 MA – 773 ka)

6.1.1 Unit 1 correlates to Westkapelle Ground Formation and comprises silty clays and sands that were deposited in a deltaic environment during the Early Pleistocene (Cameron et al. 1992). Unit 1 does not outcrop, or subcrop in the shallow subsurface in any of the licence areas and has not been sampled by geotechnical surveys or operational sampling events.

6.1.2 Unit 2 is interpreted as Yarmouth Roads Formation, also deposited in a deltaic environment during the Early Pleistocene (Cameron et al. 1992). Unit 2 comprises fine-grained sands with laminations or beds of silt and clay. Organic mud, peat or fragments of organic matter can be preserved in Yarmouth Roads Formation and represent shallowing of the deltaic environment. Yarmouth Roads correlates stratigraphically to Crag Group onshore (Moorlock et al. 2000) and the upper parts of Yarmouth Roads may correlate to the Cromer Forest-bed Formation which is associated with the key Lower Palaeolithic finds at Happisburgh and Pakefield (Parfitt et al. 2005).

6.1.3 Unit 2 is present in all licence areas and can be found outcropping at seabed, or subgrouping below overlying deposits (Unit 3b and Unit 8). Unit 2 has not been targeted directly by operational sampling and no finds were reported from Unit 2 in Area 512, 513/1 and 513/2 through the BMAPA *Protocol for Reporting Finds of Archaeological Interest*.

- 6.1.4 In Area 511 a sample of peat (**2164**) was recorded through the BMAPA *Protocol for Reporting Finds of Archaeological Interest* within an area of Unit 2 deposits. This peat sample was not radiocarbon dated but it is possible it represents an organic bed within Unit 2. However, it is noted that this find was located in Channel B which is an Early Holocene extension of the Palaeo-Yare, although no Holocene deposits (Unit 7) have been mapped in the area. Other finds reported through the protocol from Unit 2 in Area 511 include faunal remains (**2261 – 2264** and **2163**). No lithics have been recovered from Unit 2.
- 6.2 Middle Pleistocene (773 ka – 126 ka)**
- 6.2.1 There is an unconformity between deposition of Unit 2 and overlying Unit 3b deposits. This unconformity represents large-scale palaeogeographic changes that occurred during the Anglian glacial (MIS 12; 478-424 ka) when ice sheets extended as far south as Norfolk, remodelling the landscape and diverting major drainage systems (e.g. Bytham river).
- 6.2.2 At the end of the Anglian period, during deglaciation, the Palaeo-Yare initially formed and has continued to develop through to the present day (**Figure 2**) (Wessex Archaeology 2013a). The now submerged Palaeo-Yare was only active during cold periods (glaciations) when sea levels were lower than the present day. During these times, the Palaeo-Yare extended eastwards depositing sands and gravels on the valley floor, creating a palimpsest of river terraces that are now submerged.
- 6.2.3 Deposits directly associated with the development of the Palaeo-Yare include Unit 3a, Unit 3b, Unit 5, Unit 6 and Unit 7. These deposits do not correlate directly to the broader southern North Sea lithostratigraphic framework (Stoker et al. 2011) as they are local in extent, limited to the Palaeo-Yare catchment.
- 6.2.4 The extent of Unit 3a is confined to Channel A in Area 240. Interpretations of Unit 3a are based on geophysical data only as it is present at depths >6 m, beyond the reach of vibrocores. Unit 3a is expected to have formed during MIS 12, MIS 10 or MIS 8, when sea-levels were lower and climate was cooler. Given the depth of Unit 3a, no archaeological finds have been recorded and as no dredging activity has occurred within Channel A, these deposits remain buried.
- 6.2.5 Unit 3b is the most widespread deposit within the submerged Palaeo-Yare valley system and comprises gravelly sand, and sand and gravel, interpreted to have been deposited in a cold-climate glaciofluvial floodplain setting. Deposition of Unit 3b occurred between MIS 9-MIS 7 according to Optical Stimulated Luminescence (OSL) dating (Wessex Archaeology 2011; Limpenny et al. 2011)) but given the coarse-grained nature, it most likely formed during the cold climate of MIS 8. Unit 3b broadly correlates to the Yare Valley Formation onshore (Athurton et al. 1994).
- 6.2.6 Unit 3b is present in Area 511, Area 512, Area 513/1 and Area 513/2. The thickness of Unit 3b varies and is difficult to establish due to historic dredging activity. Unit 3b is most extensive in Area 513/1 where it covers the entire licence area with the exception of a small patch in the eastern corner (Figure 6). In Area 512 and Area 513/2, Unit 3b is restricted to the northern parts of the licence areas (**Figure 5** and **Figure 7**) and in Area 511, the central and northern parts (**Figure 4**). Based on the assessment of vibrocores and EMS data here, no changes were made to the extent of Unit 3b in any of the licence areas.
- 6.2.7 Operational sampling in Area 511, Area 512 and Area 513/1 targets Unit 3b deposits and the distribution of finds in each of these areas reflects this. Lower Palaeolithic and Upper Palaeolithic lithics (**2232** and **2233**) have been recovered from Area 511, along with

numerous faunal remains including red deer, sheep and mammoth (**2235, 2236, 2241, 2242, 2261** and **2262**). These finds are located within Channel B, an Early Holocene extension of the Palaeo-Yare. Given the mixed age of the assemblage in Area 511, Unit 3b deposits in Channel B are likely reworked.

- 6.2.8 Worked lithics were recovered from Unit 3b in Area 512 and 513/1, including a large scraper made on a secondary flake of possible Lower Palaeolithic age (**2237**) in Area 512. Numerous faunal remains (cow, deer, sheep and auroch) were also recovered from Unit 3b in these licence areas, some of which were heavily mineralised indicating they are of considerable age. Given the results, the archaeological potential of Unit 3b therefore remains high.

6.3 Late Pleistocene (126 ka – 11.7 ka)

- 6.3.1 After development of the Palaeo-Yare, most likely during MIS 9 - MIS 7 (Saalian), sea-levels rose during the Eemian interglacial (MIS 5e) and the lower reaches of the Palaeo-Yare would have flooded becoming submerged. There is no evidence of Eemian deposits in Area 511, Area 512, Area 513/1 or Area 513/2 (Wessex Archaeology 2013b).
- 6.3.2 As climate deteriorated into the Weichselian glacial period (MIS 5d – MIS 2; 110 ka – 11.7 ka) and sea-levels started to fall, the lower reaches of the Palaeo-Yare would have become exposed and it is during the early parts of the Weichselian, Unit 4 was deposited. Unit 4 correlates to the Brown Bank Formation (Cameron et al. 1992) and formed in a shallow, brackish North Sea. Unit 4 comprises characteristically dark grey clays, silt and sands.
- 6.3.3 Unit 4 directly overlies Unit 3b and is present in Area 513/1 and Area 513/2 (**Figure 6** and **Figure 7**). In Area 513/1, Unit 4 is present as an isolated patch in the southern corner of the licence area (**Figure 6**) and in Area 513/2 it has a patchy distribution in the north (**Figure 7**). No vibrocores were recovered within the region of Unit 4 in Area 513/1. A single vibrocore was located in an area of Unit 4 in Area 513/2 but Unit 4 was not recovered, therefore there are no changes to the extent of Unit 4.
- 6.3.4 In Area 513/1 and Area 513/2, no operational sampling events have been undertaken within the extent of Unit 4 and no finds have been recorded through the BMAPA *Protocol for Reporting Finds of Archaeological Interest*.
- 6.3.5 Unit 5 sediments are interpreted as estuarine sediments deposited or exposed during MIS 3 according to a single OSL date of 36 ± 3 ka (GL100044) (Wessex Archaeology 2013a). Unit 6 is coarser-grained than Unit 5 and is interpreted to have been deposited in a cold-climate glaciofluvial setting. While there are no dates from this deposit, this mostly likely occurred during the coldest parts of the Weichselian (MIS 3 – MIS 2) when sea levels were lower. Unit 5 and Unit 6 were not recorded in any vibrocores, nor have they been previously mapped within Area 512, Area 512, Area 513/1 and Area 513/2.

6.4 Holocene (11.7 ka – present day)

- 6.4.1 At the end of the Weichselian glacial period, climate started to warm but sea-levels remained relatively low and the lower reaches of the Palaeo-Yare would have been exposed. It is during this time, Channel B, a meandering channel that runs through Area 511, formed partially cutting into underlying Unit 3b deposits (**Figure 4**). In Area 240, a licence area directly adjacent to the east of Area 511, Channel B is infilled with Unit 7 which is characterised by a basal peat overlain by silty, clayey. These deposits reflect infilling of Channel B under the influence of rising sea level during the Early Holocene and correlate

to the Breydon Formation onshore (Moorlock et al. 2000). A small area of Unit 7 was previously mapped on the eastern margin of Channel B in Area 511 (Wessex Archaeology 2013a). However, none of the vibrocores assessed here were located in this area and Unit 7 was not recorded at any other locations.

- 6.4.2 No operational sampling events have targeted Unit 7 in Area 511. However, a number of lithics including a tertiary flake of possible Holocene age (**2233**) and a thermal flake in fresh condition also of Holocene age (**2234**) were recovered from Unit 3b within Channel B. These finds are later than the age of Unit 3b (Saalian) suggesting there is potential to preserve Upper Palaeolithic or Mesolithic archaeology in Channel B, despite Unit 7 deposits not being recorded in vibrocores. There is also the potential to recover palaeoenvironmental material, although it is not known if this originates in Unit 2 or Unit 7.
- 6.4.3 Final inundation of the lower reaches of the Palaeo-Yare is expected to have occurred ~8.5 ka (Wessex Archaeology 2103a) after which marine processes began to rework and redistribute deposits forming Unit 8, seabed sediments. Given historic dredging activity, in some areas the surficial sediments (Unit 8) may be a palimpsest of marine process and localised remobilisation due to dredging activity. Therefore, it is possible for reworked archaeological material to be present in Unit 8.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Deposit extent and survival

- 7.1.1 Based on the review of geotechnical vibrocores and EMS data (2016-2019), no updates were made to the extent of Unit 2, Unit 3b, Unit 4 or Unit 7 in Area 511, Area 512, Area 513/1 and Area 513/2. Unit 1, Unit 3a, Unit 5 and Unit 6 were not recorded in any of the licence areas.

7.2 Operational sampling

- 7.2.1 The subdivision of each licence area into Sampling Operation Groups was undertaken alongside the production of the legacy deposit model (Wessex Archaeology 2013a). Therefore, any changes in the extent of key deposits needs to be reflected in the Sampling Operation Groups. As no changes were made to deposit extent, no changes to Sampling Operation Groups were required.

7.3 Archaeological potential

- 7.3.1 The archaeological potential of each deposit within the submerged Palaeo-Yare catchment is summarised in **Table 9**;

Table 9 Archaeological potential of deposits

Unit	Archaeological Potential	Present or absent in Licence Area			
		511	512	513/1	513/2
8	Potential to comprise reworked archaeology	√	√	√	√
7	Highly likely to contain environmental archaeology (e.g. peat) and may preserve Mesolithic archaeology (faunal and lithic)	?	X	X	X
6	Potential to contain Middle Palaeolithic archaeology but no evidence found to date	X	X	X	X
5	Potential to contain Middle Palaeolithic archaeology but no evidence found to date	X	X	X	X
4	Can contain reworked Middle Palaeolithic archaeology (e.g. faunal remains)	X	X	√	√



Unit	Archaeological Potential	Present or absent in Licence Area			
		511	512	513/1	513/2
3b	Highly likely to preserve Middle Palaeolithic archaeology (faunal remains and lithics)	√	√	√	√
2	Potential to preserve Lower Palaeolithic archaeology but no evidence found to date	√	√	√	√
1	None – predates hominin occupation of Britain	Sub crops at depth below Unit 2			

7.4 Future work

- 7.4.1 The assessment of vibrocore and EMS data was undertaken to review and update the legacy deposit model constructed for the submerged Palaeo-Yare catchment assessment (Wessex Archaeology 2013a). A total of 71 vibrocores were reviewed, which tallied with the legacy deposit model, and therefore no changes were required to the extent of Unit 2, Unit 3b and Unit 4 in any of the licence areas.
- 7.4.2 While EMS data was important for identifying areas of recent dredge activity, establishing deposit thickness was problematic where dredging had occurred after the date of the vibrocore survey. Where available, bathymetry difference models showing changes in seabed elevation could be used alongside EMS data to semi-quantitatively assess if Unit 3b has been fully or partially removed by dredging activity.
- 7.4.3 Despite some of the challenges the data presented, the new vibrocore data were largely in agreement with the legacy deposit model increasing confidence in the original interpretation (Wessex Archaeology 2013a). No changes were made to deposit extent. Therefore, no changes to the Threshold for each group were required. Consideration of the outcomes of this assessment and the effectiveness of using geotechnical data to update the legacy deposit model should be given when planning future data reviews.
- 7.4.4 To support ongoing operational sampling monitoring visits, it is recommended the data sheets for each licence area are updated on a yearly basis to include new operational sampling events, any new finds and EMS data for the last year. These updates should coincide with the release of the Area Involved report published by the Crown Estate and BMAPA.

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APPENDICES

Appendix 1

Easting (m)	Northing (m)	id	Depth from (m)	Depth to (m)	Description	Unit
432395.9	5831363	VC 212-07	0.00	3.87	loose becoming dense slightly silty SAND with occasional thin laminations of organic clay	2
432226.3	5831526	VC 212-08	0.00	0.80	medium dense slightly silty very gravelly SAND with occasional shell fragments	2
422823.7	5822558	2016-VC-01	0.00	1.10	Silty gravelly SAND w/ occ. shell frags	8
422823.7	5822558	2016-VC-01	1.10	3.16	Silty SAND w/ occ. sandstone incl.	8
422823.7	5822558	2016-VC-01	3.16	3.60	Silty SAND	2
422800.7	5822226	2016-VC-02	0.00	1.12	Silty SAND w/ occ. flint gravel + shell	8
422800.7	5822226	2016-VC-02	1.12	2.78	Silty SAND	2
422772.8	5821730	2016-VC-03A	0.00	1.06	Silty gravelly SAND w/ shell frags	8
422772.8	5821730	2016-VC-03A	1.06	3.90	Silty gravelly SAND w/ shell frags	8
424304.9	5823080	2016-VC-04	0.00	0.30	Silty gravelly SAND	8
424304.9	5823080	2016-VC-04	0.30	1.12	Silty v. gravelly SAND	3b
424304.9	5823080	2016-VC-04	1.12	2.70	Interbedded SILT and silty SAND	2
424301.5	5822582	2016-VC-05	0.00	0.76	Silty gravelly SAND and sandy GRAVEL	3b
424301.5	5822582	2016-VC-05	0.76	2.82	Silty SAND w/ frequent laminations of SILT	2
423879.1	5822371	2016-VC-06	0.00	0.40	Silty gravelly SAND	3b
423879.1	5822371	2016-VC-06	0.40	1.80	Silty v. sandy GRAVEL to silty v. gravelly SAND	3b
423879.1	5822371	2016-VC-06	1.80	2.95	Silty SAND w/ occ. laminations of SILT + occ. gravel 2.10-2.20m	2
424305.5	5821818	2016-VC-07A	0.00	0.84	Silty gravelly SAND	8
424305.5	5821818	2016-VC-07A	0.84	1.14	Silty v. gravelly SAND	3b
424305.5	5821818	2016-VC-07A	1.14	3.79	Silty SAND w/ occ. gravel	2
423517.1	5821377	2016-VC-08A	0.00	0.80	Silty v. gravelly SAND	3b
423517.1	5821377	2016-VC-08A	0.80	1.60	Silty gravelly SAND	3b
423517.1	5821377	2016-VC-08A	1.60	2.24	Silty v. gravelly SAND	3b
423517.1	5821377	2016-VC-08A	2.24	2.89	Silty v. gravelly SAND	3b
423438.6	5821004	2016-VC-09	0.00	0.30	Silty gravelly SAND	8
423438.6	5821004	2016-VC-09	0.30	0.82	Silty v. sandy GRAVEL	3b
423438.6	5821004	2016-VC-09	0.82	1.20	Silty v. gravelly SAND	3b
423438.6	5821004	2016-VC-09	1.20	2.00	Silty gravelly SAND	3b
423438.6	5821004	2016-VC-09	2.00	2.52	Silty v. gravelly SAND	3b
423438.6	5821004	2016-VC-09	2.52	2.75	Silty SAND w/ laminations of SILT	2
422769.1	5820677	2016-VC-10	0.00	2.20	Silty gravelly to v. gravelly SAND	3b
422769.1	5820677	2016-VC-10	2.20	2.65	Silty gravelly SAND	3b
422769.1	5820677	2016-VC-10	2.65	2.96	Silty gravelly SAND	3b
422769.1	5820677	2016-VC-10	2.96	3.01	Silty SAND	2



Easting (m)	Northing (m)	id	Depth from (m)	Depth to (m)	Description	Unit
422644.1	5820070	2016-VC-11	0.00	0.20	Silty gravelly SAND	3b
422644.1	5820070	2016-VC-11	0.20	1.67	Silty v. gravelly SAND. Organic sandy SILT pocket @1.58-1.67m	3b
422644.1	5820070	2016-VC-11	1.67	2.70	Silty gravelly SAND	3b
422644.1	5820070	2016-VC-11	2.70	3.50	Silty v. gravelly SAND grading to silty v. sandy GRAVEL	3b
422644.1	5820070	2016-VC-11	3.50	4.61	Silty SAND w/ frequent laminations of SILT	2
422644.1	5820070	2016-VC-11	4.61	4.89	Silty gravelly SAND w/ shell frags	2
424295.5	5821023	2016-VC-12	0.00	4.93	Silty gravelly SAND w/ frequent laminations of SILT from 3.56m-base.	3b
424383.7	5820586	2016-VC-13	0.00	0.62	Silty gravelly SAND	8
424383.7	5820586	2016-VC-13	0.62	2.07	Silty becoming silty v. gravelly SAND	3b
424383.7	5820586	2016-VC-13	2.07	4.18	Silty SAND w/ occ. laminations of SILT	2
426197.8	5819207	2016-VC-14	0.00	0.70	Silty v. gravelly SAND	3b
426197.8	5819207	2016-VC-14	0.70	4.45	Silty SAND w/ frequent laminations of SILT	2
424913.2	5816623	2016-VC-15	0.00	0.30	Silty gravelly SAND	8
424913.2	5816623	2016-VC-15	0.30	1.90	Silty v. gravelly SAND	3b
424913.2	5816623	2016-VC-15	1.90	3.41	Silty SAND + fine shell frags	2
422655	5817618	2016-VC-16	0.00	5.26	Silty gravelly SAND	3b
422655	5817618	2016-VC-16	5.26	5.34	Silty SAND	2
422684.5	5816936	2016-VC-17	0.00	2.50	Silty to v. silty SAND	2
424143.4	5814705	2016-VC-18	0.00	0.28	Silty gravelly SAND	3b
424143.4	5814705	2016-VC-18	0.28	0.95	Silty v. gravelly SAND	8
424143.4	5814705	2016-VC-18	0.95	3.62	Silty SAND w/ thin bed of SILT	2
423661.6	5815591	2016-VC-19	0.00	1.20	Silty v. gravelly SAND	2
423661.6	5815591	2016-VC-19	1.20	2.73	Silty SAND w/ occ. laminations of SILT	2
423889.7	5816673	2016-VC-20	0.00	0.74	Silty gravelly SAND w/ shell frags	8
423889.7	5816673	2016-VC-20	0.74	1.19	Silty SAND	2
423889.7	5816673	2016-VC-20	1.19	1.96	Silty gravelly SAND w/ shell frags	2
426150.5	5818422	2016-VC-21	0.00	1.11	Silty gravelly SAND	3b
426150.5	5818422	2016-VC-21	1.11	4.95	Silty SAND w/ frequent laminations of SILT + shell frags	2
424281.5	5815991	2016-VC-22	0.00	1.00	Silty SAND w/ occ. gravel	8
424281.5	5815991	2016-VC-22	1.00	1.24	Silty gravelly SAND	2
424281.5	5815991	2016-VC-22	1.24	3.07	Silty gravelly SAND. Thin bed of silty gravelly SAND 2.46-2.56m. Freq laminations of SILT below 2.80m	2
428327	5818643	2016-VC-23	0.00	0.10	Silty v. sandy GRAVEL	3b
428327	5818643	2016-VC-23	0.10	2.56	Silty SAND	2
428327	5818643	2016-VC-23	2.56	3.00	Silty gravelly SAND	2
428327	5818643	2016-VC-23	3.00	3.59	Silty SAND w/ occ. gravel	2
428327	5818643	2016-VC-23	3.59	3.70	Sandy SILT	2
428327	5818643	2016-VC-23	3.70	4.12	Silty gravelly SAND w/ shell frags	2



Easting (m)	Northing (m)	id	Depth from (m)	Depth to (m)	Description	Unit
428723.1	5819135	2016-VC-24	0.00	0.40	Silty gravelly SAND	3b
428723.1	5819135	2016-VC-24	0.40	3.46	Silty SAND	2
429322.7	5819545	2016-VC-25	0.00	3.40	Silty gravelly to v. gravelly SAND	3b
429073.2	5818127	2016-VC-26	0.00	2.22	Silty gravelly to v. gravelly SAND	3b
429073.2	5818127	2016-VC-26	2.22	2.80	Silty SAND	2
429073.2	5818127	2016-VC-26	2.80	3.00	Silty SAND	2
429073.2	5818127	2016-VC-26	3.00	3.34	Silty SAND	2
429073.2	5818127	2016-VC-26	3.34	3.62	Silty gravelly SAND	2
429073.2	5818127	2016-VC-26	3.62	3.90	Silty SAND	2
428548.3	5817277	2016-VC-27	0.00	0.20	Silty gravelly SAND	8
428548.3	5817277	2016-VC-27	0.20	2.00	Silty SAND w/ occ. gravel	2
428548.3	5817277	2016-VC-27	2.00	2.56	Silty SAND becoming v. sandy SILT w/ frequent laminations of SILT	2
431083.9	5819765	2016-VC-28	0.00	0.50	Silty v. gravelly SAND	3b
431083.9	5819765	2016-VC-28	0.50	1.20	Silty v. gravelly SAND	3b
431083.9	5819765	2016-VC-28	1.20	3.19	Silty SAND w/ occ. gravel	2
429382.8	5816234	2016-VC-29	0.00	0.72	Silty gravelly SAND	8
429382.8	5816234	2016-VC-29	0.72	3.45	Silty SAND w/ laminations of SILT + occ. shell frags	2
429187.6	5815213	2016-VC-30	0.00	0.68	Silty gravelly SAND w/ frequent shell frags	8
429187.6	5815213	2016-VC-30	0.68	2.99	Silty SAND w/ occ. gravel	2
429626.3	5814390	2016-VC-31	0.00	0.05	Silty v. sandy GRAVEL	8
429626.3	5814390	2016-VC-31	0.05	2.79	Silty gravelly SAND w/ shell frags + occasional laminations of SILT	2
429626.3	5814390	2016-VC-31	2.79	3.36	Sandy SILT	2
429943.8	5813217	2016-VC-32	0.00	1.26	Silty gravelly SAND w/ frequent shell frags	8
429943.8	5813217	2016-VC-32	1.26	1.91	Silty SAND w/ occ. shell frags	2
431564.1	5814383	2016-VC-33A	0.00	0.33	Silty v. gravelly SAND w/ shell frags	8
431564.1	5814383	2016-VC-33A	0.33	1.88	Silty SAND w/ occ. gravel	2
431564.1	5814383	2016-VC-33A	1.88	2.50	Silty gravelly SAND	2
431564.1	5814383	2016-VC-33A	2.50	3.39	Silty SAND w/ thin bed of gravelly SAND 3.10-3.16m	2
434587.6	5822618	2016-VC-34	0.00	0.24	Silty gravelly SAND	3b
434587.6	5822618	2016-VC-34	0.24	0.94	Silty v. sandy GRAVEL	3b
434587.6	5822618	2016-VC-34	0.94	2.25	Silty gravelly SAND	3b
434587.6	5822618	2016-VC-34	2.25	3.23	Silty SAND w/ frequent shell frags 2.25-2.45m	2
433471.8	5823628	2016-VC-35A	0.00	2.55	Silty SAND	2
433471.8	5823628	2016-VC-35A	2.55	3.58	Silty gravelly SAND w/ frequent shell frags	2
433471.8	5823628	2016-VC-35A	3.58	4.15	Silty SAND	2
433527.3	5822927	2016-VC-36A	0.00	0.66	Silty gravelly SAND	3b
433527.3	5822927	2016-VC-36A	0.66	3.26	Silty SAND. Thin bed of silty gravelly SAND 0.90-1.08m.	2



Easting (m)	Northing (m)	id	Depth from (m)	Depth to (m)	Description	Unit
433134.8	5822907	2016-VC-37	0.00	0.95	Silty gravelly SAND w/ thin beds of silty gravelly - v. gravelly SAND	3b
433134.8	5822907	2016-VC-37	0.95	1.42	Silty v. gravelly SAND	3b
433134.8	5822907	2016-VC-37	1.42	3.28	Silty gravelly - v. gravelly SAND w/ freq beds of silty v. gravelly SAND	3b
433134.8	5822907	2016-VC-37	3.28	3.66	Silty SAND	2
433927.3	5821658	2016-VC-38	0.00	5.37	Silty v. gravelly SAND - silty v. sandy GRAVEL. Occ. beds of silty gravelly SAND	3b
433526.8	5822256	2016-VC-39	0.00	2.71	Silty gravelly - v. gravelly SAND and silty v. sandy GRAVEL	3b
433526.8	5822256	2016-VC-39	2.71	3.20	Silty SAND	2
434159.7	5822262	2016-VC-40	0.00	3.00	Silty gravelly becoming gravelly - v. gravelly from 0.65m SAND	3b
434159.7	5822262	2016-VC-40	3.00	3.95	Silty SAND w/ thin beds of SILT 3.62-3.82m	2
434140.6	5822652	2016-VC-41A	0.00	1.40	Silty SAND	2
433462.2	5820369	2016-VC-42	0.00	0.28	Silty gravelly SAND w/ shell frags	3b
433462.2	5820369	2016-VC-42	0.28	0.96	Silty SAND w/ thin bed of silty gravelly SAND 0.75-0.84m	3b
433462.2	5820369	2016-VC-42	0.96	2.00	Silty GRAVEL and SAND	3b
433462.2	5820369	2016-VC-42	2.00	4.35	Silty gravelly - v. gravelly SAND	3b
433462.2	5820369	2016-VC-42	4.35	4.73	Silty sandy GRAVEL	3b
434471.9	5818484	2016-VC-43	0.00	4.53	Silty SAND. Thin band of CLAY 4.20-4.28m	2
435468	5818207	2016-VC-44	0.00	4.11	Silty SAND	2
434936.3	5817633	2016-VC-45A	0.00	5.55	Silty SAND. Slightly gravelly 0.00-0.20m.	2
435566.5	5817182	2016-VC-46	0.00	0.78	Silty gravelly SAND w/ shell frags	8
435566.5	5817182	2016-VC-46	0.78	4.13	Silty gravelly SAND	3b
422401.8	5823318	2018-VC-01A	0.00	0.04	Silty gravelly SAND w/ shell frags	8
422401.8	5823318	2018-VC-01A	0.04	0.25	Silty SAND	3b
422401.8	5823318	2018-VC-01A	0.25	1.60	V. gravelly SAND	3b
422401.8	5823318	2018-VC-01A	1.60	3.32	SAND. Gravelly band 2.20-2.40m	3b
422401.8	5823318	2018-VC-01A	3.32	4.30	V. gravelly SAND	3b
422258.6	5822340	2018-VC-02	0.00	0.44	Gravelly SAND	3b
422258.6	5822340	2018-VC-02	0.44	0.49	SAND. Gravelly band 2.20-2.40m	3b
422258.6	5822340	2018-VC-02	0.49	1.54	Silty gravelly SAND	3b
422258.6	5822340	2018-VC-02	1.54	2.80	Gravelly SAND	3b
422258.6	5822340	2018-VC-02	2.80	4.50	Silty gravelly SAND	3b
422258.6	5822340	2018-VC-02	4.50	5.18	SAND w/ rare gravel, shell frags.	2
422345	5821197	2018-VC-03	0.00	0.42	Silty v. gravelly SAND	8
422345	5821197	2018-VC-03	0.42	0.44	Soft grey CLAY	8
422345	5821197	2018-VC-03	0.44	2.44	Silty SAND w/ occ. 0.10m bands of gravel + clay/shell	2
422345	5821197	2018-VC-03	2.44	2.76	Silty gravelly SAND w/ shell frags	2
422345	5821197	2018-VC-03	2.76	4.35	Silty SAND w/ rare gravel + shell frags	2



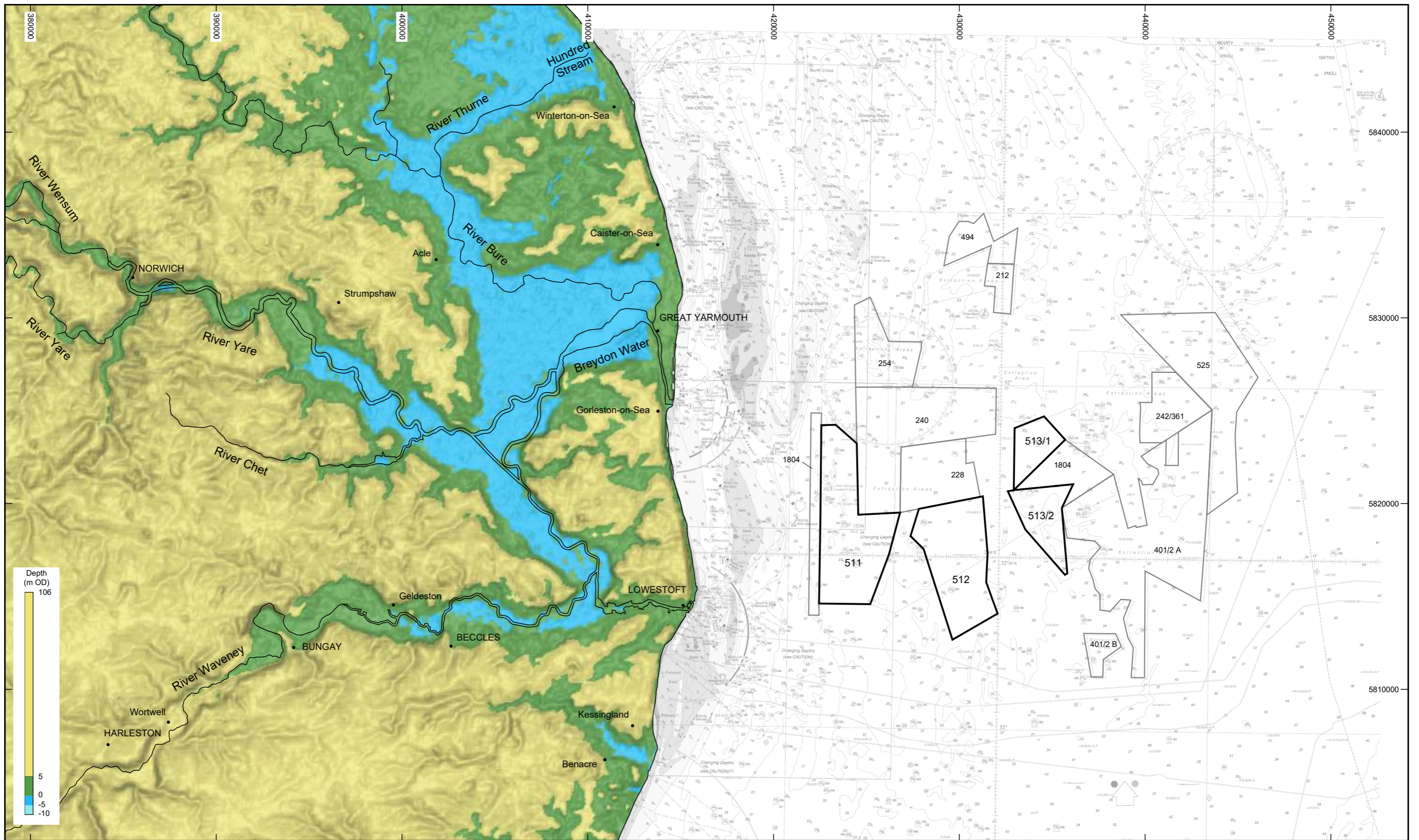
Eastings (m)	Northing (m)	id	Depth from (m)	Depth to (m)	Description	Unit
422345	5821197	2018-VC-03	4.35	4.69	Silty SAND	2
422345	5821197	2018-VC-03	4.69	4.96	Silty SAND	2
422307.4	5819790	2018-VC-04	0.00	0.20	Clayey, silty, gravelly SAND w/ shell frags	8
422307.4	5819790	2018-VC-04	0.20	0.36	Silty SAND w/ occasional thin beds of clay	3b
422307.4	5819790	2018-VC-04	0.36	0.91	Silty SAND w/ rare gravel + 0.02m band of clay @0.54m.	3b
422307.4	5819790	2018-VC-04	0.91	2.90	Interbedded silty CLAY and silty SAND	3b
422307.4	5819790	2018-VC-04	2.90	3.47	Gravelly silty SAND w/ shell frags + 0.01m band of CLAY @3.16m.	2
422263	5819003	2018-VC-05	0.00	1.52	Silty v. gravelly SAND	3b
422263	5819003	2018-VC-05	1.52	3.31	Interbedded silty CLAY + silty SAND	3b
422263	5819003	2018-VC-05	3.31	3.40	Gravelly silty SAND w/ shell frags	2
422288	5817738	2018-VC-06	0.00	0.30	Silty v. gravelly SAND	3b
422288	5817738	2018-VC-06	0.30	4.23	V. gravelly SAND	3b
422215.8	5816482	2018-VC-07A	0.00	0.69	V. gravelly SAND	3b
422215.8	5816482	2018-VC-07A	0.69	1.00	SAND and GRAVEL	3b
422215.8	5816482	2018-VC-07A	1.00	2.71	V. gravelly SAND	3b
422215.8	5816482	2018-VC-07A	2.71	2.97	Silty gravelly SAND	3b
422215.8	5816482	2018-VC-07A	2.97	3.64	Silty SAND w/ rare gravel + irregularly spaced thin beds of silty CLAY	2
434075.2	5820812	2018-VC-08	0.00	0.21	V. gravelly SAND. Thick laminae of silty CLAY @base	3b
434075.2	5820812	2018-VC-08	0.21	1.78	Silty SAND	3b
434075.2	5820812	2018-VC-08	1.78	2.72	V. gravelly SAND	3b
434075.2	5820812	2018-VC-08	2.72	3.51	SAND. Slightly gravelly after 3.25m	3b
434075.2	5820812	2018-VC-08	3.51	3.62	SAND	3b
434075.2	5820812	2018-VC-08	3.62	4.36	V. gravelly SAND	3b
434048.1	5821279	2018-VC-09	0.00	0.92	Silty v. gravelly SAND	3b
434048.1	5821279	2018-VC-09	0.92	1.84	Silty v. gravelly SAND	3b
434402.3	5821411	2018-VC-10	0.00	0.58	V. gravelly SAND	3b
434402.3	5821411	2018-VC-10	0.58	0.81	Silty SAND	3b
434402.3	5821411	2018-VC-10	0.81	1.28	Silty gravelly SAND	3b
434787.4	5821287	2018-VC-11	0.00	0.47	V. gravelly SAND	3b
434787.4	5821287	2018-VC-11	0.47	0.58	SAND	3b
434787.4	5821287	2018-VC-11	0.58	1.56	Silty v. gravelly SAND	3b
434790.5	5821683	2018-VC-12	0.00	0.15	Gravelly SAND	3b
434790.5	5821683	2018-VC-12	0.15	0.30	SAND	3b
434790.5	5821683	2018-VC-12	0.30	0.77	V. gravelly SAND	3b
434785.1	5821694	2018-VC-12A	0.00	1.44	V. gravelly SAND	3b
434785.1	5821694	2018-VC-12A	1.44	1.58	SAND	3b
434785.1	5821694	2018-VC-12A	1.58	3.19	V. gravelly SAND	3b
434785.1	5821694	2018-VC-12A	3.19	3.91	Silty SAND	2



Easting (m)	Northing (m)	id	Depth from (m)	Depth to (m)	Description	Unit
434845.4	5822141	2018-VC-13B	0.00	0.60	Gravelly - v. gravelly SAND	3b
434845.4	5822141	2018-VC-13B	0.60	0.80	Gravelly SAND	3b
434845.4	5822141	2018-VC-13B	0.80	0.88	V. gravelly SAND	3b
434845.4	5822141	2018-VC-13B	0.88	0.99	Silty gravelly SAND	3b
434839.5	5822160	2018-VC-13C	0.00	0.52	Silty v. gravelly SAND	3b
434839.5	5822160	2018-VC-13C	0.52	0.67	Silty SAND	2
434839.5	5822160	2018-VC-13C	0.67	1.28	Gravelly silty SAND	2
435190.9	5822488	2018-VC-14	0.00	0.57	V. gravelly SAND	3b
435196.4	5822479	2018-VC-14A	0.00	0.41	V. gravelly SAND	3b
435196.4	5822479	2018-VC-14A	0.41	0.53	SAND	3b
435196.4	5822479	2018-VC-14A	0.53	1.29	Gravelly SAND becoming siltier towards base.	3b
435916.1	5822471	2018-VC-15	0.00	0.23	V. gravelly SAND	3b
435916.1	5822471	2018-VC-15	0.23	0.74	V. gravelly SAND	3b
435916.1	5822471	2018-VC-15	0.74	1.07	Silty v. gravelly SAND	3b
435912.1	5822489	2018-VC-15A	0.00	0.48	V. gravelly SAND	3b
435912.1	5822489	2018-VC-15A	0.48	0.70	Gravelly silty SAND	3b
435912.1	5822489	2018-VC-15A	0.70	1.93	Silty gravelly SAND	3b
435912.1	5822489	2018-VC-15A	1.93	2.27	Silty gravelly SAND	3b
435912.1	5822489	2018-VC-15A	2.27	2.72	Silty gravelly SAND	3b
435912.1	5822489	2018-VC-15A	2.72	3.44	V. gravelly SAND	3b
435912.1	5822489	2018-VC-15A	3.44	4.81	Silty SAND w/ occasional gravel, peat. Pocket of fibrous PEAT 3.79-3.90m	3b
435598.4	5822234	2018-VC-16	0.00	0.15	Silty gravelly SAND	3b
435598.4	5822234	2018-VC-16	0.15	0.45	Silty gravelly SAND	3b
435598.4	5822234	2018-VC-16	0.45	1.85	Gravelly silty SAND w/ closely spaced thin beds of shell 1.30-1.80m	2
435598.4	5822234	2018-VC-16	1.85	2.24	Silty SAND w/ rare gravel	2
435592.9	5821758	2018-VC-17A	0.00	1.20	Silty v. gravelly SAND	3b
435644	5821176	2018-VC-18B	0.00	1.95	V. gravelly SAND	3b
436541.1	5821410	2018-VC-19	0.00	0.13	SAND	8
436541.1	5821410	2018-VC-19	0.13	1.58	Silty v. gravelly SAND	3b
436541.1	5821410	2018-VC-19	1.58	3.56	V. gravelly SAND	3b
436541.1	5821410	2018-VC-19	3.56	3.98	Silty SAND w/ irregular thin laminae of fibrous PEAT	3b
436541.1	5821410	2018-VC-19	3.98	4.28	Silty SAND w/ rare gravel (gravel = flint, sandstone + peat)	3b
436541.1	5821410	2018-VC-19	4.28	4.36	Silty SAND	2
436315.8	5820881	2018-VC-20A	0.00	0.82	Gravelly SAND	3b
436315.8	5820881	2018-VC-20A	0.82	0.91	SAND	3b
436315.8	5820881	2018-VC-20A	0.91	1.11	Gravelly SAND	3b
436315.8	5820881	2018-VC-20A	1.11	2.03	Gravelly SAND	3b
436315.8	5820881	2018-VC-20A	2.03	5.24	Silty v. gravelly SAND	3b



Easting (m)	Northing (m)	id	Depth from (m)	Depth to (m)	Description	Unit
436315.8	5820881	2018-VC-20A	5.24	5.40	Silty v. gravelly SAND	3b
436315.8	5820881	2018-VC-20A	5.40	5.50	SAND	2
436070	5820390	2018-VC-21	0.00	1.33	Silty v. gravelly SAND	3b



Licence Areas 511, 512, 513/1 and 513/2
 Other Licence Areas

0 10 km



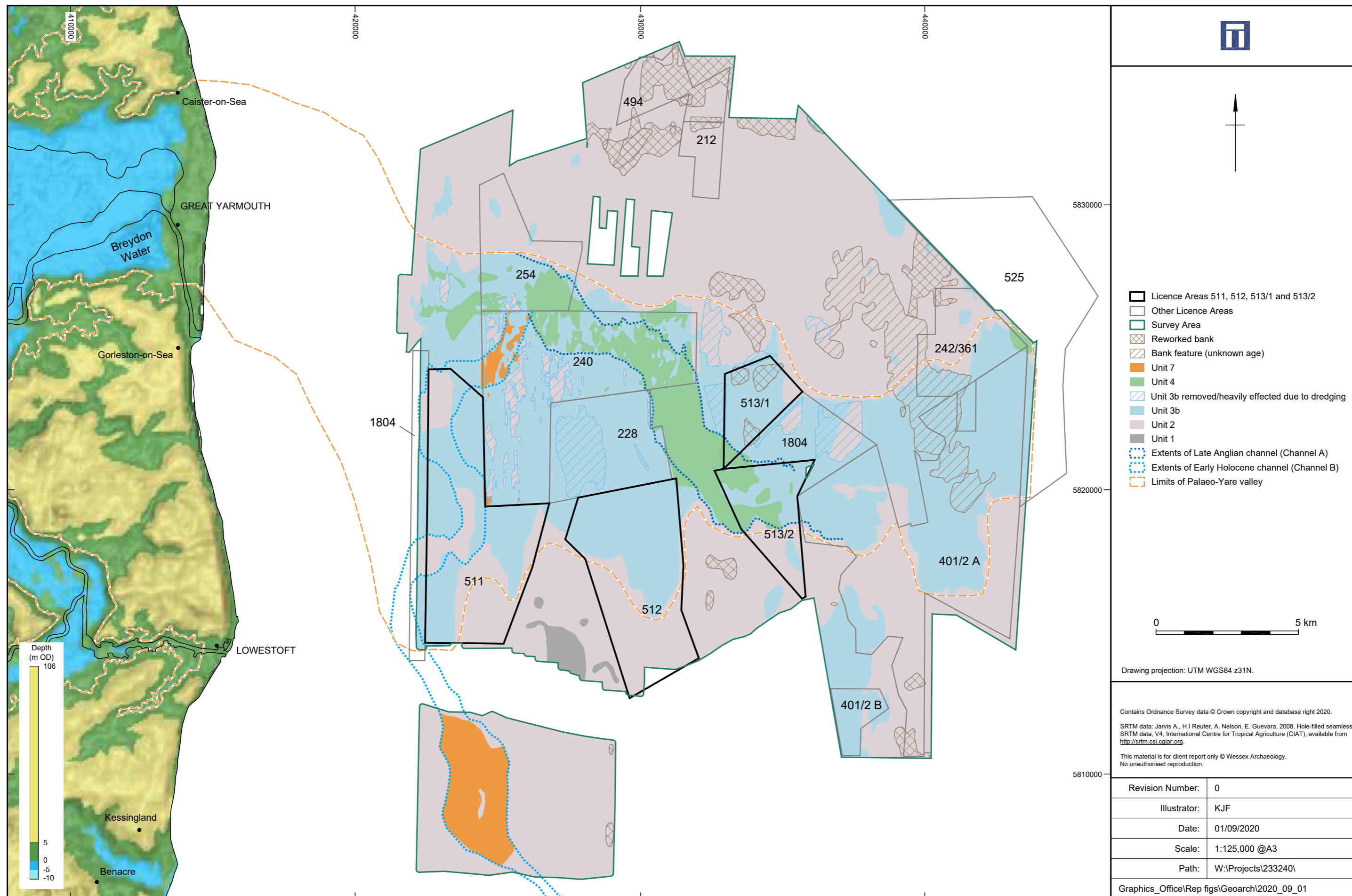
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 SRTM data: Jarvis A., H.I Reuter, A. Nelson, E. Guevara, 2008. Hole-filled seamless SRTM data, V4, International Centre for Tropical Agriculture (CIAT), available from <http://srtm.csi.cgiar.org>.
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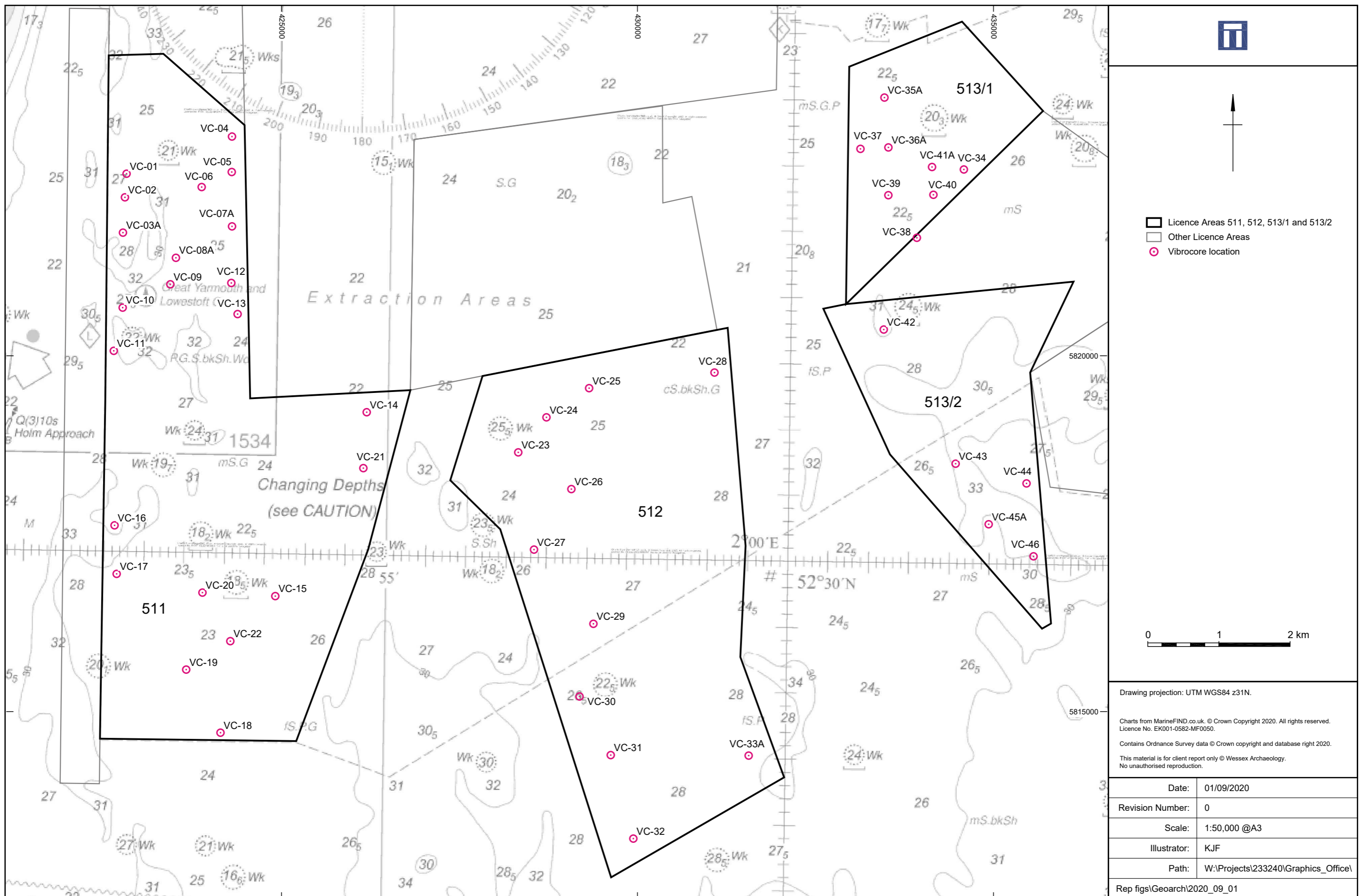
Location of Cemex Marine Aggregate Licence Areas

Figure 1



Palaeo-Yare Catchment Assessment

Figure 2



Drawing projection: UTM WGS84 z31N.

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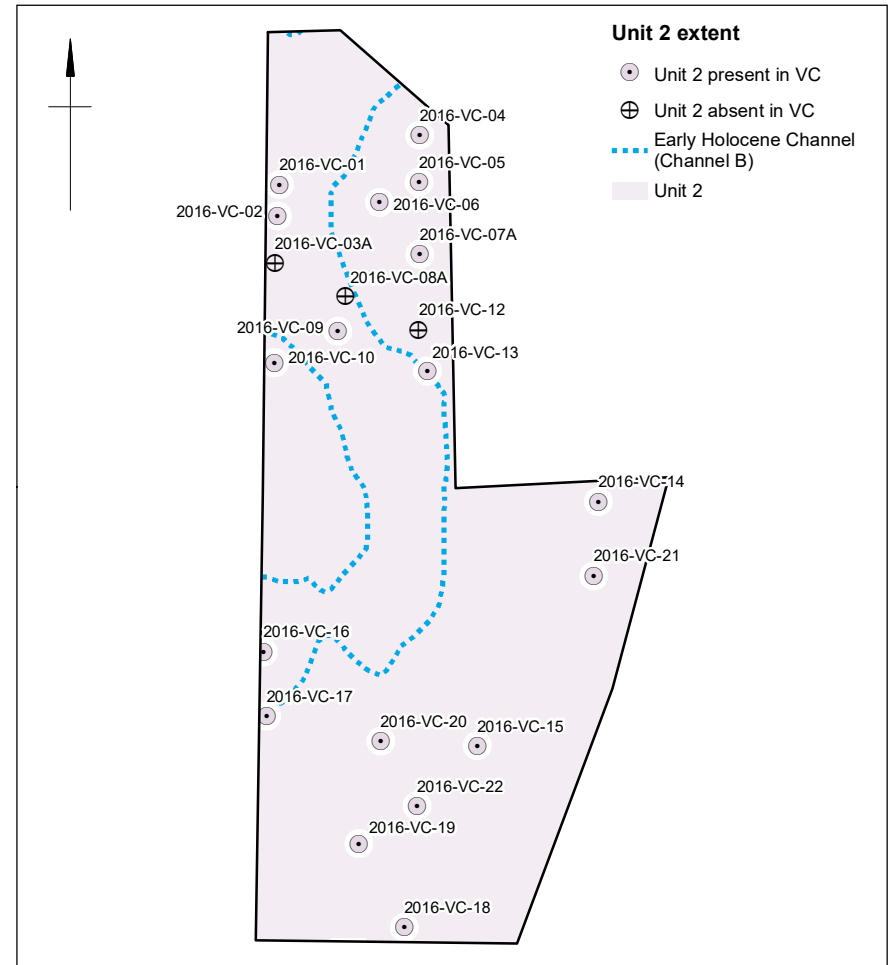
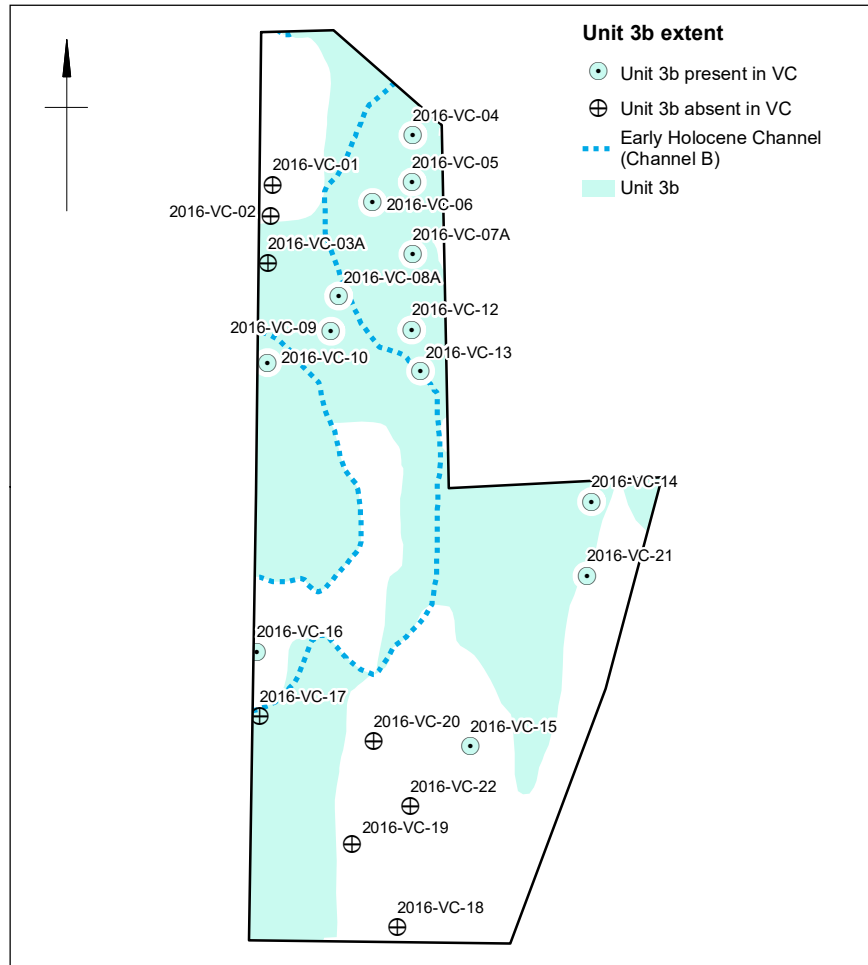
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Location of vibrocore survey data

Figure 3

Area 511



Drawing projection: UTM WGS84 z31N.

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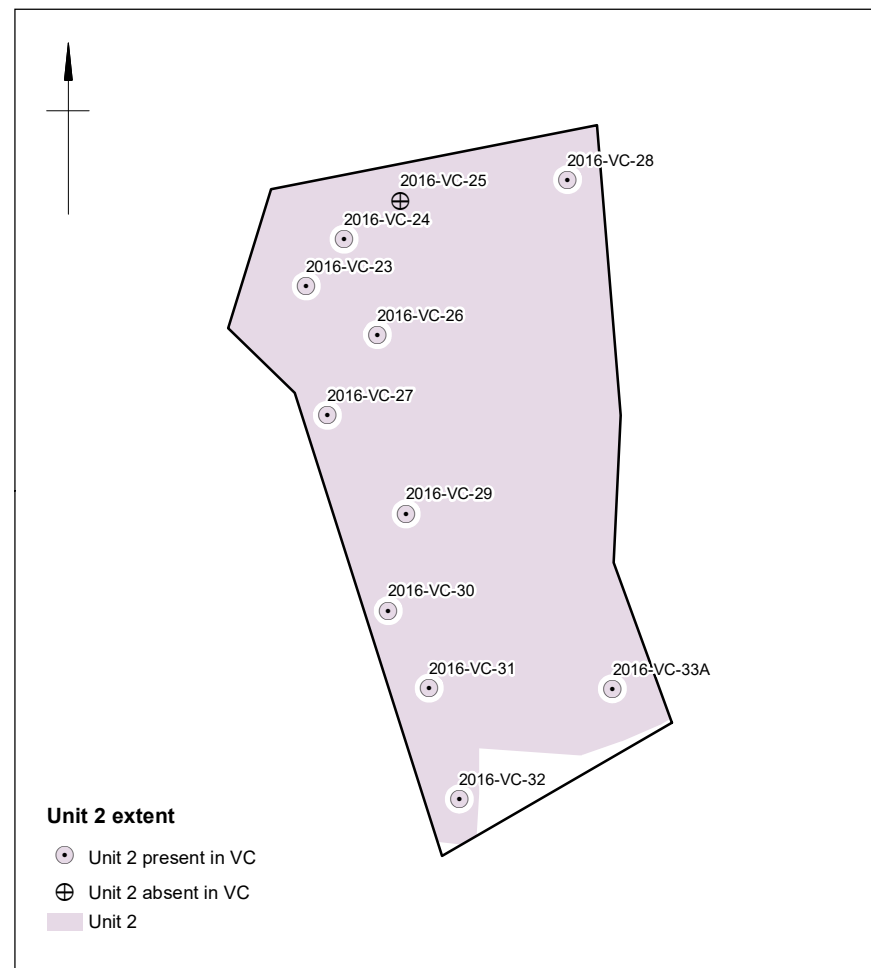
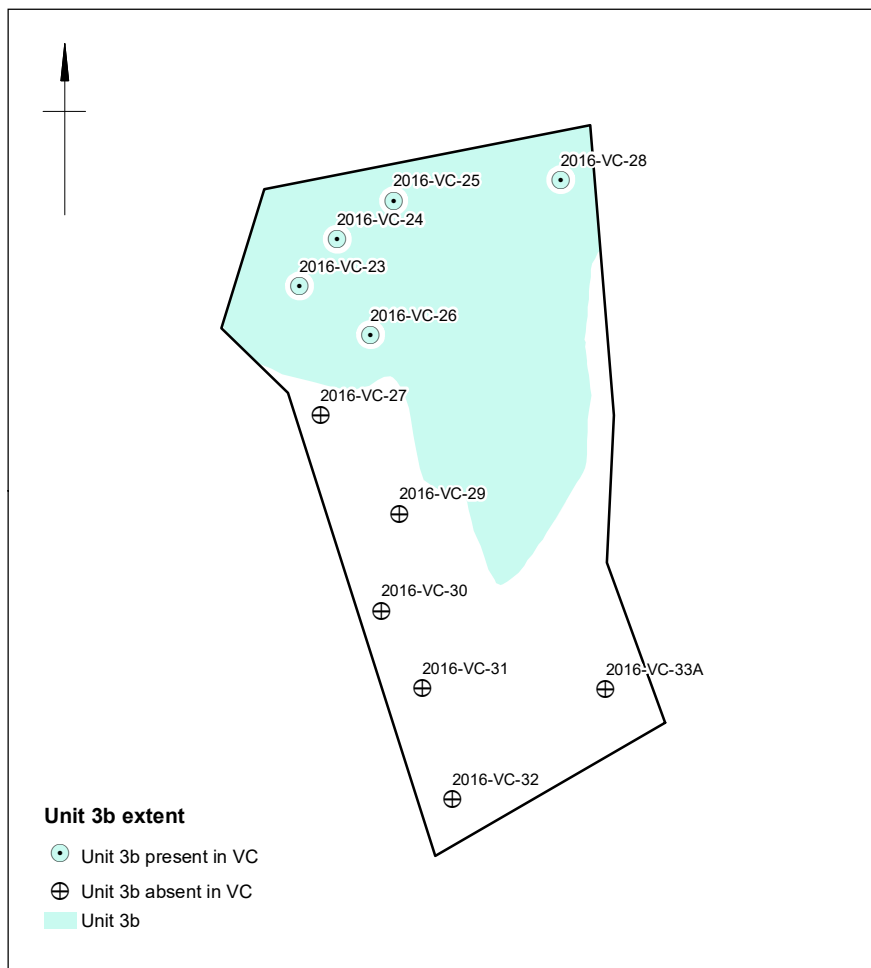


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Area 511: Review of deposit extent based on review of vibrocore data

Figure 4

Area 512



Drawing projection: UTM WGS84 z31N.

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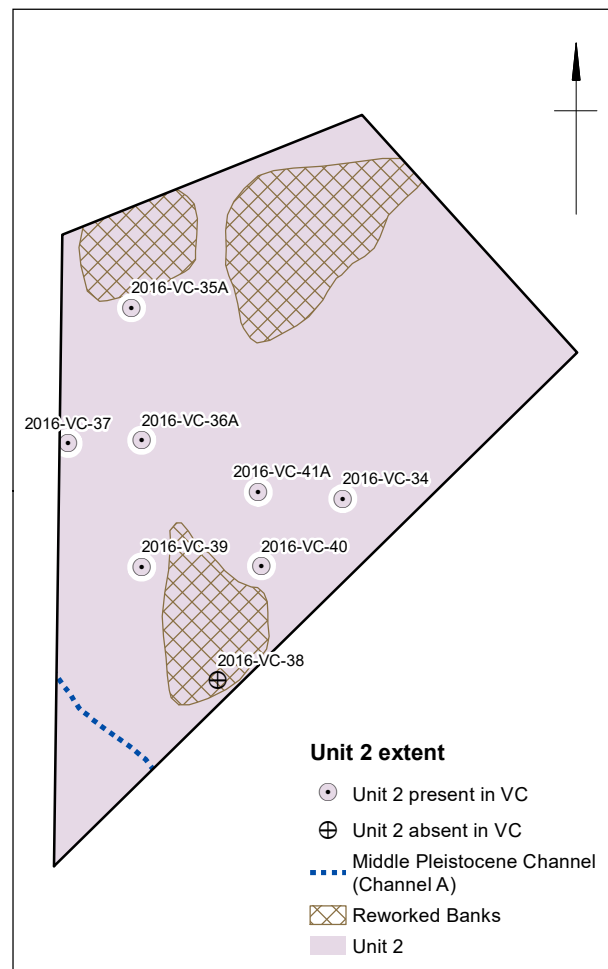
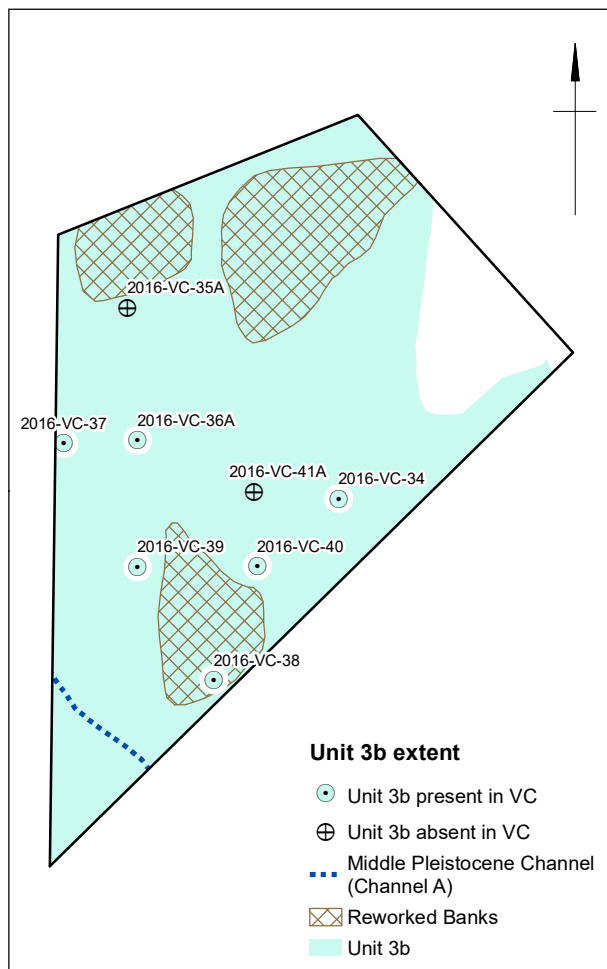
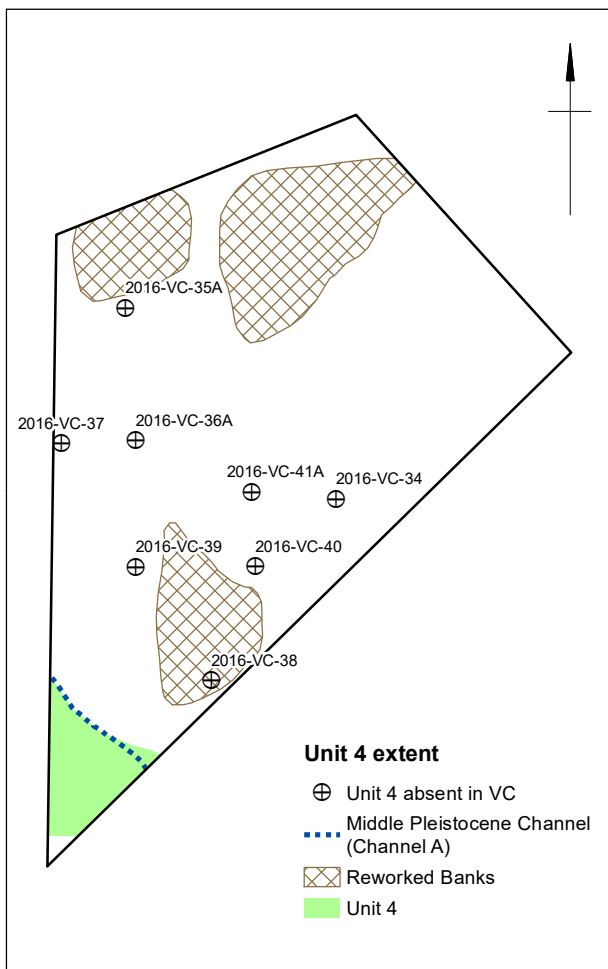


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Area 512: Review of deposit extent based on review of vibrocore data

Figure 5

Area 513/1



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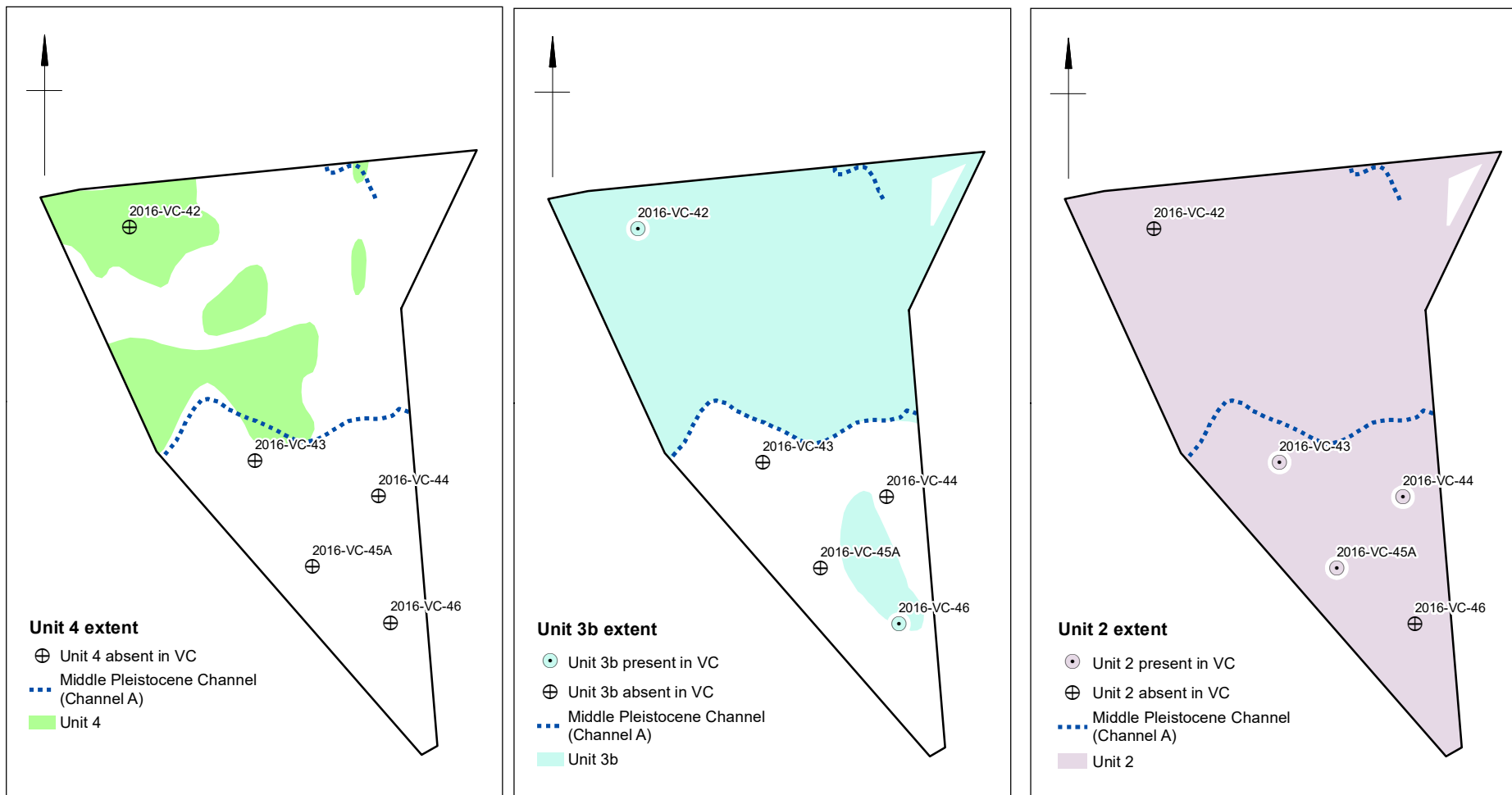


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Area 513/1: Review of deposit extent based on review of vibrocore data

Figure 6

Area 513/2



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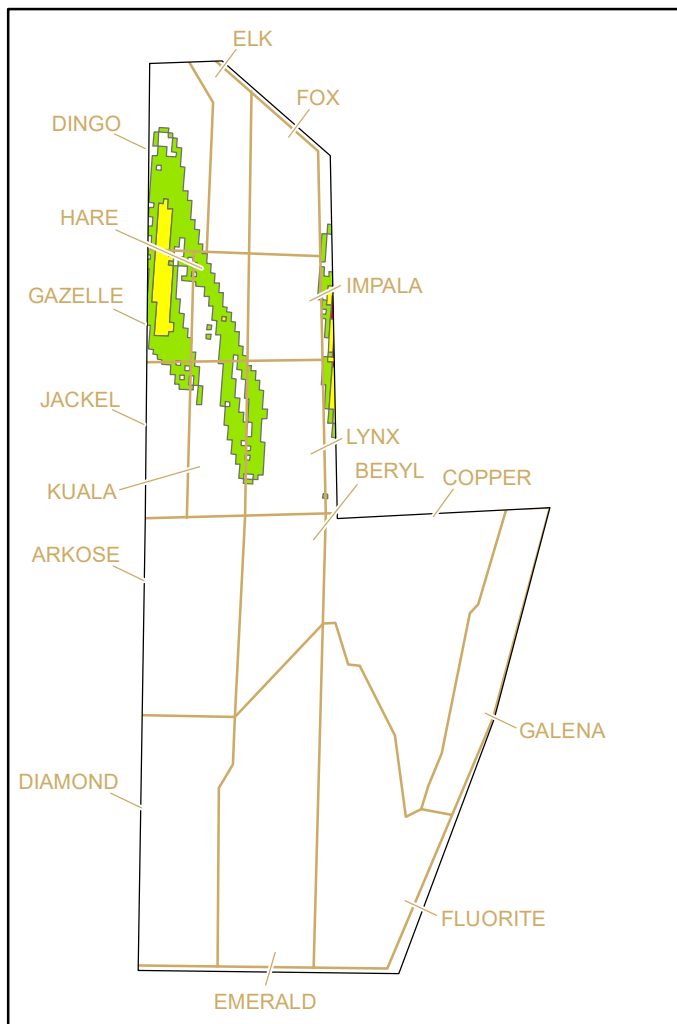


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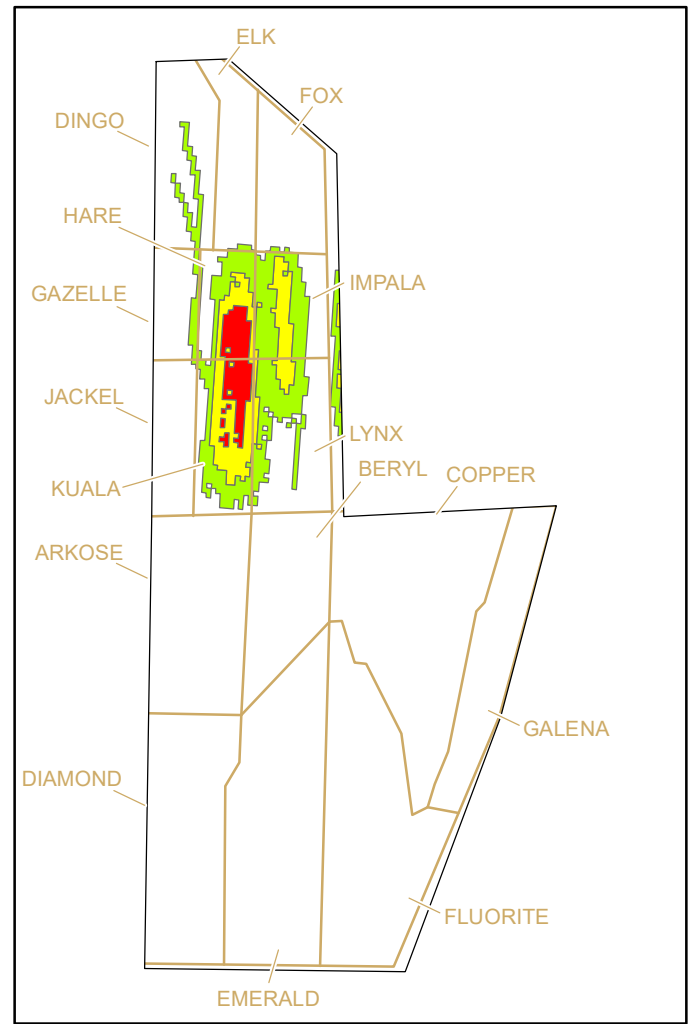
Area 513/2: Review of deposit extent based on review of vibrocore data

Figure 7

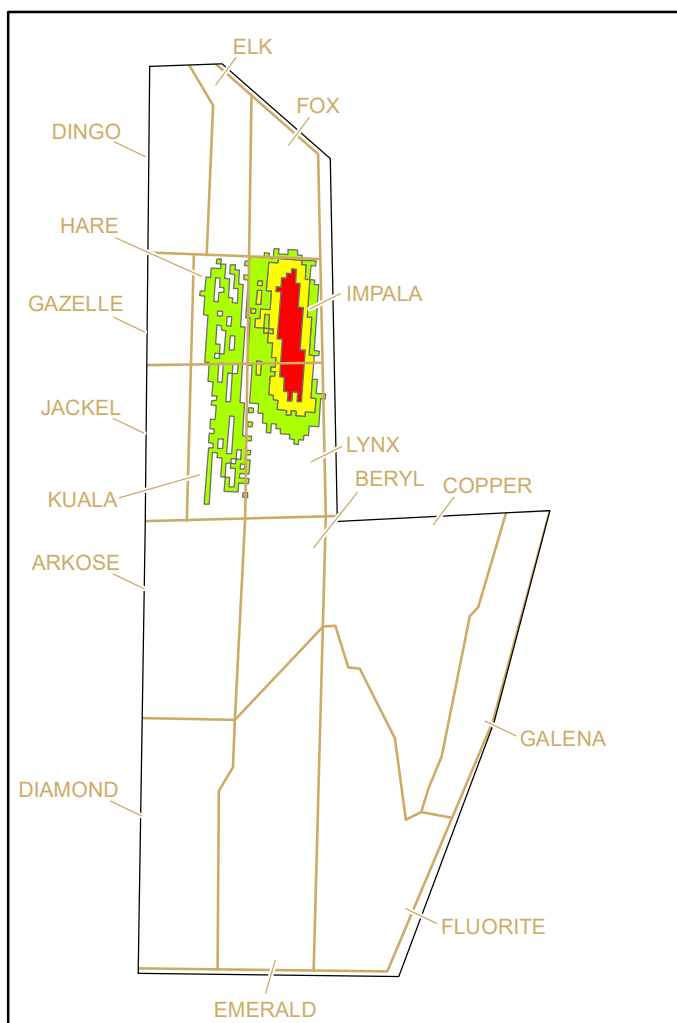
Area 511



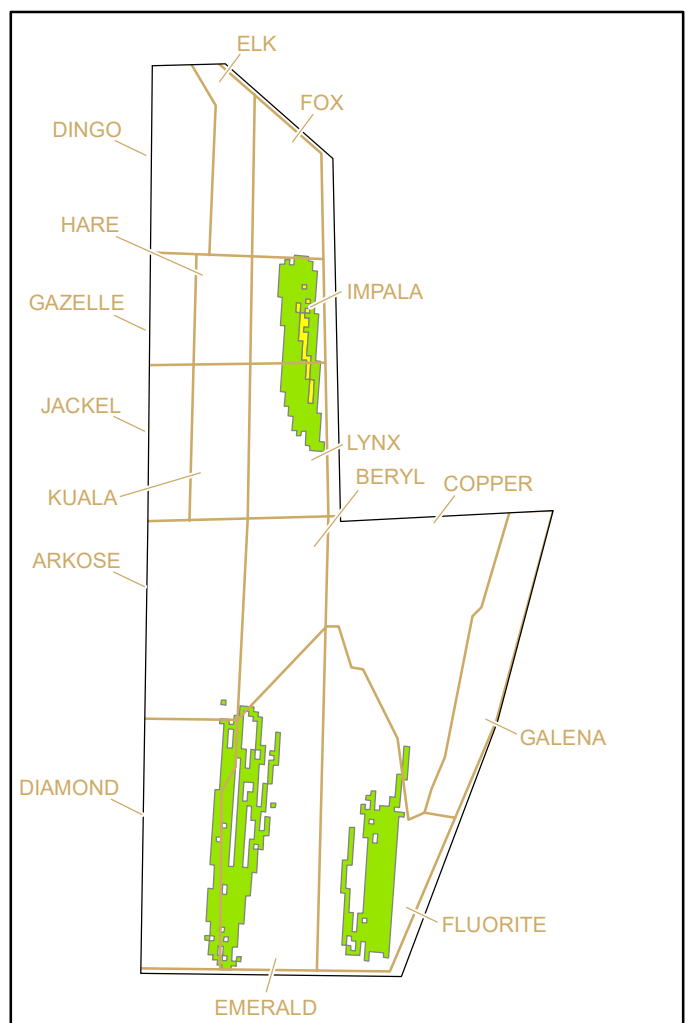
2016



2017



2018



2019

- Licence Area
- Dredging Sub Areas
- High intensity
- Medium intensity
- Low intensity

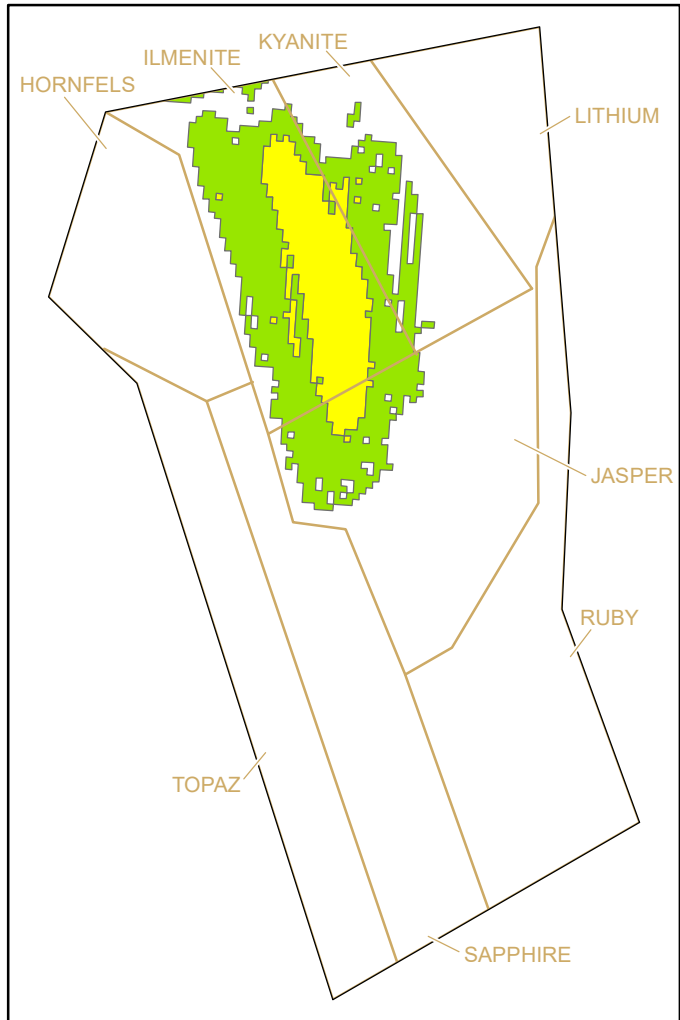


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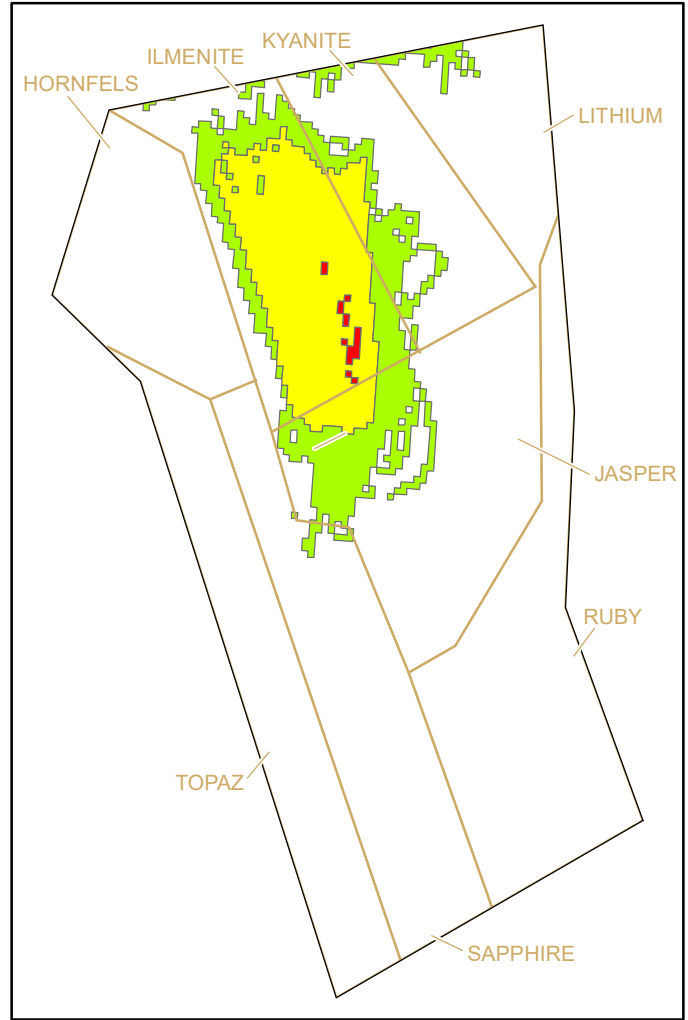
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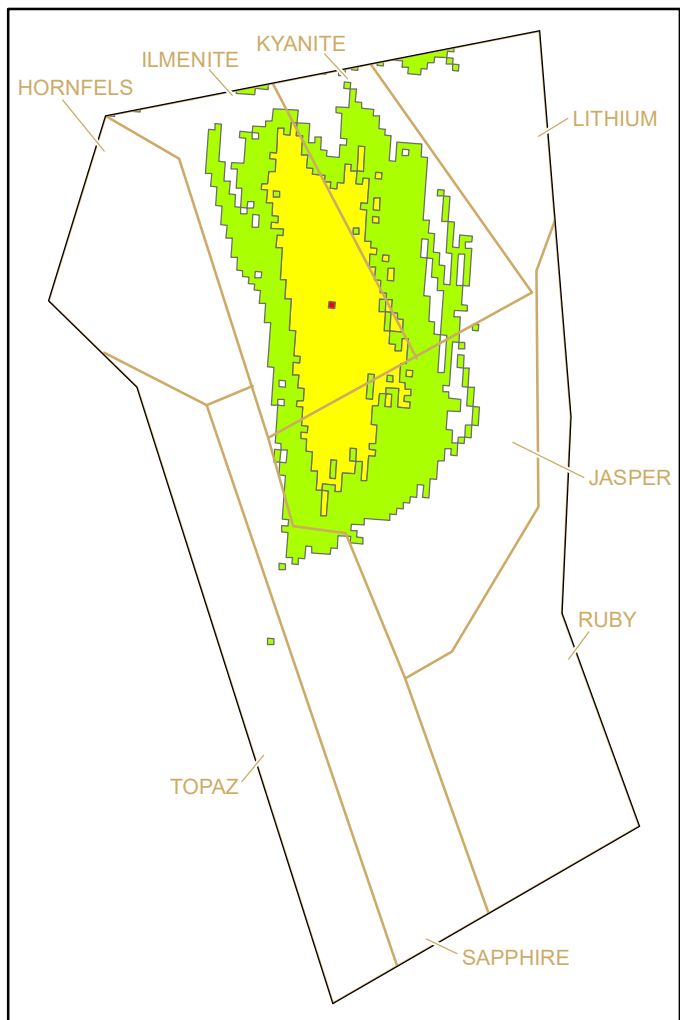
Area 512



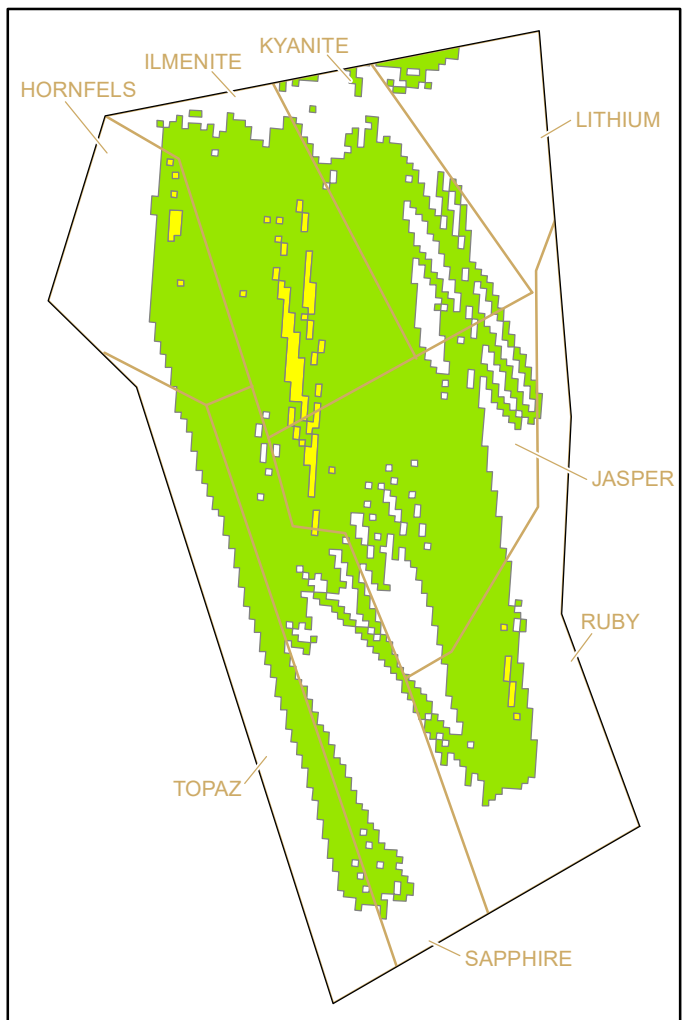
2016



2017



2018



2019

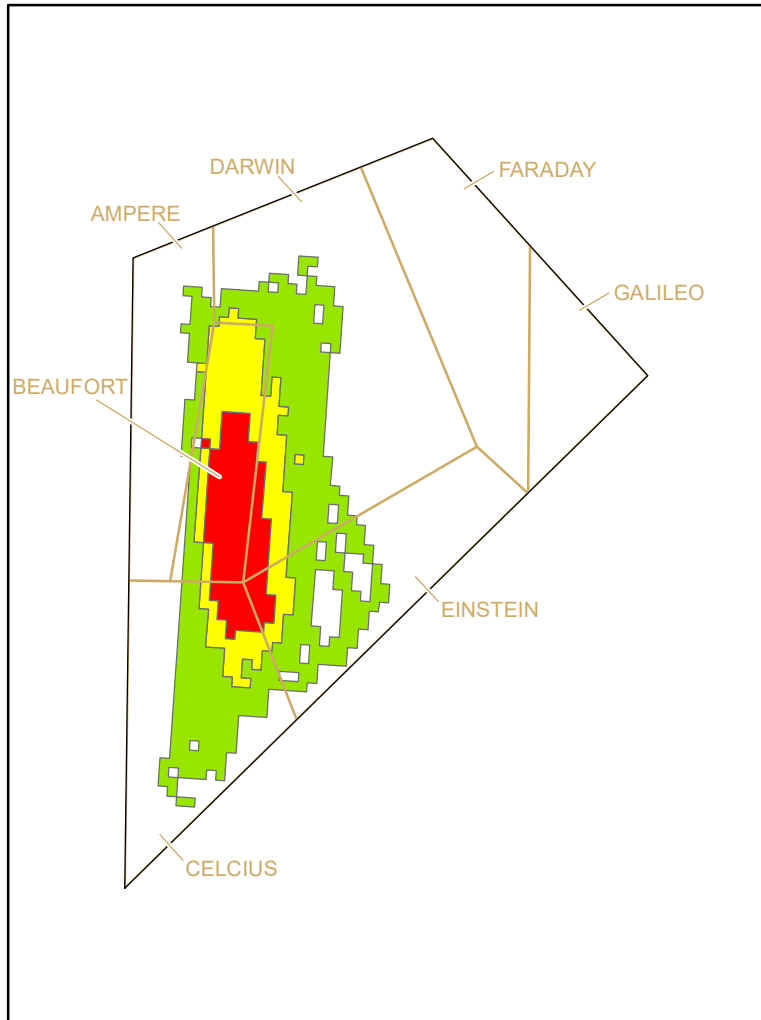
- Licence Area
- Dredging Sub Areas
- High intensity
- Medium intensity
- Low intensity



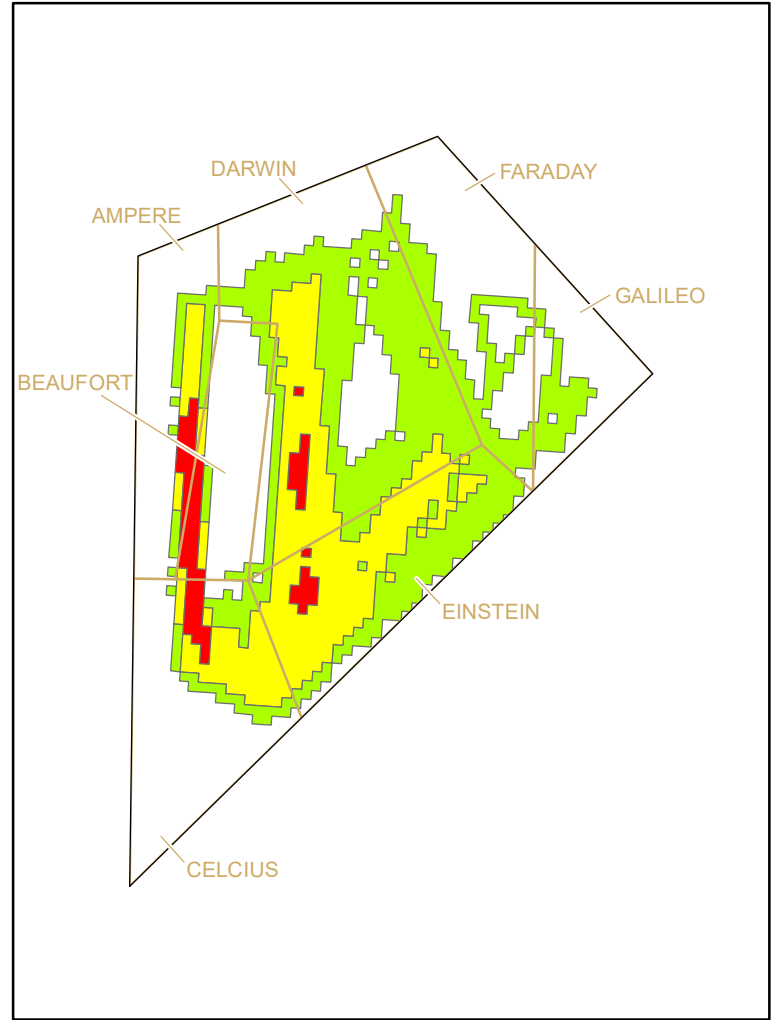
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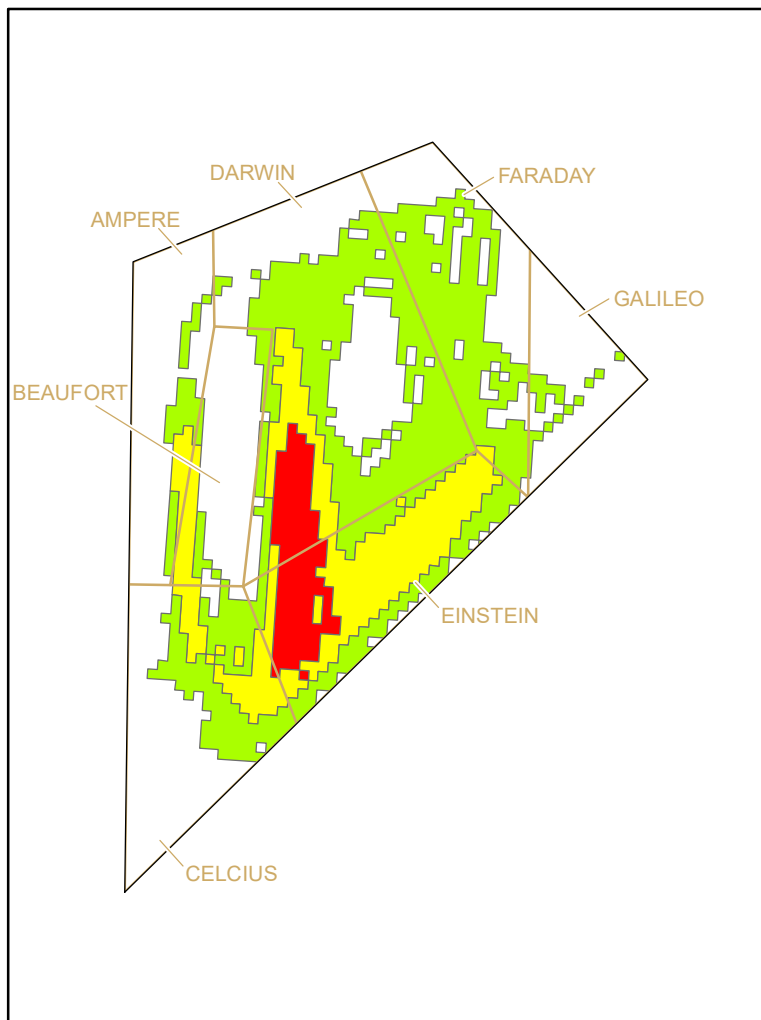
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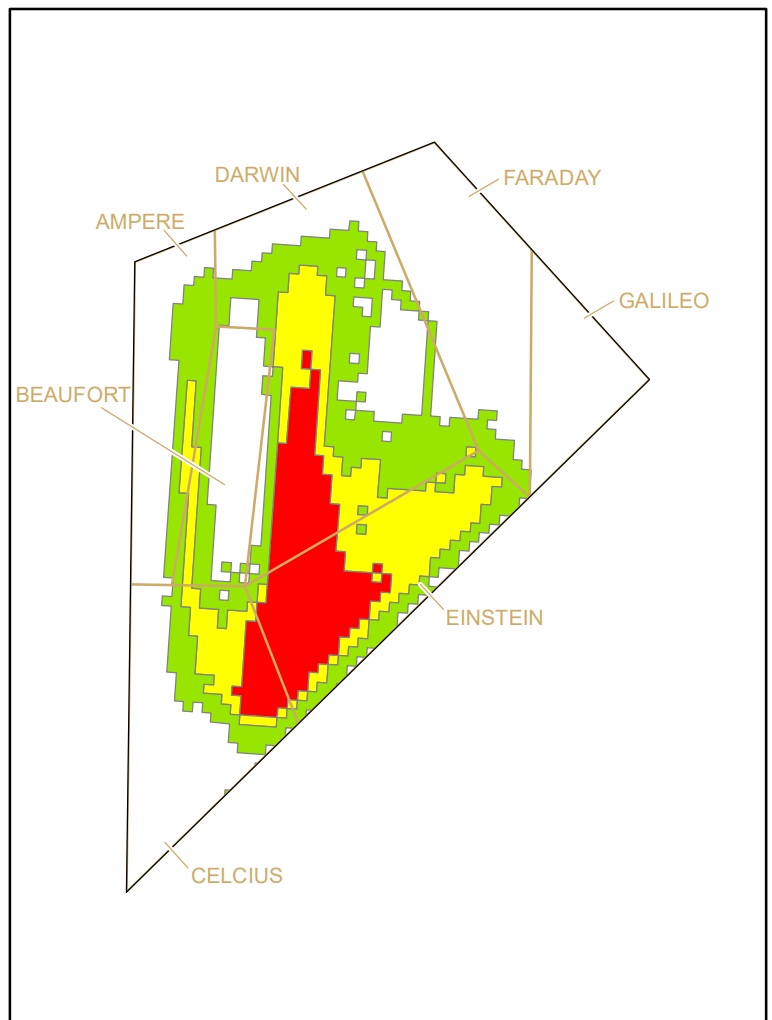
2016



2017



2018



2019

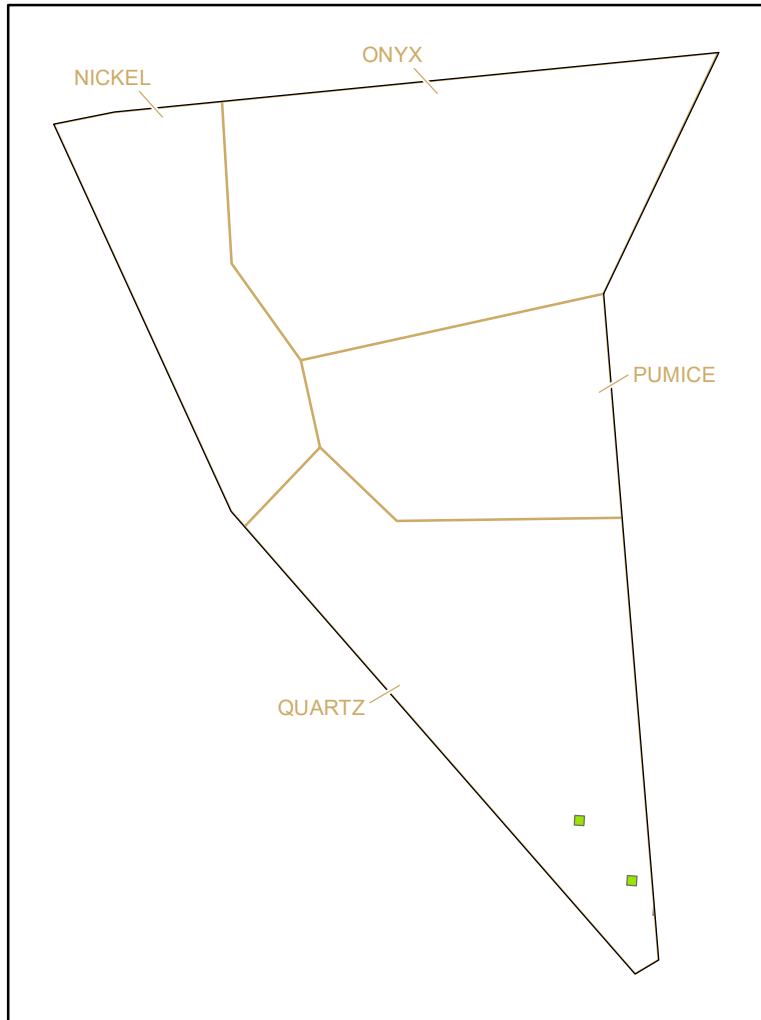
- Licence Area
- Dredging Sub Areas
- High intensity
- Medium intensity
- Low intensity



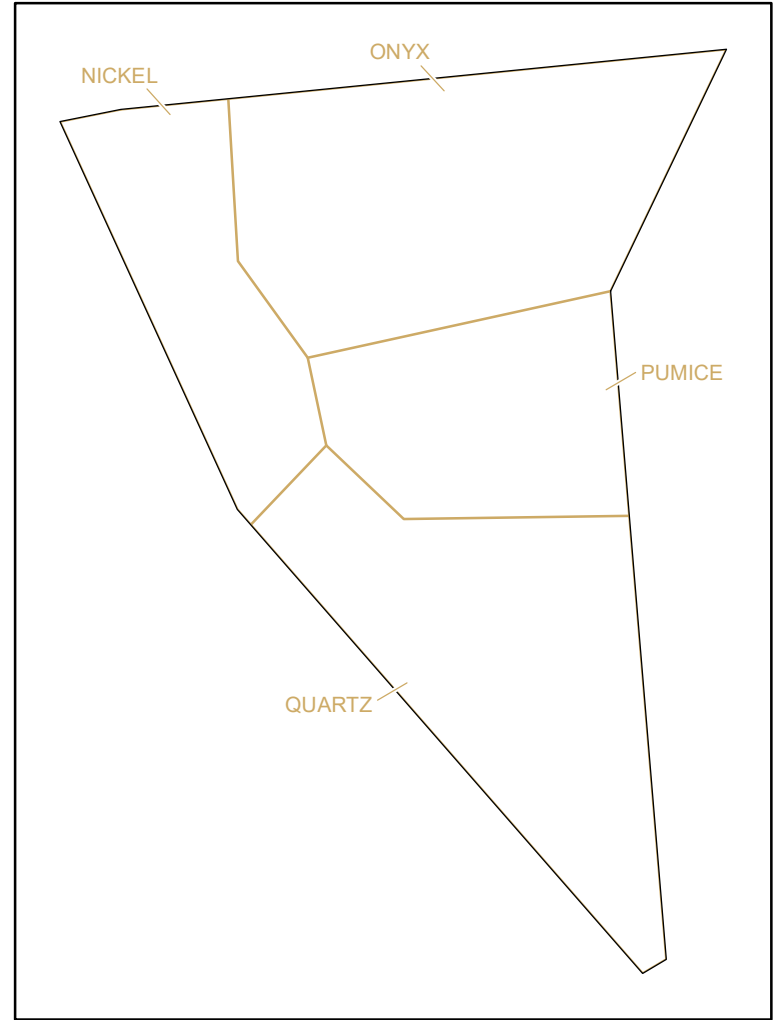
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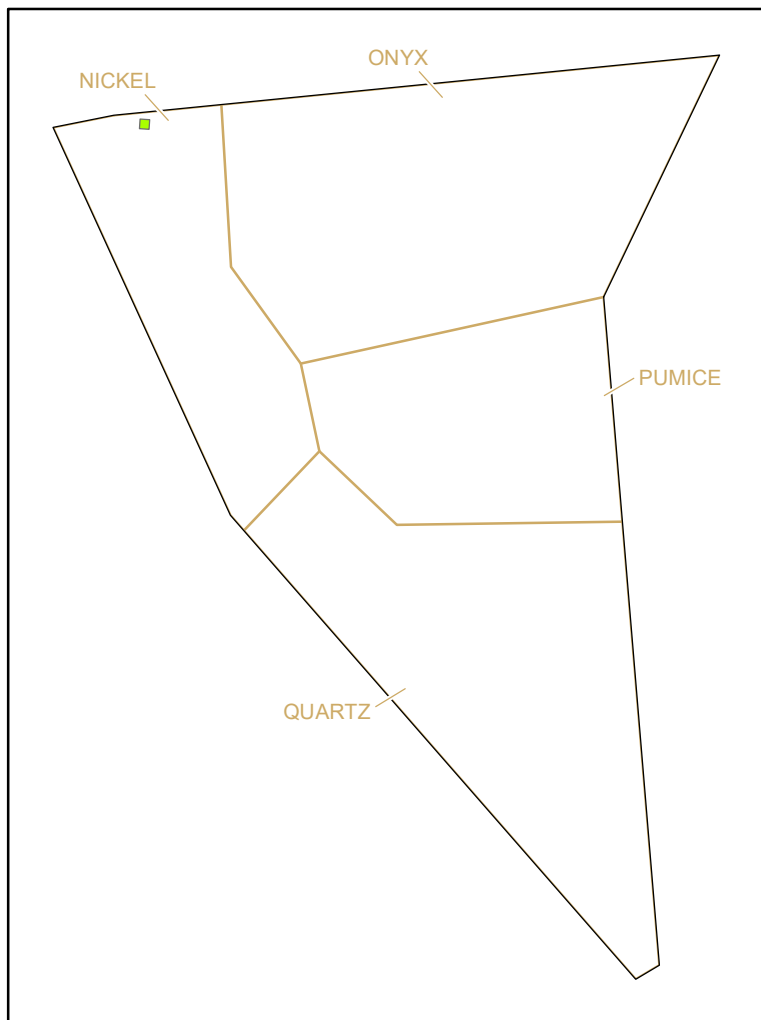
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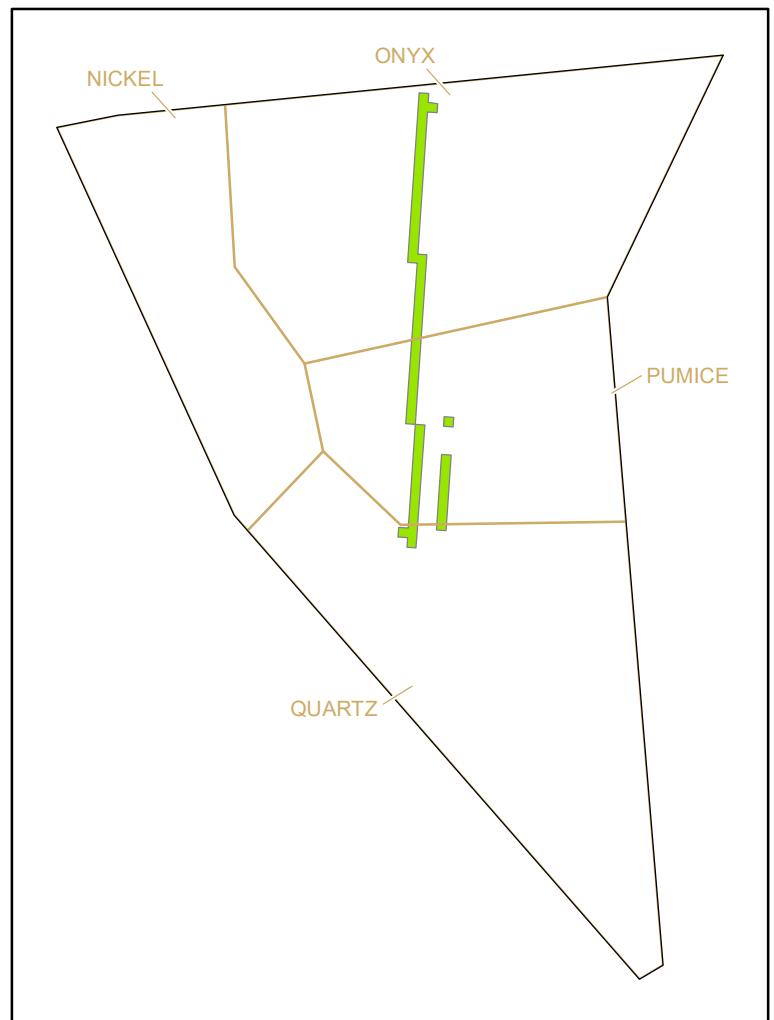
2016



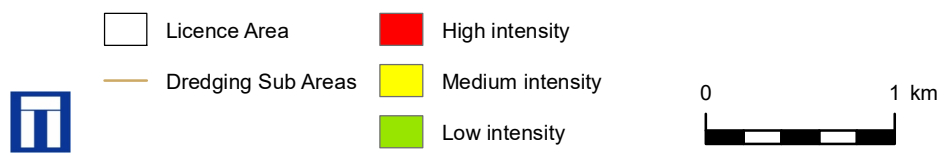
2017



2018



2019



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Area 511

Geology overview:

- Throughout the majority of Area 511, Unit 2 (Yarmouth Roads Formation) sediments are overlain by a complex unit of sands and gravels interpreted as the Wolstonian floodplain deposits (Unit 3b).
- Area 511 is dominated by the meandering north-south channel (Channel B) which developed during the early Holocene. The channel cuts into underlying Unit 3b sediments which would have been re-worked during the development of the channel.
- Within the channel there are two areas where Unit 2 sediments are interpreted and are not overlain by the floodplain deposits (Unit 3b). In these areas Unit 2 sediments appear to be overlain by up to 4 m of reworked modern sediments (probable Unit 8). However, it is possible that the reworked sediments comprise reworked Unit 3b floodplain sediments.
- There is a small localised area of fine-grained infill sediments observed within the channel, interpreted as Unit 7 deposited during the early Holocene.
- In the southeast of Area 511 Unit 2 is observed overlain by a veneer of reworked recent marine sediments (Unit 8).

Known Archaeology:

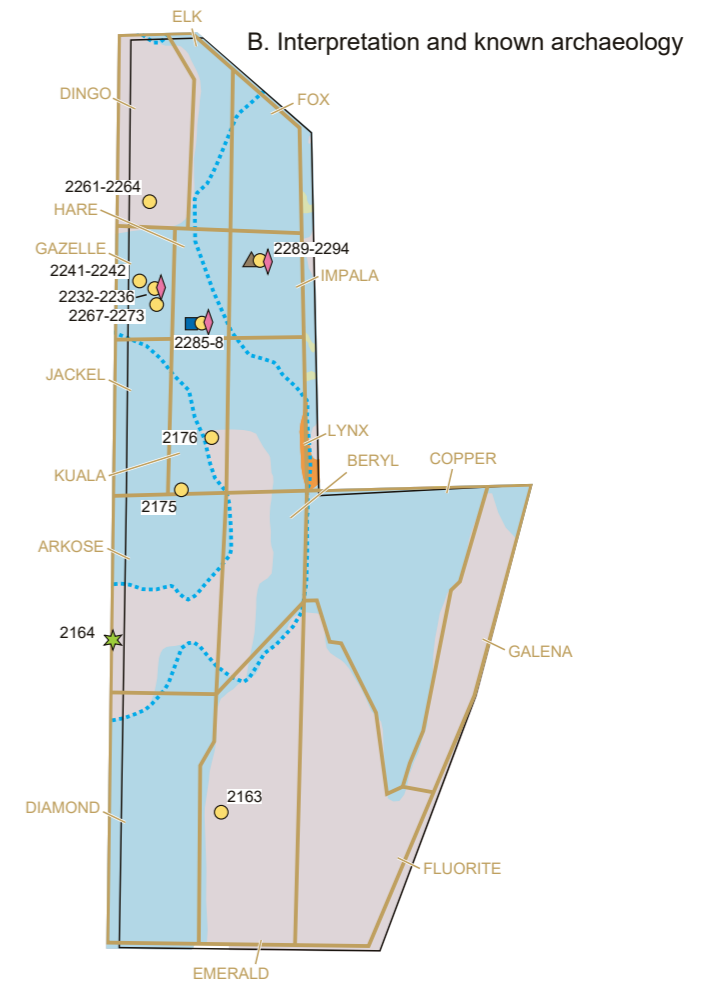
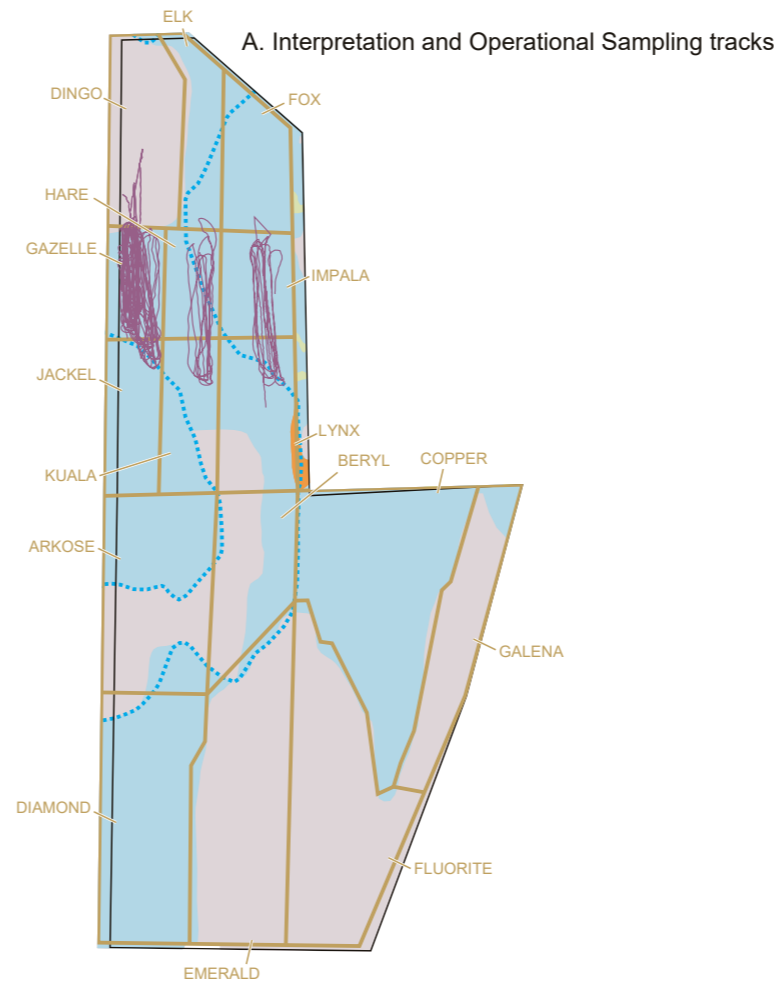
- Three reports of faunal remains (2176, 2175 and 2163), a wooden sleeper (CEMEX_0600), container twist lock (CEMEX_0866), aircraft fragment (CEMEX_0867), shaft housing (CEMEX_0871), aircraft components (CEMEX_0914), aircraft components, bollard, munition, shoes (CEMEX_0915), aircraft components (CEMEX_0918), collection of munitions (CEMEX_0920) have been reported through the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest.
- A further collection of bones and aircraft pieces (CEMEX_0948) were also reported however, whether these were recovered from Licence Area 511 or 512 is unknown.
- A sample of peat (2164) was also recorded through the protocol.
- Nine recoveries were made during operational sampling between 2013-2015;
 - Six faunal recoveries (2235, 2236, 2241, 2242, 2261 and 2262) were reported amounting to fifteen individual bones, including red deer humerus and antler, bones from mammoth and sheep and a mammoth tooth.
 - Three lithics were recovered including a Lower Palaeolithic flake (2232), a tertiary flake possibly Holocene age (2233), and a thermal flake in fresh condition and of Holocene age (2234).
- A possible flint blade core, two flint flakes and five potential flint flakes have been discovered during recent operational sampling (2017) as well as unidentified mineralised bone fragments, mammoth teeth fragments (2018).

Operational sampling undertaken to date:

- Six operational sampling events have been undertaken between February 2013 and 2019.

Sampling Operation Groups:

- Group 1:** Gazelle, Hare, Impala, Jackel, Diamond, Copper, Elk, Fox: All areas and possible dredge lanes target Unit 3b deposits
Group 2: Dingo, Emerald, Galena, Flourite: All areas and possible dredge lanes target Unit 2 deposits
Group 3: Kuala, Lynx, Arkose, Beryl: target either Unit 3b or Unit 2 depending on dredging lane



	Hypothesis	Target Group 1		Target Group 2		Target Group 3	
		Hypothesis tested	Threshold	Hypothesis tested	Threshold	Hypothesis tested	Threshold
Inhabitation	H1.1: Middle Palaeolithic material is recovered from units other than Unit 3b	Not testable	Maintain current rate of assessment (1 in 20 loads).	Testable	Within individual dredge lane if Unit 2 sediment is proved during sampling operation and no lithics recovered, no further operational assessment required.	Testable	Unit 3b target: use Group 1 threshold
	H1.2: Some of the Middle Palaeolithic material recovered from Unit 3b is <i>in situ</i>	Tested		Not testable		Testable	
	H1.3: Late Upper Palaeolithic material is recovered from other places in addition to the vicinity of Channel B	Not testable		Not testable		Not testable	
	H1.4: Some Late Upper Palaeolithic material from the vicinity of Channel B is <i>in situ</i>	Tested		Testable		Testable	
	H1.5: Some <i>in situ</i> Lower Palaeolithic material is recovered from units other than Unit 3b	Not testable		Testable		Testable	
	H1.6: Artefactual material appears to be <i>in situ</i> in areas other than Unit 3b and the vicinity of Channel B	Not testable		Not testable		Not testable	
	H1.7: Prehistoric material is recovered for periods later than the Later Upper Palaeolithic	Tested		Testable		Testable	
	H1.8: Faunal remains appear to be in primary contexts	Tested		Testable		Testable	
Choice and use of location	H2.1: Middle Palaeolithic material is recovered from the floodplain of Channel A, not from Channel A	Tested	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Testable	Unit 2 target: use Group 2 threshold	Testable	
	H2.2: Middle Palaeolithic material is recovered from outlying deposits of Unit 3b north and south of the floodplain	Not testable		Not testable		Not testable	
	H2.3: Middle Palaeolithic material is clustered in relatively large quantities at discrete locations	Tested		Testable		Testable	
	H2.4: Middle Palaeolithic material is present in small quantities throughout Unit 3b deposits	Tested		Not testable		Testable	
Natural Processes	H3.1: Middle Palaeolithic material is recovered in areas where Unit 3b has been reworked by natural processes	Tested		Not testable		Testable	
	H3.2: Middle Palaeolithic material is recovered where Unit 3b appears to be covered by major bank structures	Not testable		Not testable		Not testable	
Human Processes, including Dredging History	H4.1: Middle Palaeolithic material is recovered where dredging history indicates that a high level of dredging has taken place since the introduction of EMS	Not testable		Not testable		Not testable	
	H4.2: Middle Palaeolithic material is recovered where geophysical data indicates that a high level of dredging has taken place	Not testable		Not testable		Not testable	
Operational Sampling Methods	H5.1: Faunal and artefactual material is found at all wharves where Operational Sampling takes place	Tested		Testable		Testable	

Licence Area (2622 hectares)
 Dredging Sub Areas
 Operational Sampling tracks
 Extents of Early Holocene channel (Channel B)
 Units subcropping surficial sediment (Unit 8):
 Unit 7 Upper Palaeolithic
 Unit 3b Middle Palaeolithic (floodplain)
 Unit 2 Lower Palaeolithic
● Bone / faunal
★ Environmental sample / peat
▲ Wood
◆ Stone
■ Post-medieval / modern

0 5 km

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Area 512

Geology overview:

- The north of Area 512 is dominated by sand and gravel deposits interpreted as Wolstonian floodplain deposits (Unit 3b) and are primarily observed as a bank feature up to 5 m high and thinning to the south and northwest.
- In the south of the area fine-grained silts, sands and clays (in excess of 5 m thick) interpreted as Unit 2 Yarmouth Roads Formation are observed overlain by a veneer of sand and gravel interpreted as probable recent reworked marine sediments (Unit 8).
- Unit 3b is also present along the southern margin of Area 512, where it comprises silty gravelly sand, suggesting the Wolstonian floodplain is preserved in isolated patches in this region.

Known Archaeology:

- An alloy object with rivet holes and fabric (CEMEX_0609), aluminium fragment (CEMEX_0743), drogue parachute (CEMEX_0770), knife blade (CEMEX_0789), part of anchor (CEMEX_0904) and hook (CEMEX_0905) have been reported through the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest.
- A further collection of bones and aircraft pieces (CEMEX_0948) and (CEMEX_0951 & CEMEX_0952) were reported however, whether these were recovered from Licence 511 or 512 and 460 or 512 respectively is unknown.
- Operational Sampling was undertaken on the 13th and 14th March 2013 in sub-licence area Ilmenite (and partially in Kyanite). A single lithic was recovered and is a large scraper made on a secondary flake and is possible Lower Palaeolithic (2237).
- Further operational sampling was undertaken in December 2013 in sub-licence area Ilmenite with no recoveries.
- In April 2014 a pelvis fragment of a cow or deer (2253) was recovered from sub-licence area Ilmenite.
- In May 2015 a single piece of struck flint, a portion of a large blade was recovered (2266) from sub-licence area Ilmenite. The lithic was broken and somewhat worn, not *in situ*.
- Recent visits have produced possible auroch bone fragments (2016), unidentifiable bone fragments (2018), a section of sheep rib, two worked flint flakes and several possible worked flint flakes (2019).

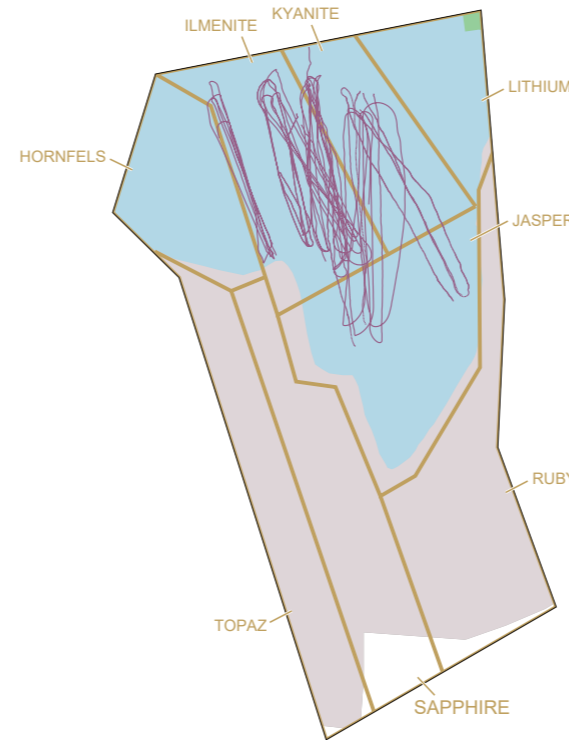
Operational sampling undertaken to date:

- Seven operational sampling events have been undertaken, targeting Unit 3b up until November 2019.

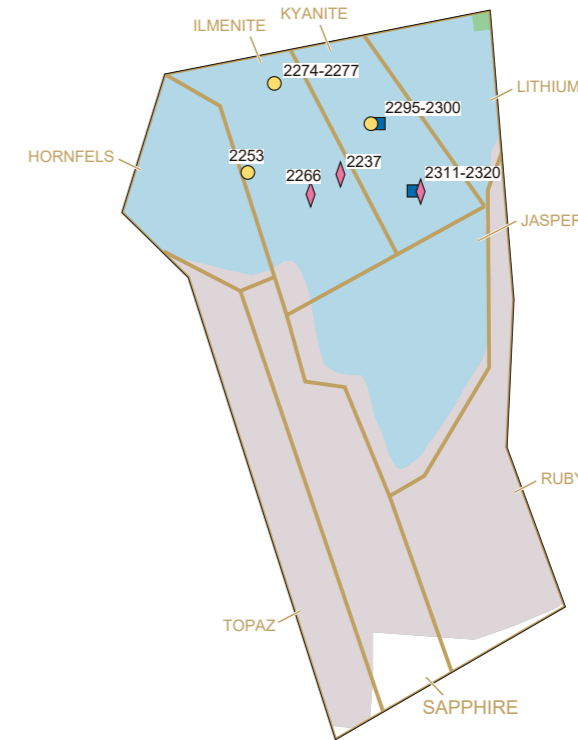
Sampling Operation Groups:

- Group 1:** Hornfels, Ilmenite, Kyanite, Lithium, Jasper: All areas and possible dredge lanes target Unit 3b deposits.
- Group 2:** Topaz, Sapphire, Ruby: All licensed areas and possible dredge lanes target Unit 2 deposits.

A. Interpretation and Operational Sampling tracks



B. Interpretation and known archaeology



	Hypothesis	Target Group 1		Target Group 2	
		Hypothesis tested	Threshold	Hypothesis tested	Threshold
Inhabitation	H1.1: Middle Palaeolithic material is recovered from units other than Unit 3b	Not testable	Maintain current rate of assessment (1 in 20 loads). On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Testable	Within individual dredge lane if Unit 2 sediment is proved during sampling operation and no lithics recovered, no further operational assessment required.
	H1.2: Some of the Middle Palaeolithic material recovered from Unit 3b is <i>in situ</i>	Tested		Not testable	
	H1.3: Late Upper Palaeolithic material is recovered from other places in addition to the vicinity of Channel B	Tested		Testable	
	H1.4: Some Late Upper Palaeolithic material from the vicinity of Channel B is <i>in situ</i>	Not testable		Not testable	
	H1.5: Some <i>in situ</i> Lower Palaeolithic material is recovered from units other than Unit 3b	Not testable		Testable	
	H1.6: Artefactual material appears to be <i>in situ</i> in areas other than Unit 3b and the vicinity of Channel B	Not testable		Not testable	
	H1.7: Prehistoric material is recovered for periods later than the Later Upper Palaeolithic	Tested		Testable	
	H1.8: Faunal remains appear to be in primary contexts	Tested		Testable	
Choice and use of location	H2.1: Middle Palaeolithic material is recovered from the floodplain of Channel A, not from Channel A	Tested		Not testable	
	H2.2: Middle Palaeolithic material is recovered from outlying deposits of Unit 3b north and south of the floodplain	Not testable		Not testable	
	H2.3: Middle Palaeolithic material is clustered in relatively large quantities at discrete locations	Tested		Testable	
	H2.4: Middle Palaeolithic material is present in small quantities throughout Unit 3b deposits	Tested		Testable	
Natural Processes	H3.1: Middle Palaeolithic material is recovered in areas where Unit 3b has been reworked by natural processes	Not testable		Not testable	
	H3.2: Middle Palaeolithic material is recovered where Unit 3b appears to be covered by major bank structures	Not testable		Not testable	
Human Processes, including Dredging History	H4.1: Middle Palaeolithic material is recovered where dredging history indicates that a high level of dredging has taken place since the introduction of EMS	Not testable		Not testable	
	H4.2: Middle Palaeolithic material is recovered where geophysical data indicates that a high level of dredging has taken place	Not testable		Not testable	
Operational Sampling Methods	H5.1: Faunal and artefactual material is found at all wharves where Operational Sampling takes place	Tested		Testable	

Licence Area (2176 hectares)
 Units subcropping surficial sediment (Unit 8):
Known archaeology:

Dredging Sub Areas
 Unit 4 Middle Palaeolithic
 Unit 3b Middle Palaeolithic (floodplain)
 Unit 2 Lower Palaeolithic

Operational Sampling tracks
 ● Bone / faunal
◆ Stone
■ Post-medieval / modern

0 5 km

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Area 513/1

Geology overview:

- The area is dominated by floodplain deposits (Unit 3b) overlying Unit 2 Yarmouth Roads Formation (fine-grained silts and sands).
- In the southwest of Area 513/1 the northern edge of the Middle Pleistocene channel (Channel A) is observed. The channel comprises sands and gravels of probable Wolstonian age and a secondary cut feature is observed infilled with fine-grained sediment unit (Unit 4).
- Three bank features are observed in the area. The banks are interpreted as reworked structures comprising reworked Unit 2, 3b and 4 sediments and are likely to have been formed subsequent to the deposition of Unit 4, most likely during the last marine transgression.
- In the east of Area 513/1 sediments comprise a veneer (generally <1 m) of reworked marine sediments overlying fine-grained silty sand (Unit 2; Yarmouth Roads Formation).
- Locally, Unit 3b may be absent in areas that have influenced by dredging activity

Known Archaeology:

- Six finds of archaeological interest have been reported through the Marine Aggregate Industry *Protocol for Reporting Finds of Archaeological Interest* and comprised a collection of worked flint, bone fragments and environmental remains (2177 - 2181), and various mammal bone fragments (2182 - 2187, 2166 and 2265).
- Operational Sampling was undertaken on the 23rd and 24th April 2013 and numerous faunal remains were recovered (2240). The bones were highly abraded and mineralised and are thought to be of considerable age.
- Operational Sampling undertaken in October 2014 recovered three fragments of bone, two unidentifiable mammal bone fragments and a mammal vertebra (2254 - 2256). Also, a Bi-polar core fragment was recovered (2257).
- In July 2017, a mineralised antler fragment was discovered along with 12 fragments of unidentified mineralised bones, and several fragments of wood not thought to be archaeologically significant.

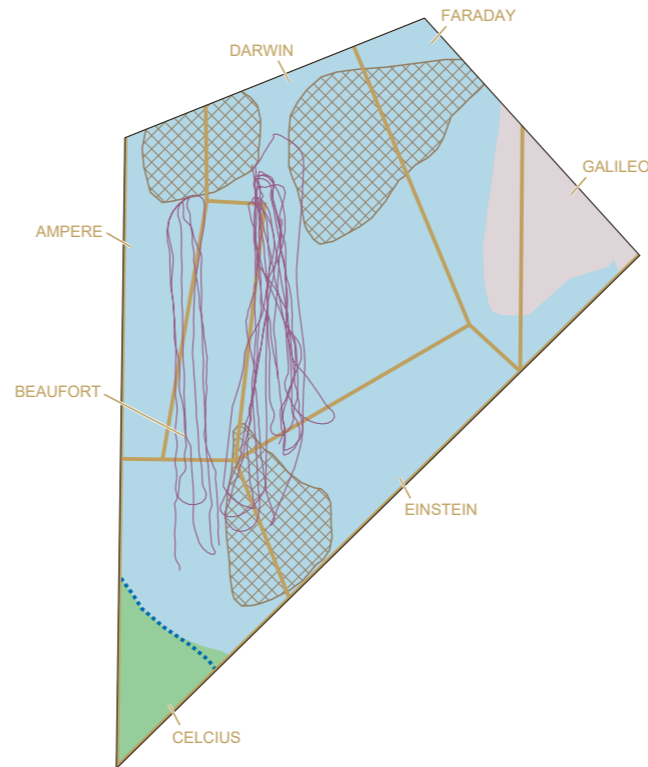
Operational sampling undertaken to date:

- Two operational sampling events have been undertaken in Area 513/1 targeting Unit 3b.

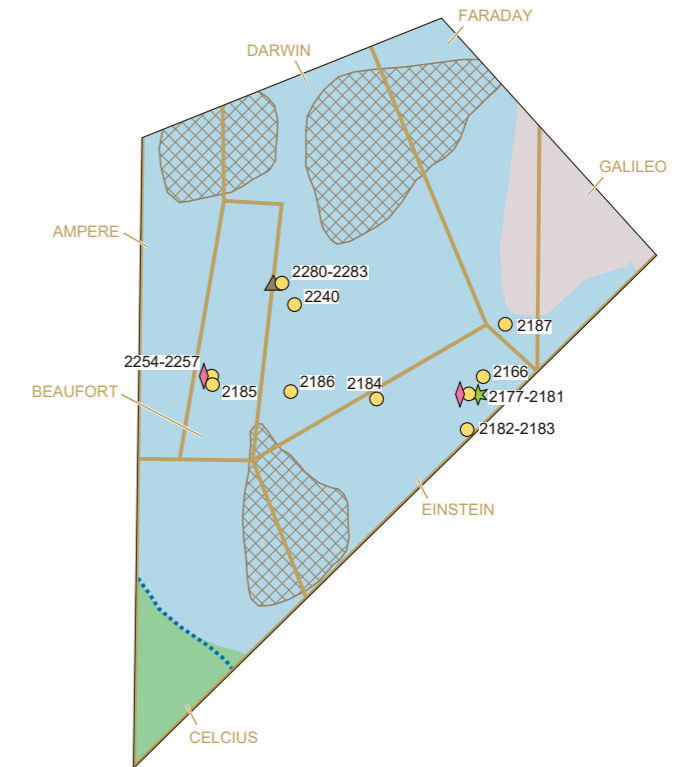
Sampling Operation Groups:

- Group 1:** Celcius, Einstein, Beaufort, Darwin, Faraday, Ampere: Licence sub-areas target Unit 3b deposits.
Group 2: Celcius, Einstein, Beaufort, Darwin, Faraday, Ampere: Licence sub-areas target reworked banks overlying Unit 3b deposits.
Group 3: Faraday, Galileo: Licence sub-areas target Unit 2 deposits.
Group 4: Celcius: Licence sub-areas target Unit 4 deposits within Channel A.

A. Interpretation and Operational Sampling tracks



B. Interpretation and known archaeology



Hypothesis	Target Group 1		Target Group 2		Target Group 3		Target Group 4	
	Hypothesis tested	Threshold	Hypothesis tested	Threshold	Hypothesis tested	Threshold	Hypothesis tested	Threshold
Inhabitation	H1.1: Middle Palaeolithic material is recovered from units other than Unit 3b	Not testable	Testable	Maintain current rate of assessment (1 in 20 loads).	Testable	Within individual dredge lane if Unit 2 sediment is proved during sampling operation and no lithics recovered, no further operational assessment required.	Testable	Maintain current rate of assessment (1 in 20 loads).
	H1.2: Some of the Middle Palaeolithic material recovered from Unit 3b is <i>in situ</i>	Tested	Not testable		Not testable			
	H1.3: Late Upper Palaeolithic material is recovered from other places in addition to the vicinity of Channel B	Tested	Testable		Testable			
	H1.4: Some Late Upper Palaeolithic material from the vicinity of Channel B is <i>in situ</i>	Not testable	Not testable		Not testable			
	H1.5: Some <i>in situ</i> Lower Palaeolithic material is recovered from units other than Unit 3b	Not testable	Testable		Testable			
	H1.6: Artefactual material appears to be <i>in situ</i> in areas other than Unit 3b and the vicinity of Channel B	Not testable	Testable		Testable			
	H1.7: Prehistoric material is recovered for periods later than the Later Upper Palaeolithic	Tested	Testable		Testable			
	H1.8: Faunal remains appear to be in primary contexts	Tested	Testable		Testable			
Choice and use of location	H2.1: Middle Palaeolithic material is recovered from the floodplain of Channel A, not from Channel A	Tested	Testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.
	H2.2: Middle Palaeolithic material is recovered from outlying deposits of Unit 3b north and south of the floodplain	Not testable	Not testable		Not testable			
	H2.3: Middle Palaeolithic material is clustered in relatively large quantities at discrete locations	Tested	Testable		Testable			
	H2.4: Middle Palaeolithic material is present in small quantities throughout Unit 3b deposits	Tested	Not testable		Not testable			
Natural Processes	H3.1: Middle Palaeolithic material is recovered in areas where Unit 3b has been reworked by natural processes	Not testable	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.
	H3.2: Middle Palaeolithic material is recovered where Unit 3b appears to be covered by major bank structures	Not testable	Testable		Not testable			
Human Processes, including Dredging History	H4.1: Middle Palaeolithic material is recovered where dredging history indicates that a high level of dredging has taken place since the introduction of EMS	Tested	Testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.
	H4.2: Middle Palaeolithic material is recovered where geophysical data indicates that a high level of dredging has taken place	Not testable	Not testable		Not testable			
Operational Sampling Methods	H5.1: Faunal and artefactual material is found at all wharves where Operational Sampling takes place	Tested	Testable		Testable		Testable	

Licence Area (591 hectares)
 Dredging Sub Areas
 Operational Sampling tracks
 Reworked bank
 Extents of Late Anglian channel (Channel A)
 Units subcropping surficial sediment (Unit 8):
 Unit 4 Middle Palaeolithic
 Unit 3b Middle Palaeolithic (floodplain)
 Unit 2 Lower Palaeolithic
 Known archaeology:
 Bone / faunal
 Environmental
 Wood
 Stone

0 1 2 km

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Area 513/2

Geology overview:

- The northern section of Area 513/2 is dominated by Channel A and associated floodplain deposits. Unit 3b sediments generally comprise sand with some gravel up to 6 m thick in places.
- Unit 3b is overlain by Unit 4 sediments observed as cut and bank features.
- In the south fine-grained sands with localised coarse-grained sediments are observed and are generally interpreted as Unit 2 overlain by a marine gravel lag deposit (Unit 8). An outlier of Unit 3b is observed in the south up to 4 m thick.

Known Archaeology:

- A single fragment of bone (2165) and shell case (CEMEX_0855) has been reported through the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest. A further bullet (CEMEX_0854) was also reported however, whether this was recovered from Licence Area 513/2 or 458 is unknown.

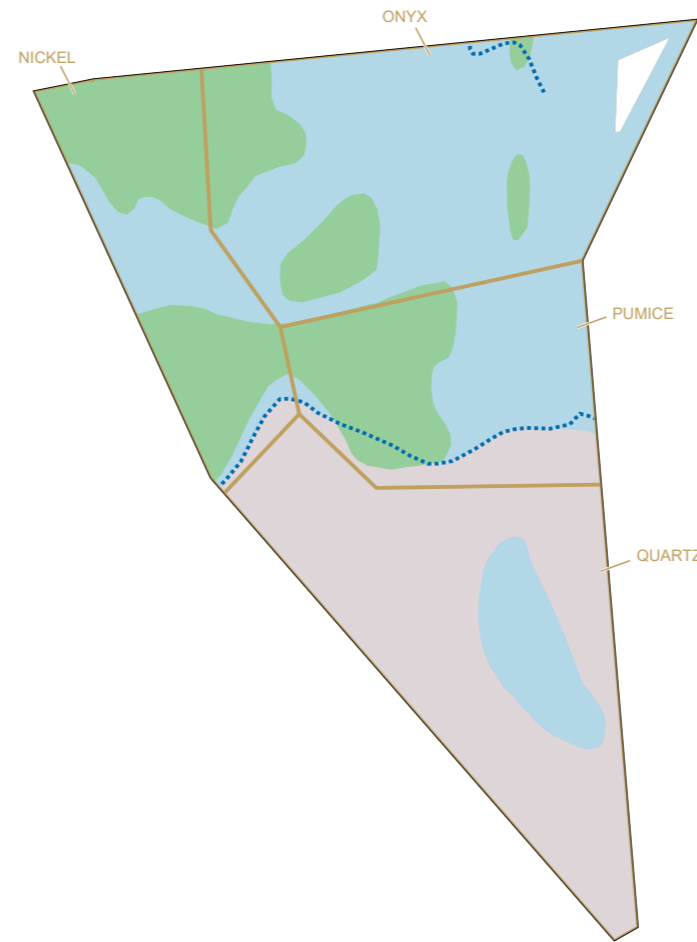
Operational sampling undertaken to date:

- No operational sampling has been undertaken in Area 513/2.

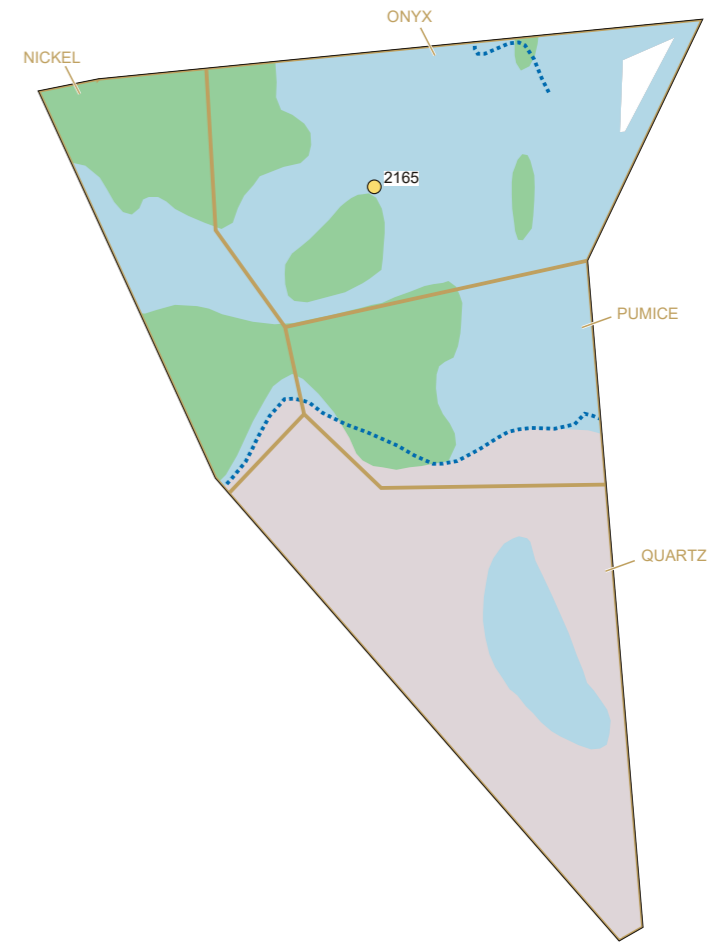
Sampling Operation Groups:

- Group 1:** Onyx, Pumice, Nickel: Licence sub-areas target Unit 3b deposits within Channel A.
Group 2: Onyx, Pumice, Nickel: Licence sub-areas target deposits within Channel A.
Group 3: Quartz: Licence sub-area targets Unit 2 or Unit 3b not from Channel A.

A. Interpretation and Operational Sampling tracks



B. Interpretation and known archaeology



	Hypothesis	Target Group 1		Target Group 2		Target Group 3	
		Hypothesis tested	Threshold	Hypothesis tested	Threshold	Hypothesis tested	Threshold
Inhabitation	H1.1: Middle Palaeolithic material is recovered from units other than Unit 3b	Not testable	Maintain current rate of assessment (1 in 20 loads). On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Testable	Maintain current rate of assessment (1 in 20 loads). On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Testable	If Unit 3b use Group 1 threshold. Within individual dredge lane if Unit 2 sediment is proved during sampling operation and no lithics recovered, no further operational assessment required.
	H1.2: Some of the Middle Palaeolithic material recovered from Unit 3b is <i>in situ</i>	Testable		Not testable		Testable	
	H1.3: Late Upper Palaeolithic material is recovered from other places in addition to the vicinity of Channel B	Testable		Testable		Testable	
	H1.4: Some Late Upper Palaeolithic material from the vicinity of Channel B is <i>in situ</i>	Not testable		Not testable		Not testable	
	H1.5: Some <i>in situ</i> Lower Palaeolithic material is recovered from units other than Unit 3b	Not testable		Testable		Testable	
	H1.6: Artefactual material appears to be <i>in situ</i> in areas other than Unit 3b and the vicinity of Channel B	Not testable		Testable		Testable	
	H1.7: Prehistoric material is recovered for periods later than the Later Upper Palaeolithic	Testable		Testable		Testable	
	H1.8: Faunal remains appear to be in primary contexts	Testable		Testable		Testable	
Choice and use of location	H2.1: Middle Palaeolithic material is recovered from the floodplain of Channel A, not from Channel A	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Testable	Within individual dredge lane if Unit 2 sediment is proved during sampling operation and no lithics recovered, no further operational assessment required.
	H2.2: Middle Palaeolithic material is recovered from outlying deposits of Unit 3b north and south of the floodplain	Not testable		Not testable		Not testable	
	H2.3: Middle Palaeolithic material is clustered in relatively large quantities at discrete locations	Testable		Testable		Testable	
	H2.4: Middle Palaeolithic material is present in small quantities throughout Unit 3b deposits	Testable		Not testable		Testable	
Natural Processes	H3.1: Middle Palaeolithic material is recovered in areas where Unit 3b has been reworked by natural processes	Testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Testable	Within individual dredge lane if Unit 2 sediment is proved during sampling operation and no lithics recovered, no further operational assessment required.
	H3.2: Middle Palaeolithic material is recovered where Unit 3b appears to be covered by major bank structures	Not testable		Not testable		Not testable	
Human Processes, including Dredging History	H4.1: Middle Palaeolithic material is recovered where dredging history indicates that a high level of dredging has taken place since the introduction of EMS	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	On four consecutive sample operations within a single dredge lane with no recovered finds reduce rate to 1 in 40.	Not testable	Within individual dredge lane if Unit 2 sediment is proved during sampling operation and no lithics recovered, no further operational assessment required.
	H4.2: Middle Palaeolithic material is recovered where geophysical data indicates that a high level of dredging has taken place	Not testable		Not testable		Not testable	
Operational Sampling Methods	H5.1: Faunal and artefactual material is found at all wharves where Operational Sampling takes place	Testable		Testable		Testable	

Licence Area (861 hectares)
 Dredging Sub Areas
 Extents of Late Anglian channel (Channel A)
 Unit 4 Middle Palaeolithic
 Unit 3b Middle Palaeolithic (floodplain)
 Unit 2 Lower Palaeolithic
 Known archaeology:
 Bone / faunal

0 1 2 km

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