Wessex Archaeology

TEDA MARINE AGGREGATE REGIONAL ENVIRONMENTAL ASSESSMENT

TECHNICAL REPORT: ARCHAEOLOGY

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Summary

Wessex Archaeology was commissioned by ERM on behalf of the Thames Estuary Dredging Association (TEDA) to undertake the archaeological assessment for a Regional Environmental Assessment (REA) of an area off the east coast of England between Kent and Suffolk.

This assessment provides an analysis of the known and potential archaeological resource within a Study Area. Information was sought from the National Monuments Records and SeaZone data. Geotechnical and geophysical data were also reviewed and integrated with the archaeological baseline. The known and potential archaeological resource reviewed is sub-divided into three sections, as follows:

- Prehistoric archaeology;
- Maritime archaeology;
- Aviation archaeology.

The Impact Assessment for this report identifies the source and nature of each effect of dredging and the degree to which the archaeological resource is exposed to and affected by dredging practices within the potential areas of impact and the MAREA Study Area as a whole.

The main impact imposed by dredging upon the archaeological resource is the use of a powerful pump to extract the marine aggregate from the seabed. The results of this impact have been identified to comprise two principle effects; substrate removal and sediment plume.

The archaeological resource is regarded as comprising three principle themes (prehistoric, maritime and aviation archaeology) within which a number of receptors were identified, as follows:

Prehistoric Archaeology

- Pleistocene fluvial gravels;
- Estuarine alluvium and peat;
- Isolated prehistoric finds.

Maritime Archaeology

- Known charted wreck sites;
- Shipping casualties;
- Unknown uncharted wreck sites;
- Isolated maritime finds.

Aviation Archaeology

- Known charted aircraft crash sites;
- Recorded aircraft losses;
- Isolated aircraft finds.

The effects of substrate removal upon each archaeological receptor are likely to be adverse, and result in permanent and non-reversible changes to the existing archaeological baseline. To minimise this impact, it is suggested that sites listed within the known archaeological resource be protected by the implementation of an exclusion zone, the extent of which will be considered during EIA stage.

The impacts of substrate removal upon the potential and unknown archaeological resource cannot be minimised in the same way, as there is currently no way to qualify or quantify the extent to which such archaeological material is encountered during dredging activities. In this case best working practice is required with the implementation of the Marine Aggregate Industry Protocol for Reporting Finds of Archaeological Interest. Areas revealed to be of archaeological sensitivity may be subject to a temporary exclusion zone.

The effects of sediment plume upon each archaeological receptor are likely to be positive, potentially concealing and promoting the favourable preservation of archaeological material that may have otherwise remain exposed and vulnerable to decay and corrosion. The preferred means of mitigation with regards to the archaeological resource is to preserve archaeological material *in situ.* Consequently, the effects of sediment plume entail either no changes to the existing archaeological baseline or desired changes, enabling the preferred means of mitigation to be obtained.

For individual Licence Areas, the regional assessment provided by this MAREA has removed the need for preparing regional overviews and (generally) for conducting searches of records of adjacent coastlines in the course of EIA. This should facilitate EIAs that are more tightly focussed on specific historic environment issues in the Licence Area itself, resulting in more succinct documents that can be prepared more rapidly. The MAREA places considerable emphasis on the detailed consideration of geophysical and geotechnical data for each Licence Area EIA. Geophysical and geotechnical surveys that are informed by this MAREA will have the effect of increasing what is known, and decreasing the scope within which previously unknown sites might potentially be found. Impacts on known sites and features can be mitigated through the existing practice of establishing Archaeological Exclusion Zones to enforce avoidance. This reduced, residual potential can be expected to fall within the operational capabilities of the Marine Aggregate Industry Protocol, which has already been demonstrated to be effective in the Thames Region.

The impact of aggregate dredging on marine archaeological receptors is different in form and extent to impacts from other types of marine development such as channel dredging, windfarm construction and cable installation. Like aggregate dredging, these other types of scheme are subject to EIA encompassing the archaeological heritage, and can be accompanied by conditions on consent to require mitigation. Consequently, the residual in-combination impact of marine aggregates and other forms of development in the Study Area is considered to be low.

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Acknowledgements

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Data was provided by TEDA, the National Monuments Record and SeaZone. We are grateful to the staff of these organisations for their co-operation. Wessex Archaeology are also grateful to Dr Justin Dix, University of Southampton, and Dr David Lloyd-Jones and Ed Hinton of Emu Ltd for their contributions concerning the Thames Regional Environmental Characterisation geophysical data.

Diana Donohue compiled this report with contributions from Louise Tizzard, Jack Russell and Antony Firth. Louise Tizzard undertook the geophysical data assessment and Jack Russell undertook the geotechnical assessment. Kitty Brandon prepared the illustrations. John Gribble and Antony Firth managed the project for Wessex Archaeology. Quality Control was provided by Euan McNeill.

Data Licences

A summary of archaeological site data in the Study Area was obtained from the National Monuments Record (NMR), Swindon. Copyright restrictions apply to any data that may be obtained by the NMR.

The digital use of Chart 2182 was made under licence (ref: HO 820/020220/11). The following notice applies:

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1 INTRODUCTION

1.1.1 Wessex Archaeology (WA) was commissioned by ERM on behalf of the Thames Estuary Dredging Association (TEDA) to undertake a Marine Aggregates Regional Environmental Assessment (MAREA) for a large coastal and offshore study area in the southern North Sea off the coasts of Kent, Essex and Suffolk.

1.1.2 This report provides an assessment of the known and potential archaeological resource within the Study Area through reviewing primary data retrieved by geotechnical and geophysical surveys, records held by national inventories and secondary sources.

1.1.3 For the purposes of this report, the marine archaeological resource is considered to comprise:

- Prehistoric archaeology;
- Maritime archaeology;
- Aviation archaeology.

2 AIMS AND OBJECTIVES

2.1.1 The aims and objects of the MAREA process, outlined in the Marine Aggregate Regional Environmental Assessment Scoping Report (Thames Estuary Dredging Association 2007) are as follows:

- To concentrate on assessing key issues of risk to the marine environment;
- To provide best use of developer resources and approach to data collection, evaluation and assessment both now and into the future in the context of existing and future government policy;
- To provide an objective, evidence-based assessment of potential impacts deriving from different development scenarios of the aggregate extraction industry;
- To provide objective, evidence-based assessments of the distribution and importance of regional resources (living and non-living) and the potential impacts from the proposed activities on these resources at a regional level. The MAREA reports will act as a reference source for this information;
- To provide a robust assessment of cumulative and in-combination impacts at a regional scale, and thus be able to contribute towards assessments of the magnitude and scale of such impacts at specific licence areas;
- To provide updated reassessments which will be provided as part of the ongoing MAREA process where new evidence or approaches are developed with the potential to offer an improved assessment;
- To provide for more targeted data collection at the Environmental Impact Assessment (EIA) stage to supplement data collected during the MAREA if the MAREA highlights issues of concern at specific licence application areas;

- To make recommendations for monitoring to be addressed at the MAREA or individual EIA level and for R&D to address gaps in knowledge, understanding or assessment tools;
- To conduct all assessments of resources, activities and impacts in a standardised manner to ensure that outcomes are directly comparable within and across regions.
- To place all data generated from the MAREAs in the public domain at the time of publication.

2.1.2 The aim of this study is to identify the range of effects of all the existing and planned future dredging operations at a regional scale on known and unknown archaeological sites within the Thames estuary region. This report will contribute towards the MAREA process which will consider the potential cumulative and in-combination effects of the existing and planned dredging operations on the marine environment as a whole within this region.

3 STUDY AREA

3.1.1 The following coordinates (**Table 1**) have been supplied by ERM to define the MAREA study area. This study area was extended by WA to form the MAREA Study Area, which encompasses the terrestrial coastal and estuarine zones adjacent to the study area as illustrated in **Figure 1**. Henceforth the term Study Area will refer to that illustrated in **Figure 1**. The coordinates, supplied by ERM in WGS84, were converted into the Universal Transverse Mercator Projection zone 31 North grid (UTM 31N). The coordinates were calculated by Wessex Archaeology using ArcGIS9.2 into UTM 31N, and are presented in **Table 1**.

Corner	Easting UTM Zone 31N	Northing UTM Zone 31N
A	407042	5793469
B	411346	5792185
C	457603	5778566
D	446898	5753284
E	426654	5705476
F	392016	5695216
G	360912	5715217
H	356793	5717866

Table 1: Study Area Coordinates

3.1.2 The Study Area (**Figure 1**) extends eastwards from the coastlines of Essex and Suffolk. The northernmost extent of the Study Area is situated approximately 6km south of Southwold on the Suffolk coast. To the south, the Study Area is situated approximately 3km south of Burnham-on-Crouch on the Essex Coast. From here, it extends in a south-easterly direction to a point just north of Margate on the coast of Kent, covering the approach to the Thames Estuary. **Figure 1** also shows the TEDA licensed dredge areas in the Thames region as of July 2009.

3.1.3 In order to provide a comprehensive account of the baseline environment within the Study Area, the potential for archaeological remains is considered with reference to archaeological studies within Suffolk, Essex and the Lower Thames region. Although the Lower Thames region is not strictly within the Study Area (see Bridgland 1994:31), the location of the Study Area on the approach to the Thames estuary renders archaeological sites within this region an important consideration for hominid/human activity within the general vicinity. Archaeological evidence from Kent and the Middle and Upper Thames regions is also considered variously throughout this report as evidence for hominid/human activity within the wider region.

3.1.4 Throughout the report, the Universal Transverse Mercator (UTM) co-ordinate system based on the WGS 84 datum is used to integrate the data supplied by the NMR, SeaZone and other sources. Where applicable, co-ordinates were translated using the Quest Geodetic calculator by Quest Geo Solutions Limited.

4 METHODOLOGY

4.1 LEGISLATION

4.1.1 The statutory planning and policy context relating to the historic environment in the Study Area is set out in **Appendix I** of this report.

4.1.2 In summary, the legislation which relates specifically to the maritime historic environment in English territorial waters is the **Protection of Wrecks Act 1973**. The **Merchant Shipping Act 1995** is also relevant as it plays a significant role in the reporting of recovered marine archaeological material. Furthermore, the **Protection of Military Remains Act 1986** relates to the marine historic environment with regards to military ship and aircraft remains of historic interest. The introduction of the **National Heritage Act 2002** has given English Heritage (EH) responsibility for archaeology below the low watermark. This includes historic wrecks and historic landscapes in, or under the seabed, out to the 12 nautical mile territorial limit around England.

4.1.3 There are currently two protected wreck sites within the MAREA Study Area; the Dunwich Bank wreck and the South Edinburgh Channel wreck. These sites are designated under Section 1 of the Protection of Wrecks Act 1973.

4.2 SOURCES

4.2.1 The Study Area has been used to define the search areas for archaeological and related data. The principle sources consulted in the assessment are as follows:

- Records of wrecks and obstructions collated by SeaZone;
- Records of Named Losses and terrestrial sites held by the National Monuments Record (NMR);
- Various secondary sources relating to the palaeo-environment and to the Palaeolithic and Mesolithic archaeology of Northern Europe with specific reference to the ALSF *Seascapes Project* (Southwold to Clacton) (Oxford Archaeology 2007);
- Various secondary sources relating to historic shipping patterns, as well as those sources relating to known and potential wreck sites and causalities, with specific reference to ALSF *England's Shipping* (Wessex Archaeology 2003a) and ALSF *Navigational Hazards* (Bournemouth University 2007);
- ALSF *Air Crash Sites at Sea* (Wessex Archaeology 2008) and various secondary sources relating to historic aviation patterns;
- Geophysical data provided by the Marine Aggregate Regional Environmental Assessment (MAREA) and the Thames Regional Environmental Characterisation (REC);

- Geotechnical data, comprising vibrocore logs, provided by United Marine Dredging, Hanson Marine Ltd and Cemex UK Marine Ltd (formerly Ready Mix Concrete Ltd. (RMC) and South Coast Shipping Ltd. (SCS).

4.2.2 Records relating to known and charted wrecks and obstructions were confined to those listed by SeaZone at this stage of enquiry. While the NMR possesses records relating to known and charted wreck sites, the degree of potential duplication and overlap of the two datasets saw that consultation of the NMR resource was restricted to terrestrial sites and Named Losses. The assessment of both SeaZone and NMR records relating to charted wreck sites and obstructions should be taken into consideration in future EIA processes.

4.2.3 At the start of the assessment it was decided that it was not feasible to include data from local sources such as the Historic Environment Records of Essex (EHER) and Suffolk (SHER). This was due to the size of the Study Area and issues relating to the integration of the HER data with the NMR data for an area of this size. Many of the records held by the HERs duplicate those held by the NMR and it was not within the scope of this report to correlate the datasets from these organisations. This approach was discussed with English Heritage at the Archaeological Methodology Meeting held at WA on the 20th August 2008 and EH agreed with this approach.

4.2.4 The importance of local sources such as the HERs was stressed by EH and it was agreed that these sources would be consulted in the course of future EIAs for specific aggregate dredging licences within the MAREA Study Area.

4.3 CONSULTATION

4.3.1 Consultation was undertaken with the English Heritage Maritime Team as the archaeological curator. This consultation took the form of an Archaeological Methodology Meeting, held at WA on the 20th August 2008 and attended by members of TEDA, project staff from ERM, project staff from WA and Dr Chris Pater of English Heritage. The project and methodology was presented, and a number of key issues, including the scope of geophysical and historical data assessments (see **Sections 4.6** and **4.2** respectively), were discussed and agreed.

4.4 APPROACH

4.4.1 The sources outlined in **Section 4.2** were consulted to provide a review of the known and potential archaeological resource within the Study Area. This review was considered with regards to three separate fields of enquiry, comprising prehistoric archaeology (**Section 5**), maritime archaeology (**Section 6**) and aviation archaeology (**Section 7**).

4.4.2 In order to assess the potential for prehistoric sites within the Study Area, various secondary sources were reviewed alongside the NMR datasets relating to the prehistoric terrestrial record within the onshore extent of the Study Area. The NMR terrestrial records were superimposed on a base map of the Study Area in the ArcView 9.2 Geographical Information System (GIS) software package and queried based on their period classification to provide an understanding of the distribution and density of the known archaeological resource from the Palaeolithic period to the Iron Age within the Study Area.

4.4.3 An assessment of 344 vibrocore logs was undertaken in order to better understand the sedimentary sequence within the Study Area and evaluate the geoarchaeological and palaeoenvironmental potential of sediments within the region.

4.4.4 Geophysical data in the form of sub-bottom profiler data were also assessed in conjunction with the results of the geotechnical assessment, with the aim of identifying prehistoric features such as in-filled palaeo-channels (evidence of cutting into the bedrock which has then been infilled), any potential land surfaces of archaeological significance and any peat or fine-grained sediment horizons. Any discernable patterns of these features which occur on a broad scale within the Study Area were also identified.

4.4.5 A review of the maritime archaeological resource within the Study Area was obtained through a consideration of various secondary sources alongside records of charted wreck sites, shipping casualties and seabed features, collated from the NMR and SeaZone. These records were superimposed on a base map of the Study Area in the ArcView 9.2 GIS software package.

4.4.6 The SeaZone records relating to charted sites were queried based on their feature classification into wrecks and obstructions. Charted wreck sites are likely to be subject to mitigation following an EIA, at which stage the appropriate level of archaeological mitigation will be determined by an assessment of the importance of each individual site. Charted obstructions represent sites where the archaeological nature is not fully understood, and may also be subject to mitigation following EIA. Consequently, the entire wreck and obstruction data was queried by date and reviewed with regards to a composite timeline (Wessex Archaeology 2008d) which sub-divides vessels into a date range based on generalisations regarding wreck sites which are likely to be of special interest.

4.4.7 In order to provide a statistical analysis of the charted wreck sites and to indicate patterning of their location, a $10km^2$ grid was implemented across the Study Area within the ArcView GIS software. The charted wreck sites were joined to the grid layer by spatial location, enabling the density of charted wreck sites within each grid square to be calculated across the Study Area. In order to present this data, the wreck density was sorted into five distinct classifications ranging from grid squares with a nil or low density of wreck sites to those with a relatively high density of wreck sites. Each classification was colour coded using graduated colours, with pale pink representing the lowest density of wreck sites and red representing the highest density of wreck sites within the grid squares. The intention of this approach was to identify areas of high wreck density as indicated by the known resource, potentially highlighting areas of navigational hazards or busy shipping routes. Areas containing navigational hazards or those subject to a high concentration of shipping activity are likely to contain currently unknown and uncharted wreck sites.

4.4.8 Data regarding recorded shipping losses (for which there are currently no known seabed remains) listed by the NMR was assessed in order to provide a review of the potential for unknown and uncharted shipwreck sites within the Study Area. The data relating to shipping losses was also queried by date with regards to the composite timeline (Wessex Archaeology 2008d) discussed above. The shipping casualties were displayed proportionately and were divided by the date ranges outlined by the composite timeline (Wessex Archaeology 2008d). The Named Locations were represented by a polygon, the sizes of which were representative of the number of shipping casualties lost at each Named Location. The proportion of shipping casualties was grouped by six distinct classes, comprising Named Locations with 0-24 casualties, 25-49 casualties, 50-74 casualties, 75-99 casualties, 100-149 casualties and 150-199 casualties.

4.4.9 Records relating to aircraft crash sites listed by SeaZone and those relating to aircraft losses listed by the NMR were considered alongside the records for WWII

Air/Sea Rescue Operations. Along with an assessment of historic aviation patterns, this data was used to provide an understanding of the density and general distribution of aircraft activity, thus highlighting the potential for the discovery of aircraft crash sites within the Study Area.

4.4.10 The review of the potential for unknown and uncharted archaeological sites within the Study Area was further supplemented by an assessment of site survival and visibility within the region. Through a consideration of the geological nature and seabed topography of the Study Area alongside various secondary resources, it was possible to highlight the potential for unknown sites of archaeological interest to exist which may be impacted by existing or future dredging operations.

4.4.11 The Impact Assessment for this report identifies the source and nature of each effect of dredging and the degree to which the archaeological resource is exposed to and affected by dredging practices within the potential areas of impact and the MAREA Study Area as a whole. The effects of dredging on archaeological receptors are considered in terms of the three main groups of receptors, comprising prehistoric archaeology, maritime archaeology and aviation archaeology.

4.5 GEOTECHNICAL ASSESSMENT

4.5.1 A total of 344 vibrocore logs provided by TEDA were assessed as part of the Stage 1 geotechnical assessment (Wessex Archaeology 2008c). A Stage 1 assessment comprises a desk-based assessment of core logs generated by geotechnical contractors. This assessment establishes the likely presence of horizons of archaeological interest and broadly characterises them on the basis of the information contained in the logs alone.

4.5.2 The vibrocore logs were collected as part of geotechnical investigations of aggregate resource areas in the Thames Estuary and southern North Sea between 1990 and 2003. The data has been provided by United Marine Dredging, Hanson Marine Ltd and Cemex UK Marine Ltd (formerly Ready Mix Concrete Ltd. (RMC) and South Coast Shipping Ltd. (SCS)). **Table 2** summarises the number of vibrocore logs and the areas in which they were obtained.

Area	Number of logs	Reference
109-1 Sunk	13	United Marine Dredging (1990)
257, 259	11	United Marine Dredging (1993)
257 Sunk	5	United Marine Dredging (1995)
109-1 Sunk	24	United Marine Dredging (1998a)
109-2, 109-3, 257 Sunk	20	United Marine Dredging (1998b)
287 Shipwash	26	United Marine Dredging (1998c)
113/1 Longsand	12	RMC South Coast Shipping (1990a)
327 Kentish Knock	2	RMC South Coast Shipping (1990b)
327 Kentish Knock	14	RMC South Coast Shipping (1991)
239 East Shipwash	20	RMC South Coast Shipping (1994a)
113/1 Longsand	22	RMC South Coast Shipping (1994b)
327 Kentish Knock	10	RMC South Coast Shipping (1999a)
239 East Shipwash	22	RMC South Coast Shipping (1999b)
118/2, 239 Shipwash	10	RMC South Coast Shipping (2002)
327 Kentish Knock	12	RMC South Coast Shipping (2003a)
113/1 Longsand	19	RMC South Coast Shipping (2003b)
Area 119-3	11	Andrews Survey (2000)

Area	Number of logs	Reference
446, 447 Cutline	77	Andrews Survey (2001)
447 Cutline	14	Andrews Survey (2002)

Table 2: Assessed vibrocores within the MAREA.

4.5.3 Data from the logs was manually input into a database including coordinates, vibrocore identification number, recovery, water depth, date and time acquired, where given. The vibrocore identification number, locations and reference are given in **Appendix III** and their locations shown in **Figure 2**.

4.6 GEOPHYSICAL ASSESSMENT

MAREA Geophysical Survey

4.6.1 Geophysical data was collected for the Thames Estuary MAREA project by Emu Ltd on the RV *Discovery* between 23rd April and 5th May 2008. Data included swathe bathymetry, sidescan sonar and sub-bottom profiler (boomer) data. For this report WA were commissioned to review the sub-bottom profiler data only.

4.6.2 The sub-bottom profiler data was acquired using an Applied Acoustics AA200 boomer plate with an external hydrophone and recorded on a Coda DA2000 machine. The data was recorded digitally and a hardcopy printed on an Ultra 120 thermal printer. Data was provided to WA in digital Coda format and hardcopy. Survey logs. Paper trackplot charts of the vessels position were also provided.

4.6.3 A total of nine sub-bottom profiler lines were acquired comprising approximately 170 line kilometres. Eight of the lines are orientated southeast to northwest and one cross-line is orientated southwest to northeast (**Figure 3**). The data acquired supports data acquired during 2007 as part of the Thames REC survey (Gardline Lankelma 2008) funded by MEPF (Marine Environmental Protection Fund).

Outer Thames Estuary REC Geophysical Survey

4.6.4 Assessment of the MAREA data alone did not provide enough data coverage to adequately assess the archaeology within the Study Area. WA was, therefore, also commissioned to assess the sub-bottom profiler (boomer) data acquired for the Outer Thames Estuary REC.

4.6.5 The data was acquired between 7th July and 13th August 2008 by Gardline Lankelma Ltd onboard the THV *Alert*. The data was acquired along a series of north-south and east-west orientated corridors.

4.6.6 The sub-bottom profiler data was acquired using an EG&G model 230 plate transducer, an EG&G 234 bang box and a SIG 8 element single channel hydrophone. The data was recorded on an Octopus 760 machine and was recorded digitally with a hardcopy printed on an Ultra 3710 thermal printer. Data was provided to WA in digital Coda format. Survey logs and digital vessel trackplot charts were also provided.

4.6.7 For the purpose of this assessment an initial data audit was conducted to select a suitable line of data from each of the corridors. The lines reviewed during this assessment are shown in **Figure 3**. The geophysical data covers a smaller area than the Study Area and its extent is illustrated in **Figure 3**.

4.6.8 In addition to the assessment WA attended two meetings (one pre- and one post-interpretation) with members of the consortium commissioned to conduct the Outer Thames Estuary REC study, to discuss the dataset and archaeological features within the area.

4.6.9 The geophysical assessment was limited to sub-bottom profiler data, because members of TEDA emphasised that incorporating sidescan sonar data at this stage would be unnecessary since they would be specifically assessed for future individual EIAs. This proposition has been agreed by EH during the Archaeological Methodology Meeting held at WA on the 20th August 2008.

Geophysical Characterisation

4.6.10 The sub-bottom profiler data was studied in order to detect any in-filled palaeo-channels, potential land surfaces of archaeological significance and peat/fine-grained sediment horizons that may have archaeological potential. Features within the survey areas were mapped and digital images created for illustration purposes.

4.6.11 The sub-bottom profiler data was processed by WA using Coda Geosurvey software. This software allows the data to be replayed with user-selected filters and gain settings in order to optimise the appearance of the data for interpretation. The software then allows an interpretation to be applied to the data by identifying and selecting a sedimentary boundary that might be of archaeological interest.

4.6.12 The sub-bottom profiler data was interpreted with two-way travel time (TWTT) along the z-axis. In order to convert from TWTT to depth the velocity of the seismic waves was estimated to be 1,600 m/s. This is a standard estimate for shallow, unconsolidated sediments.

4.6.13 As part of the interpretation the SeaZone gridded bathymetry dataset was used to provide background detail on the geomorphology of the seabed within the study area.

4.6.14 In addition to the survey data acquired specifically for this project, the results of previous archaeological assessments of geophysical data conducted by WA in the Study Area were also reviewed in the process of this assessment.

Outer Thames Estuary REC Interpretation

4.6.15 Subsequent to the assessment of geophysical data carried out for this project, the interpretation of the Outer Thames Estuary REC survey was published (Emu 2009). The project report includes several findings that are significant to gauging the archaeological potential of the Outer Thames, as follows:

- A series of palaeo-channels are interpreted on the basis of regional bathymetry and geophysical data, including a major braidplain running eastwards from Harwich. The report concludes that this channel and its tributaries is associated with the Cromerian (OIS 18) Thames-Medway system evident onshore (Emu *et al.* 2009:37-38).
- The attribution of these channels to the Cromerian is due in part to their being incised by a series of enclosed deeps considered to date to the Anglian period (OIS 12). These deeps are interpreted as having formed subglacially, close to the ice margin at the maximum extent of the Anglian glaciation and are considered, therefore, to demonstrate that the Anglian ice sheet extended 50km south of the formerly accepted maximum. Whilst this interpretation would mean

that a much large portion of the Study Area was covered by ice in the Anglian, the continued presence of palaeo-channels attributed to the Cromarian implies that the maximum advance of ice did not entirely disrupt the previous landscape (Emu *et al.* 2009:35).

- A plateau margin is mapped running north-south, close to the eastern edge of the Study Area. This plateau margin is interpreted as the margin of the ice-dammed lake associated with a glacial maximum. No conclusion is provided as to the relation between the lake margin and the eastwards flowing braidplain that meets it; nor is a date proposed for the lake margin (Emu *et al.* 2009:38).
- Previously-identified palaeo-channels associated with the later course of the Thames in the south of the Study Area are re-mapped on the basis of earlier BGS mapping and geophysics from the REC survey. This system is associated with onshore deposits attributed to the Wolstonian and Devensian glaciations and possibly – in the north – with the Anglian glaciation. However, the possibility of an Anglian channel running almost due east of Clacton is discounted (Emu *et al.* 2009:38).

4.6.16 The conclusions of the Outer Thames Estuary REC have been incorporated into this assessment where possible; features mapped as part of the Outer Thames Estuary REC have been included in Figures 5 and 6.

4.7 REVIEW OF PREVIOUS ASSESSMENTS CONDUCTED IN THE AREA

4.7.1 There are significant problems of data quality and recording biases relating to national inventories such as the UKHO and NMR. The records within these datasets relating to the known archaeological resource are limited and often poor. Conversely, information relating to the potential archaeological resource within the Study Area is extensive. Consequently, in addition to a review of secondary sources, the research pertaining to the known and potential archaeological maritime resource has been supplemented by the results of previous assessments undertaken by WA in the Study Area.

4.7.2 There are a number of previous investigations undertaken by WA that have a bearing on the discussion of the maritime archaeology of the Study Area, ranging from large-scale strategic projects to small-scale assessments of individual wreck sites. The results of these investigations are summarised in **Section 6.7** of this report, highlighting the potential for the presence of unknown wreck sites within the Study Area.

4.7.3 **Table 3** provides a summary of previous assessments undertaken in the area. The study areas for these reports are illustrated in **Figure 4.**

Project Name	Project Code	Reference (Wessex Archaeology)	Contents
Cutline – Areas 446 and 447 Archaeological Assessment	52357.02	2003	Desk-based assessment, geophysical and geotechnical review
Area 447 Cutline Pre-dredge Monitoring Survey.	68100.01	2008a	Archaeological Assessment of Geophysical Data
Bathside Bay Channel Deepening Archaeological Assessment	53824.01	2003b	Archaeological interpretation of geophysical data and review of air photographs

Project Name	Project Code	Reference (Wessex Archaeology)	Contents
Felixstowe South Reconfiguration Archaeological assessment	53768.02	2003c	Archaeological interpretation of multibeam bathymetric and magnetometer surveys
Gunfleet Sands Offshore Wind farm	51167.01	2002	Desk-based assessment and archaeological assessment of geophysical data
Gunfleet Sands 1 and 2	67760.04	2008b	Archaeological WSI
London Array Offshore Wind Farm Project	57740.02	2005	Desk-based assessment and archaeological assessment of geophysical data
Thames Estuary Offshore Wind Farm Long Sands and Shingle Bank	54157.01	2003d	Archaeological Issues Report
Thanet Offshore Wind Farm project	60070.03	2005a	Desk-based assessment and archaeological assessment
Thanet Offshore Wind Farm Project	60070.05	2006	Archaeological assessment of geophysical data
London Gateway		2001- present	Archaeological assessment of main shipping channel in the Thames

Table 3: Previous Assessments undertaken by WA in the area

5 PREHISTORIC ARCHAEOLOGY

5.1 INTRODUCTION

5.1.1 The following section presents an outline of the known geological and archaeological data for the southern North Sea. This baseline includes a discussion of all known and potential archaeological and geo-archaeological sites in the Study Area that may be impacted by existing and future dredging operations.

5.1.2 Sea level fluctuations and numerous glacial and marine transgressions and regressions have shaped the landscape within the Study Area over time. These changes in sea level have at times caused the floor of the southern North Sea to be dry and beyond the limits of the glacial ice sheet, exposing an inhabitable environment suitable for hominid/human exploitation.

5.1.3 The archaeological potential of the region has been considered with specific reference to remains that have become submerged as a result of sea level rise. Consequently, in order to assess the archaeological potential within the Study Area, the nature and causes of these fluctuations in sea level are discussed. **Appendix II** provides an approximate indication of relative sea level stands in the southern North Sea during the last *c.*800,000 years.

5.1.4 The term Before Present (BP) is used throughout this report when describing the age of archaeological events which occurred from the Lower Palaeolithic to the Mesolithic period. The BP time scale is predominantly used to report raw radiocarbon ages which cannot be directly correlated with a calendar date due to the inconsistency of C14 levels within the atmosphere. The exception to this is the Mesolithic period, the radiocarbon ages for which can be correlated with a calendar date (9,500-5,500 BP, 8,500-4,00 BC). For the purposes of this report, the Mesolithic period will adopt the BP timescale. 1950 commonly forms the arbitrary origin for the BP age scale. From the Neolithic period onwards, the time scales Before Christ (BC) and *Anno Domini* (AD) are used. Geological time, prior to periods of archaeological ineterst, is expressed in millions of years (Ma). Major glacial an interglacial stages are also referred to in terms of Oxygen Isoptope Stages (OIS) to facilitate correlation with other sources.

5.1.5 Major archaeological periods and significant archaeological discoveries and events are shown within **Appendix II** to illustrate the relationship between these periods and the relative sea level stands. The glacial maximum of the last ice age, during the Devensian, is marked by shading. **Appendix II** also illustrates the major depositional horizons of gravel terraces in the Middle and Lower Thames valley, based on the work of Bridgland (1994; *et al.* 2004) and Wymer (1999:57).

5.1.6 For the purposes of this report the discussion of prehistoric archaeology has been divided into three phases:

- Pre-Devensian, *c.*700,000-110,000 BP (OIS 18 – OIS 4), encompassing the period from the earliest evidence of hominid occupation of the UK. This period corresponds to the Lower and Middle Palaeolithic;
- Devensian to Late Glacial Maximum (LGM), *c.*110,000-18,000 BP (OIS 4 to OIS 2), encompassing the onset of the last glaciation up to and including the LGM. This period includes the Middle and Early Upper Palaeolithic which saw the transition from Neanderthals to modern humans;

- Post LGM and early Holocene, *c.*18,000-6,000 BP (OIS 1), encompassing the period of human re-inhabitation of the British Isles following the last glacial maximum through to the final inundation of the Study Area during the Mesolithic.

5.1.7 In broad terms, archaeological sites can be found in either primary contexts or secondary contexts. Archaeological sites discovered in a primary context can be defined by those in which the spatial relationship of finds has not altered since they were deposited. Artefacts found in their primary context are not necessarily exactly at their point of deposition, but the overall artefact movement is small on a regional scale (Emu *et al.* 2009:30). Artefacts discovered within their secondary contexts are those which have been derived or moved from their original positions by natural processes. Archaeological material discovered in secondary contexts may be associated with fluvial re-depositing, glacial processes and marine regressions and transgressions. Although discoveries from secondary contexts are by their very nature, derived artefacts, recent work has shown that they have the potential to provide information on patterns of human land use and demography (Ashton and Lewis 2002; Hotsfield and Chambers 2004).

5.1.8 A review of the coastal and marine processes which operate during sea level rises and stillstands highlights that a large proportion of the submerged archaeological resource is likely to be composed of artefacts within their secondary context (Westerley *et al.* 2004; Emu *et al.* 2009:30). This serves to add importance to the few primary context sites investigated (Emu *et al.* 2009:43).

5.2 SHALLOW GEOLOGY OF THE STUDY AREA

5.2.1 The underlying solid (Tertiary) geology of the Thames Estuary region is predominantly the London Clay Formation, a Lower Eocene sediment unit comprising the thickest and most widespread of the mudstone formations (Allen and Sturdy 1980:2; Cameron 1992 *et al.*; Sumbler 1996:4). This deposit is approximately 150m thick in the Thames Estuary region, and consists of stiff dark or bluish grey clayey silts, silty clays and silts (Cameron *et al.* 1992:97; Sherlock 1962:33). Dating to *c*. 53-51 Ma, this deposit pre-dates the earliest evidence of hominid/human activity in Britain and thus has no potential for archaeological material within it, though it may have provided surfaces upon which archaeological material has been deposited.

5.2.2 There are areas in which the London Clay Formation has been eroded away, revealing the underlying Paleocene Formations. To the west of the Study Area, these Paleocene deposits are revealed and consist of the Woolwich Beds (*c.*55 Ma), a complex unit of clays, loams and sands and pebble beds which are in turn overlain by the Harwich Member (*c.* 54 Ma); grey, sandy, carbonaceous mudstones with abundant volcanic ash layers (British Geological Survey 1989; Cameron *et al.* 1992:95). Within an area extending from the Rivers Stour and Orwell where these Paleocene formations are absent, the underlying Upper Cretaceous Chalk layer is exposed (*c.* 96-65 Ma). To the south of the Study Area, the erosion of the London Clay Formation reveals Upper Cretaceous Chalk overlain primarily by the Thanet Formation (*c.* 56 Ma), consisting of glauconitic sands, silts and silty clays (British Geological Survey 1989), the Woolwich Beds and ultimately by the Oldhaven Member (*c.* 54 Ma), a cross-bedded glauconitic sandy unit (Cameron *et al.* 1992:96). As with the London Clay Formation, each of these deposits have no potential for archaeological material within the deposit, but exposed surfaces may have supported archaeological deposits.

5.2.3 The strata directly overlying the London Clay Formation within the Study Area comprises of the late Ypresian Lower Bagshot Sands (*c.* 49 Ma) (Bennison and Wright 1969:340) and the Virginia Water Formation (*c.* 49-52 Ma) described by King (1981; 1984). These consist of very fine- to fine-grained, well-sorted sands which are thought to have been deposited as a nearshore, tidally influenced sand body. These are overlain by Middle Eocene Lutetian sediments known as the Middle and Upper Bagshot Sands (*c.* 48-43 Ma), consisting of fine-grained sands, silts and pebble beds (Cameron *et al.* 1992:97). These deposits also pre-date hominid/human activity in Britain and thus are unlikely to be of archaeological potential. Again, these deposits do not contain archaeological material, but where exposed they may have supported archaeological deposits.

5.2.4 Across the Eastern England sector of the southern North Sea (within the central region of the Study Area), the Eocene sequence discussed above is generally truncated and directly overlain by Quaternary deposits (Cameron *et al.* 1992:96), comprising of both Pleistocene and Holocene sediments.

5.2.5 Within the greater Thames Estuary, Pleistocene sediments typically occur as widespread river terrace sand and gravels, although other Pleistocene deposits consisting of glacial till, sand and gravel, slope deposits, clay-with-flints and loess are also present. The Pleistocene is considered to begin with the Praetiglian Stage, *c.* 2.3 Ma (Cameron *et al.* 1992:101). Current knowledge suggests that Pleistocene deposits are unlikely to have archaeological potential until those formed from the Cromerian Complex (*c.*760,000-478,000 BP) onwards. The Cromerian Complex represents the period in which the earliest evidence for hominid/human activity has been identified in Britain (see Lee *et al.* 2006; Wymer and Robins 2006). Pleistocene deposits within the greater Thames Estuary region are widespread, typically occurring as river terraces which in some cases continue offshore (Sumbler *et al.* 1996:112).

5.2.6 To the north of the Study Area, Late Pliocene and Lower Pleistocene sediments overlie the London Clay Formation. These sediments are found chiefly in East Anglia, where they extend over a considerable area from Harwich to the north Norfolk coast (Bennison and Wright 1969:351-2). These shallow marine deposits predominantly comprise of the Red Crag (*c.* 3.2-2.4 Ma) and Norwich Crag (*c.* 2.4-2.1 Ma) Formations which are up to 70m thick around parts of the eastern coastline (Zalasiewicz *et al.* 1988:226). The Red and Norwich Crags pre-date the earliest evidence for hominid/human activity in Britain and thus are unlikely to be of archaeological interest.

5.2.7 Offshore, Pleistocene sediments overlie the Red Crag Formation deposits and comprise the Lower Pleistocene Westkapelle Ground Formation (*c.* 2.43-2 Ma). The Westkapelle Ground Formation comprises clays, muddy sands and the sands deposited in an open marine environment (Cameron *et al.* 1992:105) and was formed prior to the earliest evidence for hominid/human activity in Britain. The Brown Bank Formation is also present in isolated areas and comprises laminated, silty clays infilling shallow channels in the seabed. These sediments were deposited in fluvatile or estuarine-brackish environments between *c.*110,000 and 70,000 BP (early Devensian period) and as such, there is the potential for this deposit to contain archaeological material.

5.2.8 Holocene sediments overlie the Pleistocene sands and gravels and are represented by a thick coastal accumulation of sediments within the greater Thames Estuary region (Cameron *et al.* 1992:116). Holocene sediments consist predominantly of sands, gravels, silts, clays and peats (Milne *et al.* 1997:135). These sediments were laid down in a variety of environments, including freshwater river channels, floodplains, saltmarshes, tidal creeks, sub-tidal/intertidal mudflats and sand banks (Milne *et al.* 1997:135). The Elbow Formation and equivalent deposits comprise the primary deposit and consist of fine and very fine-grained muddy sands with the inter-bedded clay (Cameron *et al.* 1992:119). The Formation was deposited during the Mesolithic period with the initial phase of the relatively rapid marine transgression which followed the melting of the Devensian ice sheets around 10,000 and 7,000 BP when sea levels rose from around 65m to around 15m below current sea level (Cameron *et al.* 1992:120). The onset of the Holocene (*c.* 10,000 BP) began in the Mesolithic period (*c.* 10,000-5,500 BP) and thus Holocene deposits have the potential to contain both archaeological material dating to this period and re-deposited Pleistocene archaeological material.

5.2.9 Within the broader Thames Estuary region, the seabed topography is dominated by numerous sandbanks, which accumulate as a result of being swept by tidal currents into ridges parallel with the shoreline. These Quaternary deposits were laid down during the present Holocene interglacial, in the course of or following the inundation of the area. The archaeological potential of sandbanks themselves is considered to comprise material of maritime and aviation archaeological interest and is addressed in those sections accordingly. The early phases of sandbank development may be of prehistoric interest, and may also have preserved underlying pre-inundation surfaces and deposits.

5.2.10 The stratigraphy of the Study Area encompassing the geology from the Cretaceous to the Quaternary period is illustrated in Table 3.1 of the REC (Emu *et al.* 2009:29).

5.3 RIVER TERRACE FORMATIONS WITHIN THE STUDY AREA

5.3.1 Pleistocene deposits within the Thames estuary region predominantly comprise of river gravel terraces. An understanding of the formation of these sediments is essential when considering the potential for submerged prehistoric remains within the Study Area. The processes for the formation of river terraces are not fully understood, although it is accepted that they are related to the climatic cycles of the Quaternary and continuing uplift of the region (Sumbler *et al.* 1996:115). However, the majority of depositional events within the Thames can be broadly related to four phases, outlined by Bridgland (1994:19).

- The sequence begins with Phase 1 - downcutting by rivers. This phase occurs during colder climatic conditions when erosion is more intense.
- Phase 2 occurs towards the end of a glacial period. Although the energy levels within the rivers remain high, sedimentation exceeds the rate of erosion, resulting in the aggradation of sand and gravel deposits and the formation of floodplains at the new level attained by the down-cutting in Phase 1.
- Phase 3 occurs in the ensuing interglacial period. During this temperate phase, there is a fall in river energy levels, resulting in limited deposition, predominantly in single-thread channels covering small areas across the floodplains. Estuarine deposits accumulate and overlie the Phase 2 deposits in the lower reaches of valleys.
- The final phase, Phase 4 occurs as the climate begins to deteriorate. This climatic change results in an increase in erosion. Once again, as with Phase 2, sedimentation exceeds this rate of erosion, causing renewed aggradation of sands and gravel along with the removal and/or reworking of existing floodplain

deposits. As the climate gets colder, erosion increases, causing renewed downcutting as Phase 1 is repeated.

5.3.2 The river terrace formations discussed above characterises the upper reaches of the Thames Estuary in the Study Area.

5.4 OVERVIEW OF KNOWN PREHISTORIC SITES

5.4.1 With the exception of a relatively small number of sites and finds, the known submerged prehistoric archaeology of the Study Area is sparse. This paucity of evidence is largely due to the difficulty in locating and identifying archaeological material within the submerged environment and should not be considered to indicate a lack of hominid activity within the offshore extent of the Study Area.

5.4.2 In order to compensate for the limits of the archaeological record offshore, the onshore boundaries of the Study Area were extended by WA to encompass the land surrounding the Rivers Crouch, Blackwater and Colne and the areas extending along the Essex and Suffolk coastlines (**Figure 1**). Due to the changes in the configuration of the coastline from the Pre-Devensian period to the modern day, it is not unreasonable to assume that the human activity represented by terrestrial prehistoric sites also occurred within the submerged extent of the Study Area at times when it was exposed as dry land.

5.4.3 A total of 6,069 NMR Monuments were recorded within the Study Area, of which 3,304 represent terrestrial sites. Altogether, 144 are records of Scheduled Monuments, which will be considered amongst the other terrestrial sites.

5.4.4 In order to obtain an understanding of the density and nature of prehistoric human activity along the river valleys and coastline adjacent to the Study Area, a number of queries were conducted on the NMR records, sub-dividing the sites based on their period classification.

5.4.5 A total of 1,735 records were post-prehistoric in date and are thus omitted from this assessment. The 87 records assigned as multi-period sites which contained no references to the prehistoric period were similarly disregarded. A further 831 records were of unspecified period and have also been omitted. Lastly, 136 Neolithic sites, 137 Bronze Age sites and 65 Iron Age sites have omitted from the assessment of prehistoric sites because these periods all post-date the last marine transgression of the Study Area during the Mesolithic. As a result, no non-maritime sites (i.e. terrestrial or living sites) from these periods can be expected on the seabed of the Study Area. These sites have, however, been used to provide context for the discussion of coastal and seafaring activity within the vicinity of the Study Area during the Neolithic, Bronze Age and Iron Age in **Section 6.2** below.

5.4.6 This left a reduced total of 313 NMR records (as represented in the GIS data supplied with this report), comprising prehistoric and multi-period sites which contain references to the prehistoric period. The results of the period classification queries are presented in **Table 4** and illustrated in **Figure 5**. To avoid overcrowding **Figure 5**, multi-period sites were excluded from the figure, and sites presented by the NMR as lines and polygons were converted into points.

Period	Number of Records
Palaeolithic (700,000-10,500 BP)	69

Period	Number of Records
Mesolithic (10,500-5,500 BP / 8,500-4,000 BC)	48
Multi-Period referring to Prehistoric sites	196
Total	**313**

Table 4: Prehistoric sites listed by the NMR and queried by period

5.4.7 A further query was conducted on the NMR records attributed to the Palaeolithic period. Where possible, these records were divided into Pre-Devensian, Devensian to LGM and Post LGM sites and finds, the results of which are discussed in **Sections 5.6**, **5.7** and **5.8** accordingly. Of the 69 Palaeolithic records, 50 sites did not contain sufficient information to enable a more specific date to be assigned. An additional 5 records assigned as multi-period sites were also seen to contain references to the Palaeolithic, although these too lacked sufficient information to enable them to be more specifically dated.

5.4.8 The figures displayed in **Table 4** should not be viewed as directly representative of the volume of human activity within a given period. The survival of archaeological sites and artefacts is variable and depends on a complex array of interrelating factors. Moreover, there are significant problems with the quality of data provided by national inventories such as the NMR, which provide often limited datasets dependent on recording biases. However, the NMR records certainly attest to human activity within the region adjacent to the Study Area throughout prehistory. This span of human activity along the river valleys and the Essex and Suffolk coastlines should be borne in mind when considering the potential for prehistoric sites in the Study Area.

5.5 PREHISTORIC LANDSURFACES AND DEPOSITS

Palaeogeographic Assessment

5.5.1 This assessment comprises a review of the geophysical data in conjunction with the geotechnical data with the aim of identifying areas within the Study Area of archaeological potential.

5.5.2 Peats are indicative of the remains of previous land surfaces, in which prehistoric objects and structures can be found. The preserved vegetation, together with other organic remains such as insects and the microscopic remains of pollen, enable archaeologists to build up a detailed picture of the environment that was once present. Remnants of fine-grained sediment units such as silt and sand can cover artefacts and also prove to be important.

5.5.3 Stone artefacts and animal bones have also been found within layers of sand and gravel, particularly those deposited as fluvatile or estuarine systems. As with peaty layers, the presence and survival of such artefacts is closely linked to the environmental processes that caused the deposit to be formed (Wessex Archaeology 2008e).

5.5.4 The geotechnical assessment identified four sedimentary units:

- Unit 1: Tertiary bedrock
- Unit 2: Pleistocene fluvial gravels
- Unit 3: Estuarine alluvium and peat

- Unit 4: Seabed sediments

5.5.5 Of these units it is considered possible that Units 2 and 3 have the potential to contain *in situ* prehistoric archaeological material. Unit 1 predates periods of archaeological interest, though it may have provided a surface for inhabitation. Unit 2 is post-transgression and its potential is constrained to maritime and aviation archaeology. The results of the integrated geotechnical and geophysical assessments are discussed in detail below.

5.5.6 For the purpose of the geophysical assessment the Study Area was divided into three zones based on the shallow geology and associated potential archaeology (**Figure 6**). The boundaries to the zones are indicative only and do not represent absolute boundaries of geological formations or features. Due to the resolution of the line spacings (**Figure 3**), the boundaries appear blocky as the vertices of the zone boundaries are associated with the data lines.

5.5.7 Zone 1 is situated to the north of the Study Area; Zone 2 in the central region and Zone 3 to the south. Each of the three zones contains features of archaeological interest. The nature of these zones and the features identified within these areas are discussed in detail below. The features identified during the assessment are listed in **Appendix IV** and are illustrated in **Figure 6**.

5.5.8 WA defined these zones on basis of the shallow geology and associated potential archaeology; they differ from the Western Zone, Central Zone and Eastern Zone, which were defined on the basis of bathymetric and morphological character for the the Outer Thames Estuary REC. The Western Zone is dominated by a large scale coast-parallel sandbank system. The sandbanks are composed of well sorted fine-medium grained sand with sandy gravels present in the troughs between the banks (Emu *et al.* 2009:8). The Central Zone is characterised by a bedrock platform overlain by a discontinuous, thin, gravelly lag deposit, dispersed sandy bedforms and isolated sandbanks (Emu *et al.* 2009:8). The seabed in the Eastern Zone consists of an extensive sand dune field (Emu *et al.* 2009:8). The boundaries of both the REA and REC zones are illustrated in **Figure 6**.

Zone 1

5.5.9 The shallow geology interpreted in Zone 1 comprises Red Crag Formation, identified as a generally seismically transparent unit with occasional layers overlying London Clay Formation sediments. In places Westkappelle Ground Formation is identified characterised by a series of weak parallel reflectors. Over the majority of the area Holocene seabed sediments are observed directly overlying these formations.

5.5.10 Within Zone 1, cut and fill and fine-grained sediment units were identified. The majority of the cut and fill features are interpreted as occurring either cutting into the London Clay Formation and are filled by Red Crag Formation, or features cutting into the top of the Red Crag Formation and infilled with Westkappelle Ground Formation. The cutting and filling of these features predates the earliest occupation of Britain, and as such these features are of no archaeological interest.

5.5.11 However, some features of potential archaeological interest are apparent and can be divided into three classes:

- features cut into the surface of the Red Crag or Westkappelle Ground Formation sediments where the fill type is unknown;
- further cuts with fill interpreted as Brown Bank Formation; and

- units of fine-grained sediments not associated with cut and fill features.

5.5.12 The anomalies classed as these features are detailed in **Table 5**.

Feature	Anomalies	Total
Cut and unknown fill	7030, 7035 – 7042, 7089, 7090, 7092 – 7095, 7097	16
Cut filled with Brown Bank Formation	7031, 7096	2
Fine-grained unit not associated with cut	7091	1
	Total:	19

Table 5: Features identified on the geophysical data in Zone 1

5.5.13 The cut and fill features are observed as either small isolated cuts with fill interpreted as fine-grained sediments (**7092**) or where the fill type is unknown (**7035** – **7039**, **7041**, **7042**, **7094** and **7097**). A larger cut type, the base of which is marked by an undulating surface is also identified. Of this type **7030** is identified with a fine-grained fill (predominantly silts and clays) compared to a more stratified layered fill (**7089**, **7090**, **7040**, **7029**, **7095** and **7093**) interpreted as layered sands. An example of this type of cut and fill is illustrated in **Figure 7A**. The cut and fill feature **7030** is seen to coincide with a channel system interpreted during the Outer Thames Estuary REC (Emu *et al.* 2009) (**Figure 6**).

5.5.14 It is possible that the unknown fills described above are remnants of the Brown Bank Formation or other undifferentiated Pleistocene sediments. Although the nature of the fill in these cuts is unknown, in general the fill is overlain by at least 1.5m surficial sediments. As such, it is likely that the fill sediments were deposited prior to the last marine transgression. Depending on the time of the cut and fill of these features there may be the possibility for the presence of derived archaeological material. If feature **7030** corresponds to the Cromerian river system proposed by the Outer Thames Estuary REC, it is possibility that it might contain archaeological material dating to the period in which the earliest evidence for hominid activity in Britain has been discovered (see Lee *et al.* 2006; Wymer and Robins 2006). The Holocene sediments within this area comprise sands and gravelly sands (British Geological Survey 1990).

5.5.15 Two features interpreted as a shallow cut and fill of Brown Bank Formation were identified in the northeast corner of the Study Area (**7031** and **7096**). Brown Bank Formation is identified by strong layered reflectors (**Figure 7B**) representing sediment deposition in fluvatile or estuarine to brackish-marine environments. The Formation is of Late Ipswichian to Early Devensian Age equating to the Middle Palaeolithic in Britain. It is possible that *in situ* material from the Lower Palaeolithic has been protected by the deposition of the Brown Bank Formation. *In situ* Middle Palaeolithic archaeological material may be associated with the deposition of this Formation.

5.5.16 Anomaly **7091** is interpreted as the remnants of a fine-grained unit. The unit is up to 2.5m thick and is situated in a very shallow depression overlying Westkapelle Ground Formation which is in turn overlain by 2.5m marine surficial sediments. The acoustically transparent nature indicates fine-grained sediments compared to the Holocene sediments and is likely to have been deposited in fluvial, estuarine or inter-tidal environment during the Pleistocene. The sediment unit appears to have been mostly removed by the last transgression leaving only a remnant.

5.5.17 There are no aggregate licence areas within Zone 1.

Zone 2

5.5.18 Zone 2 is situated in the central region of the Study Area (**Figure 6**). The main difference between Zone 1 and 2 is the Tertiary sediment type in the area. In Zone 2 there is no Red Crag or Westkapelle Ground Formation.

5.5.19 The general Tertiary geology of the area is London Clay Formation except in the southwest of the region where the London Clay Formation is observed pinching out and the underlying Woolwich Beds and Thanet Formation sediments are observed.

5.5.20 Throughout the area the Tertiary sediments are predominantly observed at the seabed covered by a veneer of Holocene seabed sediments, or a thickness of Pleistocene sediments overlain by a veneer of Holocene seabed sediments. In places, the marine Holocene sediments are observed forming large sandwaves, in places up to 15m high in the east of the area.

5.5.21 The modern seabed sediments in this area generally comprise a thin veneer (less than 1m) of sands and gravels, except where sediments accumulate in sandbanks and sandwaves. Most of the sediments overlying the bedrock were already in the area before the transgression which inundated the Thames estuary area between approximately 8,900 and 5,000 years BP.

5.5.22 In areas where an accumulation of sediments is observed overlying the bedrock it usually takes the form of a uniform layer of between 2 and 3m of relatively coarse material and is likely to represent an extensive deposit of Pleistocene sands and gravels. These gravels may represent the coarser fraction of fluvial and fluvioglacial origin (D'Olier 1972).

5.5.23 On the geophysical data there are areas where the London Clay Formation is observed within a metre (size of the seabed pulse) of the seabed. In these areas it is likely that there is a veneer of modern marine sediments and no remnants of Pleistocene sediments. D'Olier (1972) interpreted these as areas that were land at the end of the main transgressive phase and have suffered subsequent coastal erosion by waves and tidal current action.

5.5.24 Features of potential archaeological interest are detailed in **Table 6**.

Feature	Anomalies	Total
Cut and fill	7006, 7012 – 7014, 7018 – 7023, 7032 – 7034, 7043, 7045 – 7047, 7063 – 7065, 7070, 7086, 7088, 7098, 7099, 7101, 7105 - 7107	29
Cut and fill (Bank)	7072, 7087, 7104	3
	Total:	32

Table 6: Features identified on the geophysical data in Zone 2

5.5.25 The main features interpreted in Zone 2 are a series of cut and fill features. These occur as small sharp cuts into the underlying bedrock or as shallow discontinuous depressions. Tracing these features over such areas is difficult given the line spacing of the geophysics data in the area. These cuts may represent the remaining evidence of shallow river channels that flowed within the region prior to the onset of the last transgression.

5.5.26 Similar to the cut and fill features observed in Zone 1, simple cut and fill features forming shallow depressions (**Figure 8A**), small v-shaped cuts and the more complex broader undulating channels (**Figure 8B**) are observed. The simple cut features tend to be filled by only one unit of fill, overlain by a layer of coarse sediments (Pleistocene gravels), or by accumulations of Holocene sediments in the form of sandwaves or ripples. The undulating cut and fill feature may have one or more fills.

5.5.27 The fill of these channels varies in character. In some instances the fill is seismically transparent indicating fine-grained sands silts and clays (for example **7065**), however the majority of the fill unit is represented by strong stratified sediments indicating layered deposits. In certain features, such as **7098**, two units of fill are identified (**Figure 8B**) the deepest of which is represented by strong reflectors indicating a possible basal gravel layer within the cut.

5.5.28 Features **7072, 7087** and **7104** are observed on the southern limits of the Zone. At the base of the features a shallow cut into the London Clay Formation is observed. In these features the cut is overlain by a fill of coarse grained sediments which have accumulated to form gravel banks on the edge of a channel as evidenced in the bathymetric data. These features have been identified as possible remnants of gravel terrace deposits situated on the edge of the larger channels situated in Zone 3 associated with the Thames-Medway Pleistocene river system.

5.5.29 In Zone 2, 11 cut and fill features (**7019-7023**, **7034**, **7043**, **7047**, **7064**, **7070** and **7098**) correlate with channel systems interpreted in the Outer Thames Estuary REC (Emu *et al.* 2009). As these channels are attributed to the Cromerian Complex, the potential exists for pre-Anglian archaeological material to be associated with these features.

5.5.30 The geotechnical data assessed within this zone highlights areas where Pleistocene gravels (classed as Unit 2) have been identified (**Figure 6**). This unit comprised sand and gravel and was observed in the following vibrocores: **VCF4** (UMD 1998c), **VCF8** (UMD 1998c), **VC4** (RMC and SCS 1990a), **VC46** (RMC and SCS 1991), **VCT159/99** (RMC and SCS 1999a), **VCT160/99** (RMC and SCS 1999a), **VCT192/99** (RMC and SCS 1999b) and **VC028** (RMC and SCS 2002). However, in the majority of the vibrocores there is no evidence of Pleistocene gravels, indicating areas where marine Holocene sediments directly overlie the London Clay Formation.

5.5.31 The geotechnical data also indicated the presence of peaty clay and silty clay (classed as Unit 3) within this zone. This unit was recorded between 0.03 and 1.76m in thickness. Those vibrocores interpreted as containing Unit 3 are **82-SUNK** (UMD1990), **VC1** (RMC and SCS 1990a), **VC4** (RMC and SCS 1990a), **VC44**, (RMC and SCS 1991), **VC48** (RMC and SCS 1991), **VC49** (RMC and SCS 1991), **VCT159/99** (RMC and SCS 1999a), **VC031** (RMC and SCS 2002), **VC035a** (RMC and SCS 2002), **VC028** (RMC and SCS 2002), **VC019** (RMC and SCS 2003b), **VCB52**, **VCE11** (Andrews Survey 2001) and **VC10** (Andrews Survey 2000).

5.5.32 Core **VCT192/99** is situated approximately 100m to the east of the reviewed geophysical data. The geophysics data indicates that there is up to 3m of Pleistocene gravels overlying London Clay Formation which agrees with the interpretation that the laterally extensive unit overlying the London Clay Formation contains coarse grained sediments (sands and gravels) which include Pleistocene gravels.

5.5.33 Core **VC031** is situated approximately 180m to the east of reviewed geophysical data. Although there is no indication in the geophysics data of any fine-grained sediment units there are numerous cut and fill features within the extended area and it is possible that this fine-grained sediment could form in a similar manner to the cuts and fill described above.

5.5.34 The unit comprised peaty clay, clay and silt with organics and was proven to overly Unit 2 in **VC4** (RMC and SCS 1990a), **VCT159/99** (RMC and SCS 1999a), and **VC028** (RMC and SCS 2002). The unit is interpreted as estuarine alluvium and peat.

5.5.35 The aggregate areas are largely situated in Zone 2. Within the aggregate areas features of potential archaeological interest are generally absent based on the current geophysical data coverage. However, features are present in dredging area 108/3.

5.5.36 Features **7006** and **7107** are situated in dredging area 108/3. **7006** is interpreted as a shallow cut into London Clay Formation. The feature is filled by a series of chaotic reflectors interpreted as possible silts and sands overlain by less than 1m seabed sediment. Feature **7107** is a cut into London Clay bedrock between 3.6 and 4.0m sub-seabed. The cut is infilled by up to 4.0m sediments, interpreted as fine grained silts and sands, overlain by up to 3.8m coarser sediments.

5.5.37 These features have been interpreted as remnants of minor channels associated with the Thames-Medway Pleistocene river system. Vibrocores within the dredging area indicate the presence in the area of Pleistocene gravels (**82-Sunk** and **VC019**) to in excess of 3m. Also **VC028** indicates the presence of silts and peat within the upper metre.

Zone 3

5.5.38 Zone 3 is situated in the south of the Study Area. The geology and geomorphology in the area is similar to Zone 2. The significant difference between the zones is the presence of large-scale channel features.

5.5.39 A total of 49 features of potential archaeological interest are situated in Zone 3 and are detailed in **Table 7**.

Feature	Anomalies	Total
Cut and fill	7015, 7051 – 7056, 7059, 7060, 7062, 7066, 7068, 7069, 7074	14
Cut and fill (Bank)	7071	1
Bright reflector	7028	1

Feature	Anomalies	Total
Large broad channel	7000, 7007, 7008, 7017, 7024, 7073, 7075, 7076, 7077, 7110, 7111	11
Cut and fill within large broad channel	7001, 7003, 7004, 7005, 7009, 7010, 7011, 7025 – 7028, 7029 7078 – 7082, 7084, 7085, 7102	19
Fine-grained unit within the broad channel	7002, 7103	2
Complex channel	7016, 7028, 7044, 7048, 7050, 7057, 7058, 7061, 7067, 7108, 7109	11
Gas blanking	7049, 7083	2
	Total:	61

Table 7: Features identified on the geophysical data in Zone 3

5.5.40 Fourteen cut and fill features are observed in Zone 3 (**Table 7**). These features are either isolated or are observed close to the edges of either complex or broad channel features (**Figure 6**).

5.5.41 Similar to the cut and fill features in Zones 1 and 2 these features can be divided into simple cut and fill features or slightly more complex, larger features generally with an undulating basal cut and one or more phases of fill (**7053**, **7060**, **7062** and **7066**).

5.5.42 Of the simple cut and fill features these are observed where the fill unit is seismically transparent and is interpreted as fine-grained sediments (**7054**, **7056**, **7069**), those identified with strong parallel reflectors interpreted as layered sands (**7015**, **7055**, **7059** and **7074**), and those where the fill unit is undifferentiated from the overlying sediments (**7015** and **7051**). The fill associated with feature **7068** is a fine-grained unit with an associated area of gas blanking indicating the possible presence of organic matter or peat. Feature **7068** correlates with one of the northern tributaries of the Thames system in the south, as interpreted as part of the Outer Thames Estuary REC (Emu *et al.* 2009) (see **Figure 6**).

5.5.43 One cut and fill feature associated with banks was observed in Zone 3: **7071**. This feature is similar to those identified in Zone 2 (**7072, 7087** and **7104). 7071** comprises a cut into underlying London Clay Formation. Sediments infill the cuts, then form a bank approximately 4m higher than the surrounding seabed. The lower part of this fill may be fine-grained compared to the upper coarse layer. Feature **7071** correlates with the same tributary to the Thames interpreted as part of the Outer Thames Estuary REC (Emu *et al.* 2009).

5.5.44 Eleven large broad channel features are observed in the data in Zone 3. These are situated to the southeast of the Study Area and correlate with the large scale Thames system as defined by the British Geological Survey (British Geological Survey 1990) and interpreted during the Outer Thames Estuary REC (Emu *et al.*2009) (**Figure 6)**. These 11 features are likely to belong to the same large scale feature dominating the Outer Thames area. Based on the geophysical data this feature would be in excess of 35km long (**7024**) and 16.5km wide (**7007**).

5.5.45 The broad channel features cut into the Tertiary bedrock (predominantly London Clay Formation) generally comprise 5-25m stratified sediments interpreted as channel deposits (**Figure 6**). However, within these channel deposits a series of further cut and fill, and fine-grained unit sequences are observed, indicating different river flow regimes at different times associated with these large-scale features. These have been given a separate feature number in order to demonstrate the position of these features along the length of these broad channels.

5.5.46 Five of the large broad channel features have other features associated (**7000**, **7008**, **7024**, **7077** and **7110**). The cut and fill features vary in length and depth and there are a variety of fill types observed, such as fine-grained units, units with onlapping sediments, stratified sediments and those where the cuts are representing lateral changes in the channel sediment fill. An example of these features is illustrated in **Figure 9A**.

5.5.47 Feature **7028** is interpreted as a bright reflector situated at the base of a sandbank on top of channel deposits (**7024**) and is observed between 4.4 and 8.0m sub-seabed. The strength of this reflector is anomalous and is interpreted as a possible layer of peat preserved beneath the overlying sandwave.

5.5.48 The broadscale channels and associated deposits described above have not been classified as part of the palaeo-channel structure observed on the bathymetry (Emu *et al.* 2009), but as the edge of the plateau margin. These submerged deposits indicate that the channel extended further to the east, and has since been filled (**Figure 6**).

5.5.49 In addition to the broad-scale channels there are also a series of smaller channels that exhibit a series of complex fills (**Table 7**). These channels are situated to the west of the Study Area and may be extension to the larger channels observed to the east or may represent the remnants of further smaller river channels.

5.5.50 A group of complex channel features (**7044**, **7016**, **7048** and **7100**) are associated with the major braidplain running eastwards from Harwich, as identified in the Outer Thames Estuary REC. These channels form a broad cut up to 16.5m sub-seabed, such as **7109** (**Figure 10A**) and comprise a series of fills as typified by **7044** (**Figure 11A**). Fill unit 1 is observed to the north of the cut and is observed as a series of south-dipping reflectors up to 5.1m thick overlain by up to 1m of surficial sediments or up to 3.6m of the overlying fill unit 2. This unit onlaps the fill to the north. The unit is seismically chaotic with a maximum fill of 4.3m and is overlain by around 1m surficial sediments. Within feature **7100** an area of gas blanking is observed within the channel deposits indicating the presence of organic matter or possible peat.

5.5.51 Comparing these sub-seabed channel cuts to the SeaZone gridded bathymetry the sub-seabed channels are observed on the edge of a submerged channel flowing from the current River Stour. The sub-seabed channels are likely older remnants of this channel that have been infilled as the river route has migrated.

5.5.52 Further complex channels are observed in the southwest corner of the Study Area. Due to the line spacing it is difficult to ascertain whether these features are directly associated with each other or represent different channel systems, but it appears that they once formed part of the Thames-Medway system.

5.5.53 An example of one of these complex channels is feature **7057** (**Figure 11B**). Both the northern and southern edges of the channel are observed between 2.4 to 14.4m sub-seabed. The channel is cut into Woolwich Beds (Palaeocene) sediments. In the centre of the channel at approximately 3.0m sub-seabed is evidence of shallow gas indicated by gas blanking of the underlying seismic records. The likely source of the shallow gas is microbial and indicates the possibility of organic matter present within the channel. The first fill layer comprises faint parallel reflectors up to 10.6m thick. A further cut is observed cutting into the unit obscured by the gas blanking between 2.5 and 4.5m sub-seabed. The fill associated with this cut is up to 7m thick and comprises sub-parallel reflectors dipping to the north. These fills are overlain by up to 2m surficial sediments.

5.5.54 Evidence of gas blanking in the geophysical data was observed in localised areas within the zones 2 and 3. However, in zone 2 and the majority of instances in Zone 3 the gas blanking was interpreted as associated with the underlying London Clay Formation. However, in certain instances the shallow gas is situated within the fill or channel deposits and is likely generated by microbial methane indicating a presence of organic matter or peat within the channel deposits.

5.5.55 Two isolated areas of gas blanking are observed: **7049** and **7083**. Feature **7049** is also an isolated area of gas blanking approximately 3.5m sub-seabed with a complex channel (**7050**). **7083** is a large area (approximately 850m long) situated at the base of the large broad channel **7077** as an isolated feature. Further gas blanking is observed within complex channel structures (**7057**, **7067**, **7100**, **7109**, **7016** and **7109**) and within cut and fill features (**7068**).

5.5.56 Vibrocores **VCE4** (UMD 1998b) and **VC1** (RMC and SCS 1990a) are situated in Zone 3 and indicates the presence of estuarine and terrestrial sediments. **VCE4** is situated less than 15m west of the geophysics line 19C. The vibrocore indicates a thin layer (0.03m) of clay overlain by 2.47m gravelly sand. The geophysics data indicates that this vibrocore is situated within an area where there is up to 6.5m sediments (interpreted as sands and gravels) overlying London Clay Formation. This highlights the issue that small fine grained deposits may not be identifiable on the geophysics data. **VCE4** is situated within dredging area 257.

5.5.57 The broad channels observed in the southeast of the Study Area conform to the route of the Palaeo-Thames, an extension of the current Thames Estuary, as illustrated by the British Geological Survey (1990). It is likely that these channels were cut into the London Clay bedrock during the Hoxnian interglacial when the Anglian ice sheets diverted the Thames-Medway channel southwards (Brigland 1994).

5.5.58 Previous studies (D'Olier 1995; Bridgland 2002) indicate that remnants of the East Tilbury Marsh gravels and the Shepperton Gravels extend into the southern region of the Study Area (zones 2 and 3). The coarse grained sediments identified on the edges of the buried channels may equate to these gravel deposits.

5.5.59 Of particular note is the quartzite gravel recorded in **VC46** (RMC and SCS 1991) as quartzite is often characteristic of Thames river terrace sequences (Bridgland 1994; Gibbard 1995). **VC 46** is situated further north than the documented extents of the East Tilbury Marsh gravels and the Shepperton Gravels indicating that the remnants of river terrace deposits may be more extensive than previously recorded.

5.5.60 The channel features (cuts and fills, broad channels and complex channels) observed in the geophysics data highlight the complexity of the riverine/estuarine system in the Outer Thames region.

5.6 PRE-DEVENSIAN (700,000-110,000 BP)

Overview

5.6.1 During the Pre-Devensian period (700,000-110,000 BP) the entire north-west European landscape has been shaped by a series of marine transgressions and regressions that are associated with fluctuating glacial and interglacial conditions arising from changes in global climate. There are large gaps in our knowledge of the relative sea level history of the southern North Sea and the configuration of the coastline at any one time. However, the river terrace formations of the Thames and its tributaries form a relatively uninterrupted geological sequence, providing important evidence for the study of sea level fluctuations and environmental change during the Pleistocene (Williams and Brown 1999:10).

5.6.2 The lower sea levels that occurred during glacial periods meant that for long periods during the last *c.*700,000 years, areas of the southern North Sea have been exposed as dry land. As such, the Study Area was suitable for human/hominid exploitation at various times in the past. With reference to **Appendix II**, it is likely that portions of the Study Area were inhabitable for at least parts of OIS 19-6 (*c.*787,000-186,000 BP).

5.6.3 The Anglian and Wolstonian glaciations and associated transgressions and regressions had significant implications for the environment within the Thames Estuary region and along the coasts of Essex and Suffolk. The pre-Anglian landscape of the Study Area – including the path of the Thames-Medway river system – was extensively modified by the Anglian glaciation. Notwithstanding, the identification by the Outer Thames Estuary REC of a pre-Anglian (Cromerian Complex) channel in an area interpreted as lying beneath the Anglian ice margin (Emu et al. 2009) implies that not all pre-existing landscape features – or archaeological deposits – were completely destroyed and scattered by the ice sheet (Flemming 2002:6).

5.6.4 Throughout the Wolstonian and Devensian glaciations, the Study Area would have been outside of the limits of the ice front. As a result, the river terrace formations within the Thames and its tributaries represent the most complete record of the post-Anglian Pleistocene in Britain (Bridgland 1996). In some cases these river terraces continue offshore, and may be present within the Study Area. Consequently there is potential for the preservation of archaeological material within the Study Area.

5.6.5 A series of Pre-Devensian terrestrial channel systems dating between the Cromerian Complex (OIS 18) and the early Devenisan (OIS 4) – based on Bridgland (2006) and compared against the inferred palaeo-channel routes of a combined BGS and Outer Thames Estuary REC interpretation – are illustrated in **Figure 5**. Zone 3 in the south of the Study Area is dominated by large Pleistocene channel systems with associated fills and more complex channels, with Zone 2 being generally characterised by simpler cut and fill features interpreted as shallow river channels. The geotechnical results indicate that terraces and fine-grained terrestrial/estuarine sediments may be associated with these channels, though the dating remains uncertain.

5.6.6 Further data is required in order to make a more convincing link between the onshore and offshore channels within the Study Area, but there is potential for deposits associated with these offshore channels – as onshore – to yield archaeological material. Whilst there is potential for *in situ* archaeological sites to be discovered within river terrace deposits, archaeological material is likely to be found predominantly in secondary contexts (Wymer 1999:21, 195).

Cromerian Complex

5.6.7 The earliest date for hominid presence in Britain has been attributed to the Cromerian Complex (787,000-478,000 BP; OIS 21-13), from the discovery of a coastal site at Pakefield, Suffolk (Parfitt *et al.* 2005).

5.6.8 The Cromerian Complex is recognised as having at least six temperate phases (Preece 2001). With the exception of OIS 16 and OIS 14, which are thought to represent colder phases (Wymer and Robins 2006: 464-466), the Cromerian Complex has been described as having a warm climate, similar to that of the present day Mediterranean. The temperate phases within the Cromerian Complex are likely to have been favourable for hominid activity. Sea level varied, falling to approximately 90m below its current level during OIS 16. Consequently, there are periods within the Cromerian Complex between the extremes of sea level and climate when the Study Area may have supported human inhabitation.

5.6.9 The evidence from Pakefield comprises flint artefacts found within the Cromer Forest-Bed Formation (Parfitt *et al.* 2005:1008), an extensive deposit of organic mud attributed to OIS 17-19. These sediments have been exposed within the sea cliffs from Weybourne to Southwold (West 1996). North of the Study Area, a quarry in Norfolk has revealed Cromer Forest-Bed Formation sediments appearing to infill a channel that cuts into the Neogene Crag Basin, and overlain by sediments known as the Ingham Formation, or the Bytham sands and gravels (AHOB 2006). The Ingham Formation comprises cross-bedded gravelly sand sediments (Rose *et al.* 2001:10) which were deposited by the pre-Anglian Bytham River at the northernmost extent of the Study Area. The Bytham River ran from Midland England to Great Yarmouth (Rose *et al.* 2002:50; Wymer 1999:130). In the onshore area opposite the central part of the Study Area are terrace formations of the Kesgrave Group, which were deposited by the pre-Anglian Thames River. These gravelly sand sediments are extensive throughout the Thames valley and East Anglia (Rose *et al.* 2001:10).

5.6.10 The Cromer Forest Bed sediments have yielded a rich fauna of elephants, deer and other large mammals, suggesting that food sources would be available for early hominids (Parfitt *et al.* 2005; Wymer 1999:129). Clayey silts from of the Ingham Formation at High Lodge, Mildenhall, have produced a pollen assemblage indicating woodland with juniper, herbs and heath plants (Austin 1997:8).

5.6.11 Stone artefacts have been discovered within the Ingham Formation, notably at Warren Hill at Mildenhall, one of the richest sites for hand axes in Britain (Wymer 1999:130).

5.6.12 A number of Lower Palaeolithic finds have also been made within the Kesgrave gravels, although it has been noted that their context is less convincing than those from the Ingham Formation (Wymer 1999:131). Nonetheless these terraces are particularly well preserved between Colchester and the Essex Coast (Sumbler *et al* 1996:117) and have the potential to yield pre-Anglian *in situ* finds as well as material in secondary contexts.

5.6.13 The distribution of known Lower Palaeolithic sites along coastal margins and down river valleys as outlined by the Outer Thames Estuary REC highlights the high potential for Lower Palaeolithic archaeological material in association with palaeo-channels (Emu *et al.* 2009:43), adding significance to submerged river channel systems in the Study Area that have been attributed to the Cromerian. Specifically, the Outer Thames Estuary REC identified a linear channel system present at the entrance to Harwich harbour in the west, extending approximately 55km to the east (**Figure 5**; **Figure 6**). The river system is thought to predate the Anglian glacial and based on terrestrial gravel sequences described by Bridgland (2006) may correlate to the Cromerian Complex (OIS 18) (Emu *et al.* 2009:37).

Anglian

5.6.14 The Anglian glacial phase (478,000-423-000 BP; OIS 12) was the most extensive of the glaciations, with ice sheets reaching as far south as the north Cornwall coast and the Thames Valley (Wymer 1999:17). The trapping of water within the extensive Anglian ice sheets resulted in a fall in sea level thought to be the lowest recorded around the British Isles and estimated at 130m below the present level.

5.6.15 The Study Area would have been at the margin of the ice sheet during this glacial phase. In Essex, the extent of the Anglian ice sheet is thought to run in a line from Brentwood, through Billericay to a point a little west of Colchester (Allen and Sturdy 1980:2). This suggests that only the far northern portion of the Study Area was covered by the ice sheet whilst the remainder would have been exposed. As the Anglian ice sheet advanced southward into the Thames Estuary region, it eroded the Cromerian palaeosol horizon over which it passed (Allen and Sturdy 1980:2). This material was then deposited at the base of the ice sheet, forming a layer of boulder clay till (Sumbler *et al.* 1996:118). In East Anglia this till occurs as an extensive deposit known as the Lowestoft Till, which has been considered to indicate the maximum extent of the Anglian ice sheet (Austin 1997:5). However, the Outer Thames Estuary REC suggests – based on the presence of enclosed deepsevident in bathymetric data – that the Anglian glacial margin extended some 50km south within the Study Area (Emu *et al.* 2009:35) (**Figure 5**; **Figure 6**).

5.6.16 The glacial processes largely reworked the pre-Anglian landscape, transporting sediments over large distances and changing the course of major rivers (Campbell and Bowen 1989:15). These processes had significant implications for the Thames-Medway river system which, prior to the Anglian, flowed in a north-easterly course from north London through the Vale of St. Albans to Colchester (Williams and Brown 1999:10). The advancing ice sheets forced the river southwards and into a more easterly course (D'Olier 1975:269; Milne *et al.* 1997:131).

5.6.17 As the Anglian ice sheet pushed south and the climate became colder, the Study Area was transformed into a predominantly peri-glacial landscape, being predominantly ice-covered during the glacial maximum. The peri-glacial landscape may have been was suitable for human inhabitation during the Anglian, as indicated by the discovery of numerous palaeoliths within the Black Park Terrace, the first deposit of the Thames after its diversion to the south (Wymer 1999:44). It might be anticipated that artefacts dating to the Anglian in the Study Area would predominantly derive from secondary contexts, due to the disruption caused by the ice sheet. However, as noted above, the apparent survival of a pre-Anglian river system running across the Study Area at a point where it would have lain beneath the ice sheet (Emu et al. 2009) suggests that some *in situ* features and deposits – including archaeological material – may have survived the Anglian glaciation.

Hoxnian

5.6.18 The Hoxnian interglacial (423,000-380,000 BP; OIS 11) was a temperate phase. A terrace formed by the Orsett Heath Gravel is recognised in the Lower Thames region to contain interglacial sediments (Sumbler 1996:120). Post-Anglian terrace formations such as this often continue into Eastern Essex where they comprise the Low-level East Essex Gravel subgroup (Bridgland 1994:6). These formations extend northwards from the Southend district, roughly parallel with the coastline (Bridgland

1994:6). Those which correlate to the Lower Thames Orsett Heath gravel are known as the Southchurch, Asheldham, Mersea Island and Wigborough gravel deposits in Essex (Bridgland 1994:7, 22-23).

5.6.19 In the north of the Study Area within East Anglia, further Hoxnian deposits have been noted, represented by the Nar Valley Beds (West and Whiteman 1986), the lake deposits at Hoxne (West 1956), Clacton Channel deposits (Bridgland 1994:330-331) and the lake sediments at Marks Tey (Turner 1970).

5.6.20 During the Hoxnian, Britain is likely to have become a peninsula of north-western Europe. The Thames-Medway channel was diverted southwards in the Late Anglian and filled with sediment during the warm stage (Bridgland 1994:295). Freshwater deposits in Marks Tey, central Essex, have provided a pollen sequence yielding a complete vegetation record of the Hoxnian interglacial within this area (Allen and Sturdy 1980:2). The landscape, which consisted of predominantly open grassland at the onset of the interglacial, saw the development of boreal birch and pine forests. This was followed by temperate oak forest before a return once more to pine and birch, and then back to a predominantly heath vegetation as the Wolstonian glaciation approached (Allen and Sturdy 1980:2).

5.6.21 The Thames valley has yielded abundant traces of occupation from the Hoxnian (Darvill 1987:31). The discovery of three early human skull fragments at Swanscombe in north-west Kent known as the 'Swanscombe Skull', provides direct evidence of a human presence within the wider region. The 'Swanscombe Skull', which was found alongside flint artefacts, has been assigned to the *Homo heidelbergensis* species (Bridgland 1994:13; 205; Sumbler *et al.* 1996:120; Williams and Brown 1999:10). These finds were made within interglacial sediments of the Orsett Heath Gravel (Sumbler *et al.* 1996:120). Further Lower Palaeolithic artefacts within the wider region have been discovered at Hoxne in Suffolk (Wymer 1999:156-159) and Clacton in Essex, within sediments assigned to the Hoxnian Stage (Allen and Sturdy 1980:2; Bridgland 1994:330-331; Wymer 1999:100-102).

5.6.22 Within the onshore extent of the Study Area, five sites listed by the NMR contain references to Clactonian flakes, which is a flake tool industry dating to the early Hoxnian Interglacial (Darvill 1987:29). A further two sites listed by the NMR contain references to Acheulian flint implements. The Acheulian is the main Lower Palaeolithic tradition in Europe dating to the middle of the Hoxnian Interglacial (Darvill 1987:31).

5.6.23 The distribution of known sites both within the onshore extent of the Study Area and within the wider region suggest that river valleys and lakeside situations were favoured for settlement during this period (Darvill 1987:31). With the exception of two sites, the known sites dating to the Hoxnian period within the onshore extent of the Study Area are concentrated along the present coastline at the northern fringe of the Blackwater estuary. There is thus the potential for further Hoxnian sites to be present offshore along submerged palaeo-valleys. The presence of channel features in Zone 3 of the Study Area highlights this potential. The rich Lower Palaeolithic archaeology of the adjacent coastline means that any preserved landscape fragments within the Study Area will be of significant archaeological potential (Emu *et al.* 2009:35).

Wolstonian

5.6.24 The Wolstonian (380,000-130,000 BP; OIS 10-16) comprised three cold stages (OIS 10, 8 and 6) interspersed with two temperate phases (OIS 9 and 7). The extent of the ice sheets during the cold stages are a matter of ongoing discussion. It has been tentatively suggested that the ice margin ran across Lincolnshire and the Midlands (Wymer 1999:18). British ice sheets are thought to have joined with the Scandinavian ice across the northern North Sea, leaving the sea floor south of an approximate line from Southwold to Scheveningen outside the limits of the ice front (Flemming 2002:8). The Study Area would thus not have been covered by an ice sheet during the Wolstonian. As a result, the post-Anglian Hoxnian and Wolstonian deposits laid down by the Thames and its tributaries are generally well-preserved. Sea levels are estimated to have been up to approximately 120m below their current level during Wolstonian cold stages, which means that very extensive areas of the Study Area would have been exposed. Climatic conditions would have provided a landscape of bare ground and heath (Allen and Sturdy 1980:3) that was largely suitable for human activity within the Study Area.

5.6.25 Within the Wolstonian, two temperate phases have been identified - the Purfleet interglacial (339,000-303,000 BP; OIS 9) and the Aveley interglacial (245,000-186,000 BP; OIS 7)). Interglacial deposits within a terrace formed by the Corbets Tey Gravel in the Lower Thames sequence have been assigned to the Purfleet interglacial (OIS 9)(Sumbler 1996:120) and further interglacial deposits of this age have been observed in Essex, within the Shoeburyness Channel sediments (Bridgland 1994:7). Analysis of deposits assigned to the Purfleet interglacial indicates a range of habitats including riparian, woodland and grassland environments with climatic conditions that are thought to be warmer than the present day (Bridgland *et al.* 1995:178).

5.6.26 The lowest terrace above the floodplain of the Thames, known generally as the Floodplain Terrace, is represented by terraces of different ages along the river Thames at various points (Sumbler 1996:120). In the Lower Thames region, the Floodplain Terrace is formed by the Mucking Gravel (Sumbler 1996:120). Interglacial deposits within the Mucking Gravel Terrace, observed notably at Aveley and Uphall Pit in Ilford amongst other places in the Lower Thames region, have been assigned to the Aveley interglacial (OIS 7) (Sumbler 1996:120). Deposits representing this interglacial phase within Essex are thought to be submerged (Bridgland 1994:7) and Britain is thought to have become an island as sea level rose.

5.6.27 A number of hand axes in secondary contexts have been discovered in the Orsett Heath Gravel and Corbets Tay Gravel deposits in the Lower Thames region, suggesting hominid activity within the general vicinity of the Study Area intermittently from *c.*380,000-245,000 BP (OIS 10-8) (Wymer 1995:80). Also, a number of Lower Palaeolithic artefacts have been discovered within the Pufleet interglacial deposits within the Lower Thames (Bridgland *et al.* 1995:167).

5.6.28 To the south of the Study Area, Kent has yielded the largest concentrations of Lower Palaeolithic hand axes dating to this period in Britain, the majority of which are thought to have been deposited on the edges of river valleys (Wymer 1982:9). This suggests that these hominids favoured the areas along major river valleys and highlights the potential for such finds within the Study Area.

5.6.29 In the north of the Study Area (Zone 1), it is possible that *in situ* material from Lower Palaeolithic has been protected by the deposition Brown Bank Formation.

Ipswichian

5.6.30 The Ipswichian interglacial (130,000-110,000 BP; OIS 5e) is not represented by terrace formations downstream from London, as deposits of this age are overlain by modern floodplain sediments (Bridgland 1994:7; Sumbler 1996:120). Equivalent deposits within the Essex region are submerged (Bridgland 1994:7).

5.6.31 Britain remained an island during the Ipswichian. The climate is thought to be for much of the time as warm as our current climate (Wymer 1999:33). Faunal remains dating to this period discovered at sites such as Bobbitshole near Ipswich and Trafalgar Square in London indicate a climate suitable for large mammals such as lions, hippopotami, straight-tusked elephants, rhinoceri, giant deer, red deer, fallow deer, aurochs and bison within the Thames floodplain (Wymer 1999:33). Evidence from Essex suggests vegetation comprising predominantly mixed oak forests (Allen and Sturdy 1980:3) within the general vicinity of the Study Area.

5.6.32 During the Ipswichian, Britain was an island and it is suggested that Middle Palaeolithic hominids known on the Continent were absent here (Wymer 1999:33; Ashton and Lewis 2002). This absence is enigmatic, given the favourable climate and availability of large mammal fauna. Nine sites listed by the NMR in the onshore extent of the Study Area contain references to Levallois flakes, a technique of flintworking dating back to the Wolstonian period but also employed throughout the Middle Palaeolithic – encompassing the Ipswichian – by some Mousterian communities (Darvill 1987:33). Three of these sites relate to individual findspots, with the remaining sites representing duplicate flint implements. The sites are predominantly concentrated in areas adjacent to the rivers Stour and Orwell, a distribution which suggests a preference for hominid settlement along river valleys. If hominids proved to be present in the Ipswichian, then there is potential for archaeological material to be present along submerged river valleys in the offshore extent of the Study Area.

5.7 DEVENSIAN TO LGM (110,000BP – 18,000 BP)

Geology and Sea Level

5.7.1 The **Devensian glaciation (110,000-13,500 BP)** was the last glacial stage to occur before the present climatic amelioration. The Devensian maximum, when the glaciation was at its greatest extent, occurred *c.*18,000 BP. At the height of the Devensian, the water locked up in ice sheets caused a lowering of sea level to approximately 120m below its current level. This phase is known as the Dimlington Stadial, named after the type site just north of Easington in south-east Holderness. With the southern edge of the ice sheet extending in a line from the Severn to the Wash (Flemming 2002:7) the Study Area would again been outside the limits of the ice but within a peri-glacial zone during this phase.

5.7.2 The Devensian is represented by the deposition of cold-climate gravel such as that found in the East Tilbury marshes in the Lower Thames area (Sumbler 1996:122). The Quaternary deposits of the Thames system which correlate to this phase of the Devensian glaciation in Essex are now submerged and thus unrepresented (Bridgland 1994:7).

5.7.3 During the Dimlington Stadial (*c.*18,000-13,500 BP), the downcutting and incision of the Thames River created the lowermost level of the river, known as the 'buried channel' (Gibbard 1995:32). This was followed by the aggradation of the Shepperton Gravel, which occurs throughout the valley from the Upper Thames region to the area beneath the North Sea, east of the coast of Essex (Gibbard 1995:32). These events, which are paralleled in tributary valleys such as the Lea, Roding, Fleet, Darent and Cray, represent the last major gravel and sand aggradation in the Thames system (Gibbard 1995:33).

5.7.4 Having reached its maximum at approximately *c.*18,000 BP, the ice sheet of the Dimlington Stadial retreated. As the weight of the ice was removed, the land within the Study Area region rose faster than the sea level, resulting in an increase in the area of dry land exposed throughout during this period (Flemming 2005:15; Murphy and Allen 1997:6). As such, with reference to **Appendix II,** it is probable that portions of the Study Area were inhabitable for substantial periods of OIS 3-5d (*c.*110,000-40,000 BP). The archaeological record for this period includes evidence for Neanderthals and Cro-magnon hominids in some contexts within wider Europe. Although an upward trend of relative sea level has been recognised within the greater Thames Estuary region which is typical of an area at the margins of the Devensian ice-sheet (Shennan *et al.* 2000:284), the Study Area would have at first predominantly remained above sea level, forming a landscape in which the rivers of the region flowed eastwards towards the Continent.

Topography and Climate

5.7.5 From the beginning of the Devensian glaciation (*c.*110,000 BP) through to the Late Mesolithic (*c.*8,500 BP), Britain would have been connected to the Continent. Within the Study Area, which would have been situated on the margin of the ice sheet during the Devensian, a landscape of peri-glacial vegetation and tundra would have prevailed. During the Early Upper Palaeolithic, from *c.*22,000 BP, the Devensian glacial was approaching its maximum extent and the climate became progressively colder, making the Study Area uninhabitable.

5.7.6 From the Late Devensian onwards a complex interplay of factors affected sea level changes and the rate of sediment supply in the greater Thames Estuary region. These in turn had significant implications for the landscape of the Study Area, both with regards to vegetation and the configuration of the coastline. The way in which these factors interrelated provided a wide range of habitats along the estuaries, including mudflats, salt marshes, reed swamps and fen woods, capable of being exploited by humans (Wilkinson and Murphy 1995:57).

Archaeological Potential of the Study Area

5.7.7 The UK's terrestrial archaeological record suggests that Britain was uninhabited from *c.*180,000-60,000 BP. However, the possibility of a human presence throughout the Devensian prior to the glacial maximum (*c.*110,000-40,000 BP) should not be disregarded within the Study Area. Although the Late Middle Palaeolithic period is marked by the onset of the Devensian glacial, it is unlikely that the initial cooling stages of the glaciation would immediately rule out a human presence within the Study Area.

5.7.8 Recent archaeological finds in the southern North Sea suggest that archaeological deposits of this period can survive offshore. At least 28 hand axes have been dredged up approximately 13km off the coast of Great Yarmouth and have been tentatively dated to the early stages if the Devensian glacial. As the hand axes do not appear to have been subject to a high level of abrasion, it has been further suggested that they were dredged from a deposit in which they lay *in situ,* demonstrating the possibility of such finds to be present within their primary context offshore within the Study Area.

5.7.9 The first evidence for the presence of modern humans (*Homo sapiens*) dates to the Early Upper Palaeolithic (*c.*40,000-30,000 BP) in Britain, which at the time was connected to the European mainland as a result of the fall in sea level. The Study Area would have been on the margins of the ice front during this phase, exposing it as a peri-glacial landscape. This, together with the availability of protein-rich foods within the rivers valleys that ran through the region suggests that the Study Area would have provided a landscape suitable for human exploitation during the early stages of this glacial phase. Despite this, the Early Upper Palaeolithic is very poorly represented across the wider region of the Study Area. This may be due to a low population density in East Anglia during this period, although it has been suggested that the dearth of Early Upper Palaeolithic may be largely due to the lack of cave sites which have proved to be so important for the preservation of Upper Palaeolithic sites in other areas of Britain (Austin 1997:9). It is also reasonable to assume that many Early Upper Palaeolithic sites within the wider region of the Study Area now lie submerged offshore.

5.7.10 The known Upper Palaeolithic material in the region consists of stray artefacts and a few stratified sites, although the potential exists for the favourable preservation of finds within the alluvial deposits of the river valleys and under fen deposits (Austin 1997:9). Where such material is found, it is likely to be indicative of occasional hunting forays as the peri-glacial landscape within the Study Area would not have been conducive to any long-term or sustained human occupation (Wymer 1980:11). As the glacial maximum approached, the conditions became too cold to be favourable for human exploitation, rendering the Study Area region uninhabitable between *c.*22,000-13,000 BP.

5.7.11 Within the onshore extent of the Study Area, the NMR lists three sites which contain references to Proto-Solutrean or Solutrean flint implements. The Solutrean is a western European Upper Palaeolithic industry which appears to have developed in the Rhone Valley area of France. Solutrean assemblages are principally found in France and Spain dating between 21,000 and 18,000 BP (Champion *et al.* 1984:54), a period in which evidence suggests that Britain was not occupied. Of these sites, one comprises a surface find and another was discovered amongst construction material and thus they do not present *in situ* material. It has been argued that the remaining site containing references to Solutrean implements may in fact be Bronze Age in date. These sites are not thus indicative of human activity within Britain during this period.

5.7.12 A fragment of mammoth tusk comprises further evidence which may relate to known Devensian sites in the Study Area. The tusk was identified as belonging to a *mammuthus primigenius*, also known as a woolly mammoth. It is possible that this fragment dates to the Devensian. Mammoth fossils occur in the archaeological record from the Wolstonian glacial (*c.* 380,000-130,000 BP) to the end of the Devensian glacial (*c.* 10,000 BP), although the *mammuthus primigenius* species was first recorded in *c.* 150,000 BP. The tusk was reported under the Marine Aggregate Industry Protocol (Cemex_0201), after being recovered during aggregate dredging in Area 447 and thus highlights the potential for archaeological material dating to this period to be present on the seabed.

5.7.13 If the wider region of the Study Area was inhabited by humans during this period, there is the potential for *in situ* Middle and early Upper Palaeolithic archaeological material to be present to the north of the Study Area (Zone 1) associated with the deposition of the Brown Bank Formation. In addition to this, the potential for Devensian archaeological material to be present within the currently undated features identified from the geophysical data must not be discounted.

5.8 POST LGM AND EARLY HOLOCENE (18,000-6,000 BP)

Geology and Sea Level

5.8.1 The seabed within the Study Area lies at depths between approximately 10 and 40m (Cameron *et al.* 1992:118). According to existing models of sea level change, the Study Area would initially have remained exposed as dry land following the retreat of the Devensian ice sheet. By *c.*9,600 BP the sea had advanced into the deepest sections of the Thames complex and with sea level at approximately -34m by *c.*9,000 BP, it had extensively flooded the channels of the Thames-Medway-Crouch river complex as far as Foulness point (D'Olier 1972:125-6).

5.8.2 During the Early Mesolithic period (*c.*8,900 BP) the rising sea level saw the development of the present Thames Estuary as an extensive area of salt marsh and tidal flats (Sumbler *et al.* 1996:126). Sea level reached -22m at approximately 8,300 BP and the river valleys running across the present area of the Thames Estuary became completely submerged (D'Olier 1972:127). By *c.*8,000 BP practically the whole of the present Thames Estuary was submerged, although a continual rise in sea level saw the gradual expansion of the estuary (D'Olier 1972:128). With this gradual rise in sea level, the Study Area was inundated during the Late Mesolithic period between *c.*7500-7000 BP, enabling the processes of estuarine erosion and deposition to form the large sand banks and channels that characterise the broader Thames Estuary region today.

5.8.3 Following the retreat of the Devensian ice sheet the rate of erosion diminished and the Thames River and its tributaries stabilised as they ceased to aggrade sands and gravels (Gibbard 1995:33). This stabilisation extended to the surrounding ground surface, which enabled the establishment of woodlands and resulted in the formation of peat deposits on the floodplain (Gibbard 1995:33). Due to this stabilisation, the river received small amounts of sediments which accumulated and progressively buried the Shepperton Gravel deposits which overlay the lower-most level of the Thames River (Gibbard 1995:33).

5.8.4 At the onset of the Holocene (*c.*10,500 BP) the continuing rise in sea level resulted in the deposition of alluvial mud around the Thames Estuary and along the coastal plain of the Essex Coast (Sumbler *et al.* 1996:126). The occurrence of temporary, minor falls in sea level enabled plants to colonise the exposed mudflats, resulting in the development of peat beds interspersed within the marine alluvium (Sumbler *et al.* 1996:126).

5.8.5 This deposition of early Holocene sediments occurs below the modern tidal range and thus cannot be seen in coastal sections along the coast of Essex (Wilkinson and Murphy 1995:57). However, deep boreholes within the Thames Estuary have provided information about the geology and sea level rise of the Lower Thames region during this period which may be used to provide a generalised understanding of the region as a whole. A series of marine transgressions and regressions within the Lower Thames Estuary region resulted in a complex sequence of Holocene depositional events, collectively referred to as the Tilbury Alluvium (Devoy 1979). This interbedded sequence of alluvial deposits consists of inorganic clay and silt units which indicate the occurrence of four or possibly five marine transgressions termed Thames I-V by Devoy (1979). These inorganic units are interleaved with five biogenic units comprising monocot or wood peats and associated gyttja (Devoy 1979:365). These sediments, termed Tilbury I-V (Devoy 1979) are evidence of five Holocene regression phases within the Lower Thames region.

5.8.6 The sequence starts towards the beginning of the Late Mesolithic period with the deposition of Tilbury I, radiocarbon dated to *c.*8,300 BP (Sumbler *et al.* 1996:126). Following a rapid rise in sea level from -25.5 to -8.9m OD, the tidal head of the estuary reached Tilbury at *c.*7,700 BP, resulting in the deposition of Thames I (Gibbard 1995:34; Sumbler *et al.* 1996:126). It was during the deposition of Thames I that the Study Area became inundated (*c.*7,500-7,000 BP), and Britain's land bridge to the Continent was breached for the last time (Austin 1997:9).

5.8.7 During the Late Mesolithic period, a regression which began *c.*7,000 BP is recorded by a second bed of peat (Tilbury II) which in turn became submerged as sea level rose from -10.1 to -5.0m O.D. at *c.*6,600 BP during the Thames II transgression (Gibbard 1995:34; Sumbler *et al.* 1996:126). The following regressive period resulted in the deposition of the thickest biogenic unit (Tilbury III), commencing at about *c.*6,000 BP and marking the end of the Mesolithic period. This succession of transgression and regression phases continued within the Lower Thames Estuary region, concluding with the Thames V transgression which continues to the present day with sea level currently rising at about 2-3mm per year (Sumbler *et al.* 1996:128).

Topography and Climate

5.8.8 At approximately 12,000 BP, during the **Windermere Interstadial (13,500-11,000 BP)** Britain was re-colonised by humans for the last time. Following the end of the Dimlington Stadial, the Windermere Interstadial provided a warmer climate and a landscape containing a mixture of light birch woodland, grassy meadow and areas of wetland vegetation within the Study Area region, favourable for human occupation and exploitation (Wessex Archaeology 2003:17).

5.8.9 During the following stadial phase, known as the **Loch Lomond Stadial (11,000-10,000 BP)**, glaciers formed once again in the Scottish Highlands and colder conditions returned until the climate finally ameliorated with the onset of the Holocene period, approximately *c.*10,000 BP.

5.8.10 The **Pre-Boreal period (10,000-9,500 BP)** which occurred towards the beginning of the Early Mesolithic period in Britain saw a marked improvement in climate, accompanied by the development of a closed birch forest environment within the general vicinity of the Study Area (Allen and Sturdy 1980:4). With the gradual rise in sea level, the North Sea advanced into the deepest sections of the Thames River complex and the modern Thames Estuary became a relatively flat region covered by fluvio-glacial drift and floodplain alluvium towards the end of the Pre-Boreal period (D'Olier 1972:125).

5.8.11 In **Boreal** times **(9,500-7,200 BP)**, from the Early to Middle Mesolithic period, Essex was characterised by a predominantly hazel and pine forested landscape (Allen and Sturdy 1980:2). The basal peat at Tilbury (Tilbury I) dating to *c.*8,300 BP suggests a landscape covered by a woodland of oak and hazel within the area now submerged beneath the Thames Estuary, and one of pine, elm and oak on the drier valley sides and in the uplands (Sumbler *et al.* 1996:126). During this time, an environment of reed-swamp or sedge-fen is thought to have existed closer to the Thames river channels (Sumbler *et al.* 1996:126).

5.8.12 The **Atlantic period (7,200-5,500 BP)** saw the end of the Late Mesolithic period and the start of the Neolithic in Britain. During this stage, the landscape within the Essex region and elsewhere in lowland Britain developed predominantly into mixed oak forest, comprising of alder, oak, elm and lime (Allen and Sturdy 1980:4; Austin

1997:10). Variations in the composition of the Tilbury I-V biogenic layers indicate a predominance of a *Phragmites* reed and saltmarsh environment at the eastwards end of the Thames Estuary, changing upstream to a freshwater environment of fen woodland (Devoy 1979:388).

5.8.13 Further variations can be noted in the peat profile of the Tilbury III regression, which began *c.*6,000 BP. The Tilbury III peat layer is characterised by fen wood remains and fruits comprising *Corylus, Alnus* and *Quercus* although small quantities of *Betula* and *Salix* have also been noted, indicating strong local variations in the vegetation of the wood fen environment within the Thames Estuary region during this period (Devoy 1979:38). The Atlantic phase is thought to have been the warmest of the post-Devensian period, known as the Flandrian climatic optimum, with summer temperatures some 2-3°C above current averages (Lamb 1965).

Archaeological Potential of the Study Area

5.8.14 It was not until *c.*13,500 BP, during the Late Upper Palaeolithic, that the warming stages of the **Windermere Interstadial (13,500-11,000 BP)** provided a climate which was conducive to human re-occupation and exploitation of Britain. It was during this period that Britain is thought to have been slowly re-colonised by modern humans from the Continent, and areas of the southern North Sea and the Study Area may have been populated by human communities. The discoveries of butchered or worked animal bones trawled from Dogger Bank certainly support this contention (Coles 1998:60). Furthermore flint and bone artefacts have also been trawled up around Brown Ridge and Dogger Bank (Louwe Koojmans 1970; Verhart 1995; Flemming 2002), indicating the likely presence of archaeological sites on the seabed in these areas.

5.8.15 Evidence for the Late Upper Palaeolithic in the Study Area region is scarce (e.g. Wymer 1980:11). However, this dearth of evidence should not be taken to imply a lack of human activity in the area during this period. Given a landscape with access to major river valleys and a burgeoning resource of plants and animals, it is highly likely that Late Upper Palaeolithic human groups were present within the vicinity of the Study Area. The discovery of a flint assemblage at Herne Bay in Kent which includes Long Blades and 'Bruised Blades' typical of assemblages belonging to the Late Glacial-Early Postglacial period, provides evidence for Late Upper Palaeolithic activity in the wider Study Area region (Gardiner *et al.* 2006). This is further supported by the discovery of a flint leaf point in gravels overlying the 'arctic plant bed' at Broxbourne in the Lea valley, and a number of shouldered flint points from Oare, Kent, which support the presence of humans in the wider Thames Estuary region during the Windermere Interstadial. The fluvial processes that followed the deglaciation of the Devensian would have destroyed, scattered or buried Late Upper Palaeolithic sites beneath the thick accumulation of Holocene alluvial mud that characterises the surface geology of the area.

5.8.16 The **Loch Lomond Stadial (11,000-10,000 BP)** brought with it the final cold climatic conditions before the current climate amelioration at the beginning of the Holocene period *c.*10,000 BP. Despite the stabilisation of the Thames River and its tributaries during the Holocene, there was a continuing, albeit gradual, rise in sea level accompanied by a slowly increasing rate of sediment deposition within the Study Area region. The deposition of these various sediments indicates a pattern of continually shifting and rapid environmental change during the Holocene (Milne *et al.* 1997:135) offering a wide variety of habitats which provided the resources suitable for human exploitation and occupation.

5.8.17 In the Early Mesolithic period, the Study Area would have comprised an undulating lowland drained by a complex of Pleistocene river systems. This extensive lowland would have been attractive for human occupation, not only providing access to both terrestrial and marine resources, but also enabling these early Mesolithic communities to exploit the herds of red deer and other such mammals which migrated into Britain from the Continent as the climate ameliorated (Sumbler *et al.* 1996:136).

5.8.18 The estuaries, rivers and their tributaries form the most marked geographical feature of the Study Area (Jacobi 1980:24). Early Mesolithic sites and find spots are often found adjacent to wetlands and estuaries (Oxford Archaeology 2007:11), indicating a preference by these Mesolithic communities for areas in which they could exploit the marine resources available in such environments. A number of sites identified during the Hullbridge Survey (Wilkinson and Murphy 1995) in Essex support this contention. The discovery of two such sites in Essex, at Hullbridge and Maylandsea, consisting of concentrations of flint artefacts have been found in areas which are likely to have been dry land sites in the Mesolithic period, located on a clayey head deposit adjacent to freshwater streams (Wilkinson and Murphy 1995:62). A number of sites have also been discovered in the Lea valley area, where the remains of Mesolithic occupation have been discovered within organic peat deposits that accumulated in the area during this period (Austin 1997:9). Further Mesolithic occupation sites have been discovered beneath peat, tufa or alluvial deposits within the swampy regions of the Thames tributaries, such as the Kennet, Colne, Mole and Wey (Sumbler *et al.* 1996:136).

5.8.19 By the Late Mesolithic period, brackish conditions would have begun to occur within the river estuaries of the Study Area and the low-lying ground would have been subject to periodic flooding and the generation of marshland (Wessex Archaeology 2003:17). Mesolithic occupation sites within the Study Area during the Late Mesolithic period are unlikely as the rising sea level would have progressively forced people further inland. However, Mesolithic communities will have continued to exploit the marine resources within the marshland of the Study Area, until its full inundation *c.*7,500-7,000 BP.

5.8.20 There have been a number of Mesolithic sites discovered within the broader region. East Anglia is quite rich in Mesolithic sites, yielding a more widespread distribution of known remains than for the Upper Palaeolithic (Austin 1997:9). However, these comprise predominantly surface finds, with very few sites containing material in primary contexts (Austin 1997:9). A similar pattern can be noted in finds from Essex, where the bulk of evidence for Mesolithic activity is based on isolated, but diagnostic, artefacts (Jacobi 1980:14).

5.8.21 There are 52 known sites listed by the NMR dating to the LGM and Early Holocene period, all of which are thought to be Mesolithic in date. Four of these sites are assigned as multi-period records all of which contain references to the Mesolithic period.

5.8.22 Eight of these sites are within 2km of the Blackwater Estuary and 10 are within 2km of the Stour and Orwell Rivers. A further five sites are within 2km of the current coastline in the Study Area. This comprises a total of 23 sites which are located in areas adjacent to the present shoreline or estuary fringes. Although the coastline would have been further to the east in the Mesolithic period, the steady rise in sea level at this time may have subjected these areas to periodic flooding and the consequent generation of marsh land, providing a landscape preferable to Mesolithic communities for exploitation. These sites thus highlight the potential for further sites dating to this period in wetland areas which now lie submerged within the Study Area. The Mesolithic sites and findspots along this stretch of the coastline are relatively few in relation to the suggested volume of human activity in the region, and as such should be viewed as a bare minimum baseline of activity (Emu *et al.* 2009:44).

5.8.23 The river terraces within the Study Area region provide the most complete record of the post-Anglian Pleistocene in Britain (Bridgland 1996) and due to this high level of preservation there is the potential for Mesolithic sites to remain *in situ* within the area. However, the fluvial processes of the Holocene, which have resulted in the formation of peat deposits and the deposition of alluvial sediments, would have sealed and buried parts of the landscape in which these sites may occur (Austin 1997:9). Consequently, it is from below the recent alluvial infill of the estuaries and river valleys within the Study Area region that Mesolithic finds ultimately derive (Jacobi 1980:24).

5.8.24 To the south of the survey area (Zone 3) a localised bright reflector was observed on the geophysics data, possibly representing the remnants of a peat layer overlying channel deposits and overlain by Holocene seabed sediments. Undated features in Zones 2 and 3 may also be attributable to the Late Devensian and Early Holocene.

6 MARITIME ARCHAEOLOGY

6.1 INTRODUCTION

6.1.1 Maritime sites can be defined as broadly comprising either vessels or debris which has been accidentally or deliberately lost overboard from a vessel. As an island nation, the UK has a long maritime history and there is potential for the archaeological evidence of maritime sites of all periods dating from the Mesolithic period to the present within the Study Area.

6.1.2 The evidence for coastal and maritime activity within the vicinity of the Study Area will be discussed with regards to the composite time line for shipwrecks around England, produced by Wessex Archaeology (2008d). The timeline takes into account the broad chronology of shipbuilding and employment and draws out a few generalisations regarding the age and special interest of vessels.

- **Pre-1508 AD**: The earliest category within the time line covers the period from the earliest Prehistoric evidence for human maritime activity to the end of the medieval period, *c.*1508. So little is known of watercraft or vessels from this period and archaeological evidence of them is so rare that all examples of craft are likely to be of special interest.
- **1509-1815**: The second category covers the period from 1509-1815, encompassing the Tudor and Stuart periods, the English Civil War, the Anglo-Dutch Wars and later the American Independence and French Revolutionary Wars. Wrecks and vessel remains from this date range are also quite rare, and can be expected to be of special interest.
- **1816-1913**: Category three falls into the period 1816-1913, a period which witnessed great changes in the way in which vessels were built and used, corresponding with the introduction of metal to shipbuilding and steam to propulsion technology. Examples of watercraft from this period are more numerous and as such it is those that specifically contribute to an understanding of these changes that should be regarded as having special interest.
- **1914-1945**: The fourth category on the time line extends from 1914-1945, encompassing the First World War (WWI), the inter-war years and the Second World War (WWII). This date range contains Britain's highest volume of recorded boat and ships losses. Those which might be regarded as having special interest are likely to relate to technological changes and to local and global activities during this period.
- **Post 1946**: The last category extends from 1946 through the post-war years to the present day. Vessels from this date range would have to present a rather strong case if they are to be considered of special interest.

6.1.3 Of the vessels which passed through the Study Area, it can be assumed that many are likely to have foundered, as a result of natural causes (sea and weather), collision or war. The seabed topography within the Study Area is characterised by numerous long narrow sandbanks which run parallel to one another along the coasts of Suffolk, Essex and within the greater Thames Estuary. The crests of the sand banks are very shallow and some are exposed at low tides (Cameron *et al.* 1992:124*)* posing a navigational hazard to vessels using the area. This risk is increased by the nature of the shore, which is exposed to prevailing winds from the north-east, increasing the risk to vessels being blown on to the shallow mobile banks (Bournemouth University 2007:34).

6.2 COASTAL AND SEAFARING ACTIVITY: PRE-1508

Early Prehistoric (Palaeolithic – Mesolithic)

6.2.1 There is no evidence for Palaeolithic watercraft pre-dating the Devensian glacial maximum (*c.* 40,000-18,000 BP) in the UK. This lack of evidence should not, however, be taken to indicate a lack of maritime activity during this period around the UK, as the resources and technology required to construct small craft would certainly have been available to these early communities.

6.2.2 It has been suggested by human settlement patterns around the North Sea that sea voyages were conducted as early as 7,000 BC, during the Mesolithic period. The type of craft used for these voyages and how extensively they were used is unknown. Vessels for which there is archaeological evidence from the Mesolithic are logboats. The oldest logboat in Europe has been assigned the date range 7,920-6,470 BC and was found in Pesse in the Netherlands (McGrail 2004:173). Further examples of Mesolithic logboats include one discovered in Noyen-sur-Seine (France) dated to *c.*7190-6340 BC (McGrail 2004:173) and another from Lough Neagh in the north of Ireland, radiocarbon dated to *c.* 5300 BC (Breen 2004). It is generally thought that logboats were used for transport and fishing in inland and sheltered waters during the Mesolithic period. However, ethnographic evidence suggests that logboats can be modified making them suitable for use at sea.

6.2.3 Other simple craft seen in later contexts, such as the hide boat, may also have been used, although their light construction would make them much less likely to survive in the archaeological record. The marine transgression of the Mesolithic period saw the fairly rapid inundation of the lowland areas of the southern North Sea and the deposition of Holocene alluvial muds over the former land surfaces on which Mesolithic activity may have taken place. As such there is the potential for the survival of remains of such early craft beneath the alluvial deposits which are currently well offshore.

Neolithic and Bronze Age (4,000 – 700 BC)

6.2.4 By the early Neolithic (*c.*4,000 BC) the Study Area would have been completely submerged and its adjacent coastline would have attained a form approaching that of today. In providing a landscape rich in resources for hunting, fishing and shellfish collecting, evidence suggests relatively common Neolithic activity within the coastal and outer estuarine areas in the vicinity of the Study Area. Evidence relating to such specialist activities has been revealed in a number of places along the Essex coastline during the Hullbridge Survey (Wilkinson and Murphy 1995), such as the Neolithic sites at Rolls Farm (Blackwater Site 18 Hullbridge Survey) and the Stumble (Blackwater Site 28 Hullbridge Survey), located towards the centre of the coastal extent of the Study Area. The exploitation of coastal and estuarine resources in the Study Area is further suggested by a concentration of Neolithic finds near the major river estuaries in south-east Suffolk (Bradley *et al.* 1997:156).

6.2.5 The available archaeological evidence for the later Neolithic period suggests a fairly low-density human occupation within coastal and estuarine areas of the Study Area. This could be due to the poor survival of Neolithic sites rather than representative of a *de facto* low level of human activity (Wilkinson and Murphy 1995:71).

6.2.6 Logboats provide the only archaeological evidence in the UK directly relating to watercraft during the Neolithic period. Evidence relating to seafaring is provided by the discovery of a number of Neolithic vessels within the general vicinity of the Study Area, such as the Neolithic dugout canoe at Jaywick near Clacton (Warren *et al.*

1936). Watercraft may have facilitated the transportation of goods by water throughout the Neolithic. The discovery of porcellanite stone axes from Ireland on the UK mainland and the Western Isles of Scotland certainly implies trade and transport of goods by sea during this period (Breen and Forsythe 2004:32).

6.2.7 Marine contexts are generally regarded to offer a greater preservation to organic material than that provided by terrestrial contexts. As such, there is the potential for the remains of Neolithic watercraft to be present within the offshore extent of the Study Area, although the discovery of such material would be exceptionally rare. The Outer Thames Estuary REC further characterised the Neolithic landscape of the Study Area as of some potential for submerged terrestrially deposited archaeology, which if present would be predominantly found at the shallower western extent of the Study Area (Emu *et al.* 2009:53).

6.2.8 The scale of seafaring activities continued to grow through the Bronze and Iron Ages. Alongside this increase in the scale of seafaring, the chance for finding wreck related material within the Study Area, although still exceptionally rare, becomes slightly increased over that of the preceding periods (Emu *et al.* 2009:46).

6.2.9 There is evidence of significant advances in technology and vessel size from the Bronze Age onwards. Although dugout logboats were still used, evidence suggests that hide boats were also being constructed in the UK during this period. Other forms of Bronze Age watercraft include flat-bottomed sewn plank boats, a more advanced form of early water transport, suitable for a variety of functions and a range of environments.

6.2.10 Some of the earliest examples of Bronze Age watercraft in Northern Europe have been found on the east coast of Britain. Discoveries within the Humber Estuary, notably the Kilnsea fragment dating to 1,870-1,670 BC (Van de Noort *et al.* 1999) and the Ferriby boats 1, 2 and 3 built between *c.*2000-1,700 BC, suggest types of craft suitable for riverine, estuarine and possibly even sea-going use (Lillie 2005). A Bronze Age vessel found at Dover is certainly thought to have been seaworthy (Clark 2004; Crumlin-Pedersen 2006) and a paddle discovered in the Crouch estuary in Essex may be broadly contemporary with the Dover Boat (Wilkinson and Murphy 1995:104) thus strongly suggesting Bronze Age seafaring within the Study Area region.

6.2.11 The greater Thames Estuary would have provided a convenient landfall for cross-Channel traders from the Continent (Couchman 1980:42) and as such, it is possible that trading activities took place within the general vicinity of the Study Area during the Bronze Age. The discovery of what has been interpreted as a shipwreck, comprising 363 Middle Bronze Age objects of Continental origin offshore at Langdon Bay, Dover, certainly suggests maritime trade across the southern North Sea during this period (Fenwick and Gale 1998:26).

6.2.12 Bronze Age communities also continued to exploit the resources along the coast and within estuarine zones of the Study Area region. Marshes were used for grazing, and estuaries provided areas for hunting, fishing and shellfish gathering (Wilkinson and Murphy 1995:219). It was also during this period that other specialised coastal activities such as salt production first appear in the archaeological record (Wilkinson and Murphy 1995:132).

6.2.13 To facilitate this increasing level of exploitation of the coastal margins, Bronze Age communities built a variety of wooden structures commonly comprising fences, short trackways or brushwood masses to bridge creeks or areas of soft mud on the saltmarshes and mudflats, and short landing stages at the edge of the salt marshes to gain access to the channels (Wilkinson and Murphy 1995:164, 218). The rise in sea level of the Thames II transgression preserved a large number of these wooden structures within the intertidal zone of the Study Area in Essex (Wilkinson and Murphy 1995:132).

6.2.14 The attractive nature of the coastal pasture to Bronze Age communities is further attested by the distribution of Bronze Age sites within the Study Area region. The majority have a riverine or coastal distribution, clustering in the Stour valley, near the streams draining into the Colne, Chelmer and Blackwater and along the coast between Harwich, Clacton and above the Thames (Couchman 1980:40). Further to this, the distribution of ritual and funerary monuments around watercourses in Suffolk suggests that coastal and estuarine areas within the region may have had significance beyond that of transport and subsistence in the Bronze Age (Hegarty & Newsome 2004:31).

6.2.15 Archival searches as part of the Outer Thames Estuary REC reveal a rich record of Bronze Age sites in the onshore area adjacent to the Study Area, a large number of which were reported along the coastal margin, eroding out of beach contexts (Emu *et al.* 2009:46). As such, the potential exists for secondary context material dating to this period to be present offshore within the Study Area.

Iron Age and Roman (700 BC – 500 AD)

6.2.16 While sites dating to the Late Bronze Age/Early Iron Age transition appear to be concentrated along the principle river valleys in Suffolk and Essex (Bryant 1997:24), there is only limited evidence for settlement along the coast during the Iron Age. The remains of wooden structures facilitating access to and from the salt marshes indicate a continued exploitation in the coastal pasture during the Iron Age (Wilkinson and Murphy 1995:165). Salt production comprised an important element of this exploitation, as evidenced by the Red Hills in Essex, one of the more common types of sites within the county thought to represent the waste resulting from Late Iron Age and Roman salt working (Wilkinson and Murphy 1995:166). Salt-making is also thought to have occurred in Suffolk during this period, evidence for which has been discovered around the River Alde (Bradley *et al.* 1997:159).

6.2.17 It is clear that from at least the Iron Age onwards seagoing vessels passed through the southern North Sea. Trading ports investigated at Mount Battern in Plymouth and Hengistbury in Dorset, and Roman accounts of the Veneti people based in Brittany suggest that England's Iron Age populations were using sea-going sailing ships (Wessex Archaeology 2009:53). Despite this, evidence for early Iron Age seacraft is rare in the UK. A single plank from Ferriby dated to *c.*775-700 or 530-375 BC, suggests a continuing use of the plank-boat tradition. Of the 22 logboats recorded from the Thames and its tributaries, a number have been firmly dated to the Iron Age (Marsden 1996:222) attesting to seafaring activity within the vicinity of the Study Area.

6.2.18 The Outer Thames Estuary REC characterises the Study Area as an area for which there is possibility of finding material associated with the use of the offshore extent of the Study Area. Such material might be present in the form of inter-tidal structures at the shallowest extents of the Study Area or wreck material (Emu *et al.* 2009:53).

6.2.19 Following the establishment of the port of Londinium by AD50 (Merrifield 1983:32-6), the Thames Estuary region became a focus for overseas trade and commerce, with London the political and economic centre of Roman Britain. The sheer quantity and variety of imported goods from the Continent in the Thames Estuary region not only provides evidence of this role of London as the provincial distribution centre for overseas trade (Tyers 1985:41-2) but is also suggestive of a high density of shipping activity within the southern North Sea and English Channel during the Roman period. This is further supported by extensive evidence of quays and warehouses, the remains of which have been revealed in excavations in London (Milne 1985) and other ports in the Study Area region, such as that at Felixstowe on the Suffolk coast (Hegarty & Newsome 2004:49). Pottery concentrations discovered in Pan Sands, east of the Isle of Sheppey in the Thames suggest the potential for the survival of lost cargoes and shipwrecks from the Roman period (Hill *et al.* 2001).

6.2.20 Direct evidence of seafaring activity comes from the discovery of three plank-built vessels within the Thames Estuary; the Blackfriars ship I, the New Guy's House boat and the County Hall ship (Marsden 1994:15-130). Dating to the 2nd century AD, the Blackfriars ship I is the earliest known seagoing sailing ship discovered to date in Northern Europe, and is representative of a native Celtic tradition of shipbuilding (Marsden 1994:33). The New Guy's House boat provides the only known example of a vessel built in Britain within the Romano-Celtic tradition, dating to the late 2nd century AD (Marsden 1994:97). The County Hall ship dates to the late 3rd/early 4th century AD and provides an example of the Mediterranean tradition of shipbuilding (Marsden 1994:109). These substantially constructed plank-built ships were suitable for cross-Channel and ocean voyages, enabling goods to be transported through the region from the Continent and much further afield.

6.2.21 The exploitation of coastal and estuarine resources continued to take place during the Roman period. The earthwork sites known as the 'Red Hills' provide evidence for Roman salt working in Essex (Wilkinson and Murphy 1995:166). While the Suffolk coastal zone does not contain as large an area of reclaimed saltmarsh as seen in its neighbouring county of Essex, a number of possible Red Hill sites have been noted, indicative of at least some level of salt working industry within the county during this period (Hegarty and Newsome 2004:56).

6.2.22 The coastal zone within the Study Area was also strengthened by coastal defences during the Roman period. As the perception of the vulnerable stretch of coast within the Study Area increased with the threat imposed by Germanic incursions, a series of defended land bases were constructed around the coast of south east Britain, extending from the Wash to the Solent (Rodwell 1972:46). The Roman fort Othona on the Dengie peninsula provides one such example of the Saxon Shore defence system within the Study Area, located on the southern bank of the Blackwater estuary.

6.2.23 The Outer Thames Estuary REC characterises the Roman landscape of the Study Area as one with potential for material relating to the use of the offshore extent of the Study Area, including inter-tidal structures at the shallowest extents of the area and wreck material (Emu *et al.* 2009:53).

Early Medieval and Medieval (AD 500 – 1508)

6.2.24 The archaeological evidence for Anglo-Saxon settlement in Britain is poorly understood. There is no archaeological or historical evidence to indicate that London existed as a port and an organised urban centre from the 5th and 6th centuries AD after the collapse of the Roman Empire (Merrifield 1983:255-9; Vince 1990:12). With London no longer a distribution centre for traded goods, it is likely that the volume of seafaring activity decreased somewhat within the Thames Estuary region during the Early Saxon period, although small-scale local seafaring is likely to have continued.

6.2.25 Despite this, Saxon migration into Britain from the Continent in itself implies continued seafaring within the region during this period. This influx of Saxon settlers introduced Scandinavian-style clinker-built vessels into the UK. The Sutton Hoo ship, an early Anglo-Saxon ship burial found on a promontory overlooking the River Deben in Suffolk, not only represents the type of Northern European shipbuilding practices in use during this period, but provides evidence of the perceived social or cultural importance of ships and seafaring to those living within the vicinity of the Study Area at this time (Bruce-Mitford 1972; Evans 1994).

6.2.26 In the 7th and 8th centuries there is indirect evidence of overseas trade in the development of settlements on both sides of the North Sea with the Germanic word-element *wic,* which means 'trading place', in their names (Friel 2003:25). *Ludenwic*, which was established to the west of the Roman city walls of Londinium, was under the successive control of the Kings of Kent and Mercia, and by the mid 7th century AD, it had been established once again as an important trading centre (Marsden 1994:131). The discovery of coins dating to the 7th and 8th century AD in southern England, northern Netherlands and around the mouth of the River Rhine points to a trade conducted by Saxon and Frisian merchants across the southern North Sea (Hill 1958).

6.2.27 The exploitation of the coastal zone continued into the Saxon period. Although there is little evidence relating to salt-production which had formed a significant element of the Roman economy in the Study Area region, the coastal marshes continued to be valued and were principally used for sheep-pasturage in the Anglo-Saxon period. In enabling the production of cheese, meat, skins and wool, these sheep pasturages were regarded as highly valuable, and both coastal and inland villages were given rights of pasture (Wilkinson and Murphy 1995:208). Fisheries were also an important component of the maritime activity along the region's coastline during the Saxon period. Aerial photographs from Essex have revealed the remains of a number of fish-weirs, notably off Bradwell and Mersea Island (Clarke 1993, Crump and Wallis 1992). The remains of a fish-trap in Holbrook Bay, Suffolk have also been found, dating to the Anglo-Saxon period (Hegarty & Newsome 2004:61-63).

6.2.28 Two primary types of vessels are thought to have been used within the Thames Estuary region during the Saxon period (Milne 2003:37). Logboats were used for transport along the inland waterways within the region. Evidence of such vessels within the Study Area region comes from a dugout canoe radiocarbon dated to between 775 and 892AD (Wessex Archaeology 2003:33). The canoe, which was trawled up by a fisherman 1-2 miles off Covehithe, is thought to have either washed out of a river valley or to have sank while travelling along to coast close to the shore (Wessex Archaeology 2003:33). The remains of dugouts have also been found at Walthamstow dating to the 7th century AD (Marsden 1996:222) and Hackney dating to 950-1000 AD (Marsden 1997:56-59).

6.2.29 The other type of vessel used within the Thames Estuary region was a larger, planked boat, propelled by oar or sail that was suitable for use within the estuaries, along the coast or across the Channel. An example of such a vessel is the Graveney Boat, a Saxon clinker-built vessel with seagoing capabilities discovered in a marsh in north Kent (Fenwick 1997:175-6).

6.2.30 Viking raids on the British coast started in the 8th century AD. In AD 842 and AD 851 the Viking raiders passed through the Study Area *en route* to London, indicating a presence of these overseas invaders within the general vicinity of the Study Area. At various times, Mersea, Shoebury, Benfleet and Sheppey were all used as Viking bases at various times during this period (Williams and Brown 1999:13). Despite the

Viking raids, England's existing trade routes across the North Sea continued to function during the 9th century, although a lower volume of trade passed along them (Friel 2003:44).

6.2.31 After King Svein of Denmark established himself as King of England in AD 1013, the North Sea would have been important in providing a communication, trade and migration route from the Scandinavian home countries to Britain during the Late Saxon period. This importance of waterborne trade continued after the Norman Conquest of AD 1066, demonstrated by the extensive use of Kentish Rag and Reigate stone in the churches of south and east Essex (Williams and Brown 1999:13).

6.2.32 The early medieval period saw an expansion of maritime trade which remained a central component of London's wealth, and seafaring within the Study Area region intensified. In addition to London as an important hub of maritime activity at this time, the coasts of Essex and Suffolk had a number of ports that would have attracted significant maritime activity. This is evidenced by the harbour at Harwich, Essex, which was a centre for thriving trade and seafaring activity during the medieval period. It was from this harbour that in 1340 Edward III sailed his fleet to gain his victory over the French at Sluys (Wessex Archaeology 2003:33). Suffolk was also an important centre of maritime activity and East Anglian ports enjoyed a degree of eminence throughout the medieval period (Malster 1969:3). Hollesley Bay on the Suffolk coast provided an attractive shelter to ships, and was large enough to accommodate large fleets (Wessex Archaeology 2003:33).

6.2.33 The increase in the exploitation of marine food resources through the medieval period saw a growth in fisheries in the Study Area region. At Culver Street, in Colchester, fish bones were markedly more common in medieval deposits than in Roman ones (Murphy 1997:64) and at least 28 localities for fisheries were noted in the Domesday Book records within Essex (Darby 1952:245). Similarly, in Suffolk fish bones are exceedingly common in medieval urban deposits (Murphy 1997:64) and many coastal settlements such as Southwold and Aldeburgh established fishing industries in the late medieval period, particularly with the development of the Icelandic fisheries (Oxford Archaeology 2007:12). Fishing activity within the Study Area is further attested to by the discovery of a timber fish trap in the mudflats of the intertidal zone of the Stour in Holbrook Bay, Suffolk, dating to the middle Anglo-Saxon period (Everett 2007:4-7).

6.2.34 The Thames Estuary has a rich archaeological record for the remains of ships, boats and waterfronts dating to the medieval period. A number of ship timbers dating to the 10th and 11th centuries have been discovered at wharves in Southwark and the City of London (Marsden 1996). During the 13th and 14th centuries, shipbuilding practices altered to construct deep-draught vessels carrying fore- and after-castles and hung rudders. This change in ship building practices saw the development of large merchant vessels such as cogs and hulcs and keels needed to accommodate larger cargoes (Kemp 2002).

6.2.35 From the 12th to 15th centuries, the remains of ships within the Thames Estuary are predominantly seen to be found in two contexts; as shipwrecks sunk in the bed of the River Thames and as parts of broken-up hulls re-used in waterfront structures (Marsden 1996:20). The remains of three ships - the late 12th century Custom House Boat, and the Blackfriars ships 3 and 4 both dating to the 15th century - provide examples of seafaring vessels from the middle to late medieval period in the Thames Estuary region (Marsden 1996).

6.2.36 By the late medieval period, purpose-built warships were constructed and the shipbuilding practices for both warships and merchant vessels were adapted to cope with an increase in tonnage. In order to facilitate the propulsion of these more substantial vessels, the single mast was replaced by three or four masts and extra rigging (Wessex Archaeology 2009:55). The introduction of the carvel technique of flush planking became a common shipbuilding practice for larger craft throughout Europe, although the clinker technique continued to be used on smaller vessels. The development of reliable navigation techniques had further implications on medieval maritime activity, enabling long oceanic voyages and greater distances to be travelled (Kemp 2002).

6.2.37 The medieval period relating to the Study Area was characterised by the Outer Thames Estuary REC as having potential for archaeological material relating to the use of the Study Area, taking the form of both inter-tidal structures at the shallowest extent of the area and to a greater degree, wreck related material (Emu *et al.* 2009:53). The REC notes that the known maritime resource within the Study Area must be viewed as a base-line, whereby the possibility exists for a greater number of currently uncharted wrecks relating to this period within the Study Area (Emu *et al.* 2009:53).

6.3 COASTAL AND SEAFARING ACTIVITY: 1509 - 1815

6.3.1 Maritime activity in the wider region of the Study Area expanded dramatically in the Tudor period. With the opening up of the New World and the founding of the East India Company in 1599, the Thames Estuary region became one of the centres of large-scale global commercial shipping activities (Williams and Brown 1999:13). Direct evidence for commercial shipping within the Study Area is provided by the 'Gresham Ship' wreck, a carvel built merchant vessel found in the Princes Channel in the Thames Estuary, with ship timbers dating to 1574 (Auer and Firth 2007). Carvel-built vessels prevailed throughout this period, although the discovery of a 16th century reverse clinker boat in Southwark not only provides further evidence of shipping activity within the region but also suggests variability in shipbuilding practices during this period and the persistence of older construction techniques (Marsden 1996:136).

6.3.2 Naval warfare played a significant role in the region during the period, encompassing both military engagements and supporting actions. A number of naval dockyards were established in places such as Deptford, Woolwich and Greenwich, although these were gradually superseded by yards further from London, such as Harwich in Essex and Chatham in Kent (Wessex Archaeology 2005:40).

6.3.3 The Anglo-Dutch Wars of the 17th century provide an example of naval warfare in the Study Area region. The Anglo-Dutch Wars are marked as significant events in the history of naval warfare, whereby as struggles for commerce rather than territory, they were paramount in determining the development and control of the trade routes across the sea. The Raid on the Medway, which occurred in 1667 as part of the Second Anglo-Dutch War (1665-7), saw Dutch ships penetrate the Thames Estuary up the River Medway as far as Chatham, destroying a large proportion of the British fleet. The Raid on the Medway remains the greatest naval defeat of England. Further naval conflicts relating to the Anglo-Dutch Wars took place off the coast of Suffolk, including the Battle of Lowestoft 1665 which was the first engagement of the Second Anglo-Dutch War and the Battle of Sole bay 1672 which was the first engagement of the Third Anglo-Dutch War (1672-4).

6.3.4 This period also saw the development of fortifications along the coastline within the Study Area. With a long and low-lying shore facing the Continent, the region was considered to be at risk from raiding and invasion during the post-medieval period and major defences were built from the reign of Henry VIII onwards (Gilman 1997:67). These defences were predominantly located on the coast, with particular attention paid to the Thames Estuary and ports and harbours such as Harwich which were considered to be vulnerable to seaborne attack (Gilman 1997:67).

6.3.5 Coastal, estuarine and overseas shipping continued to be a significant component of the trading and exporting of goods to and from the Study Area region throughout the post-medieval period. London was an important centre for overseas commerce at this time, and at the beginning of the Industrial Revolution towards the end of the 18th century it was estimated to carry 77% of the value of all Britain's foreign trade (Williams and Brown 1999:13). Lowestoft, Parkeston Quay (Harwich) and Ipswich also emerged as important centres during this period (Gould 1997:74). The completion of the Chelmer and Blackwater navigation helped to reshape maritime trade in East Anglia during the 18th century, and further increased the volume of commercial traffic transversing the Study Area (Emu *et al.* 2009:50). Direct evidence for shipping in this period is provided by the South Edinburgh Channel wreck, thought to be a large unidentified Swedish vessel released in the early 19th century. The vessel may have been one of a number of large armed Swedish merchant vessels which exported goods from Sweden to London for onward export to the Indies. The South Edinburgh Channel wreck is designed under Section 1 of the Protection of Wrecks Act 1973.

6.3.6 Alongside overseas ventures, inland navigation and local coasting continued to be important within the post-medieval period. East Anglia was at the forefront of the 'Agricultural Revolution' in the 18th century, whereby communications were developed to serve the farming economy (Gilman 1997:67). Consequently, a number of Parliamentary Acts were passed towards the end of the 17th century in East Anglia in order to improve these inland routes within the region (Gould 1997:74). The Blackfriars ship 2, a 17th century clinker-built vessel discovered in the City of London, further supports this riverine activity within the Study Area region (Marsden 1996:145). The vessel has been interpreted as a river vessel, and traces of previous cargos of coal have been discovered within the remains (Marsden 1996:145), suggesting the use of inland navigation in the transportation of bulk commodities during this period.

6.3.7 The exploitation of marine food resources continued to comprise a significant aspect of the maritime activity within the Study Area during the post-medieval period. Many coastal towns had fishing fleets with associated harbours, and the Essex coast provided a valuable resource of shellfish and oysters for the post-medieval communities (Gould 1997:77). There are a number of abandoned boats associated with these activities within the extensive creek system in the Study Area region (Gould 1997:77). For example, in an area north-east of Crane's Creek in Suffolk the remains of a probable post-medieval oyster dredger have been discovered adjacent to oyster beds and a late 19th century boat hard (Hegarty and Newsome 2004:112). Fishing activities continued to grow in importance with the development of deep sea fishing in the 19th century (Rasmussen 1985:217). Coastal centres such as Lowestoft enjoyed an expansion in their fisheries, resulting in a high density of shipping activity and traffic across the Study Area.

6.3.8 With regards to the post-medieval period, the Study Area is considered by the Outer Thames Estuary REC to be a zone of intense civilian and military use, for which there is a possibility for finding associated evidence within the Study Area (Emu *et* *al.* 2009:53). Archaeological material within the Study Area for this period is considered to predominantly comprise of wreck material, a significant proportion of which have already been documented (Emu *et al.* 2009:53).

6.4 COASTAL AND SEAFARING ACTIVITY: 1815 - 1913

6.4.1 In the late 18th and early 19th centuries, merchant vessels and warships alike were dominated by wooden sailing vessels. However, during the course of the 19th century the technological innovations of the Industrial Revolution brought fundamental changes in maritime technology, which amongst other advances in naval engineering, enabled the development of steam propulsion and iron and steel construction. However, despite these advances there was some time between their earliest use to their widespread adoption, and as such the early years of this period continued to be dominated by wooden sailing vessels such as schooners, brigs, brigantines and snows (Breen and Forsythe 2004:127-128).

6.4.2 The use of iron in shipbuilding can be dated back until at least the late 18th century, but it did not displace wood as the primary construction material in shipbuilding until the 1860s and 1870s (Ville 1993:52). Initially, iron was used to supplement structural elements in shipbuilding, although it was later used to frame vessel and provide the covering of the hull. Further advances in hull construction took place with the introduction of steel in shipbuilding practices. Steel was used periodically for ship construction from the late 1850s but did not supersede iron generally until the introduction of the Bessemer and Siemens processes in 1885 (Greenhill 1993:89; Ville 1993:52). The use of metal in shipbuilding enabled the construction of more durable vessels with a larger stowage capacity (Ville 1993:73).

6.4.3 The advent of the steamboat brought a new type of traffic to the Study Area. Early steamers were propelled by use of paddle wheels, and equipped with single cylinder engines and low pressure boilers. Steamships were quickly put to use for coastal voyages and shorter cross-Channel passages, and by the 1820s steamboat transport formed an extensive network around the British Isles (Pearsall 1985:195). Paddle steamers were high in coal consumption, thus limiting their range and competitiveness, and as such they were largely confined to the passenger trade where reliable quick passages were more important than cost (MacRae and Waine 1990:11). This form of shipping activity soon became prevalent within the Thames Estuary region. By 1831 about 120,000 passengers travelled annually from London to Margate (Wessex Archaeology 2005:40).

6.4.4 The introduction of the screw driven vessel in the 1830s provided an alternative and more efficient means of propulsion than that afforded by the paddle wheel. The screw, coupled with the compound engine which was introduced in 1854, halved coal consumption, both reducing running costs and enabling a larger volume available for cargo on short voyages or double the mileage covered for a given bunker capacity (Thomas 1992:11). Further advances in the 1880s saw the construction of high pressure steel boilers at competitive costs and the consequent application of the triple expansion engine, leading to the production of vessels which could be operated with a much greater efficiency and was more economical than a sailing vessel (Allington and Greenhill 1997:6).

6.4.5 In the 19th century, there was a dramatic growth in sea trade. Imported raw materials guaranteed a continuing high level of trade (Jackson 1983:113) and between 1876 and 1913, the tonnage entering or clearing UK ports increased from 117 million tons per annum to 295 tons. Britain was at the forefront of the trade expansion, and in the 1870s British merchant tonnage was larger than the combined tonnage of the three major European maritime nations (Simper 1982:61). The steamship enabled long-distance trades to grow rapidly which was further enhanced by the opening of the Suez Canal in 1869 which provided a route which cut several miles off voyages to the Orient. The introduction of the railway and the advent of the more economical steamship further stimulated trade with Europe. The laying of the trans-ocean telegraph cables further revolutionised trading patterns, with the first successful Atlantic cable laid in 1865. Within a decade a network had been established linking the major cities of the world with London.

6.4.6 London, as the chief population and production centre, continued to be a hub for British commerce and was a major instigator and beneficiary of the colonial trade during this period. London dominated foreign trade, both by providing a transhipment point for foreign and colonial goods, and by attracting a huge coastal traffic which catered for the capitals demand for foodstuffs, fuel and building material (Jackson 1986:96).

6.4.7 Coastal traffic also continued to grow during the 19th century, though at a diminishing rate, up to 1913, experiencing the largest coastal tonnages on record (Jackson 1983:114). It was not until 1880 that the tonnage of vessels carrying goods out of the country regularly exceeded that clearing coastwise (Jackson 1983:114). The transport of coal was a major contributor to coastal trade, whereby some 22 million tons were carried coastwise, including around 9 millions for the London market (Jackson 1983:117).

6.4.8 This growth in sea trade, coupled with the technological innovations regarding propulsion and hull construction saw the introduction of more specialised vessels, such as the tramp steamer. Tramp steamers were designed to carry bulk goods, and ran on an *ad hoc* basis, when the owner had obtained enough cargo (Dawson 2005:40). The use of steam also enabled the possibility for ships to be operated on a regularly scheduled basis also saw the introduction of passenger liners and liner traders. Ocean liners traded on scheduled routes and sailed at advertised times. In 1900, London, alongside Liverpool and Glasgow, were home to regular passenger and cargo liners, and between them they owned 66% of British shipping and 64% of steamships in 1900 (Jackson 1986:104).

6.4.9 These advances in technology also radically affected warfare, providing steam-powered ironclad warships which could operate regardless of the limitations imposed by winds and tides (English Heritage 2000). However, the period from late 19th century onwards is characterised by the absence of major naval warfare or any form of fleet manoeuvres designed to reproduce possible strategies and tactics for war, thus there was a general lack of consideration for the development of the fleet as a whole during this period (Roberts 1992:105). It was not until the late 19th and early 20th century that the increasing threat imposed by Germany saw the development of the Royal Navy to a more homogenous fleet. Between 1900 and 1914, the Royal Navy underwent a rapid revolutionary change which effectively resulted in the total replacement of the frontline ships of the fleet with vessels that were larger, more powerful, and in terms more capable to the conditions of naval war (Roberts 1997:7).

6.4.10 The recording of ship losses was better centralised in the late post-medieval period, and as such, the available record of shipping casualties is both more complete and accurate. The incorporation of metal elements within vessel designs also means that wrecks dating to this period are often more evident on the seabed than their predecessors as their upstanding components are apparent to bathymetric and geophysical survey, and they generate strong magnetic anomalies.

6.5 COASTAL AND SEAFARING ACTIVITY: 1914 - PRESENT

6.5.1 The technological innovations associated with the Industrial Revolution had a profound impact of naval warfare which was to have significant implications on the world wars of the 20th century. The progress of the steam engine, the torpedo and steel hull construction revolutionised both ship-building and tactics (Whitley 2002:7). These advances in naval engineering enabled the construction of larger and faster vessels with improved endurances and equipped with better armaments.

6.5.2 The Study Area was a focus for military activity during both World Wars. The southern North Sea provided an obvious arena for naval action between Britain and its Continental adversaries (Till 1985:227) and the sheer number of vessels lost during this period was immense. The new technologies of submarine, torpedo and mine were largely responsible for the huge toll, coupled with the outright intention by all sides to intentionally destroy shipping, a deviation from earlier centuries where maritime conflict was primarily concerned with blockade or capture (Wessex Archaeology 2009:60, 2008e).

6.5.3 The approaches of the Thames Estuary had long been subject to a high volume of shipping activity, and World War I further increased the demand for shipping during this period. Alongside military requirements, the need for raw materials to be shipped to Britain intensified which ensured that the Thames Estuary region continued to see a high level of commercial shipping activity. Britain relied on shipping for much of its food, and used armed convoys to protect merchant vessels transporting cargoes across the southern North Sea. This vulnerability was recognised by the German navy which developed the Unterwasserbooten. The effects of the U-boat offensive was disastrous for Britain, whereby so much shipping was sunk that at one time there was only enough food in Britain to last three weeks (Maw 1999:1). Although there was great hostility directed at warships, the greatest losses in this period were amongst merchant vessels. During WWI the merchant convoys that traversed the southern North Sea were obvious targets for the Germany navy (Bowyer 2003:25; Maw 1999:1) and from February 1917 to January 1918, an average of 46 German U-boats were at sea in any one month, sinking a total of 2,684 British merchant ships (Miller 2004:8).

6.5.4 The onset of the Inter-War years saw a brief post-war boom in shipbuilding to replace the merchant shipping tonnage lost in WWI, but soon fell following the Great Depression and the Wall Street Crash of 1929 (Lavery 2004:300). Despite this, Britain was still the largest shipbuilding nation and the British merchant fleet remained the largest in the world, though at a declining rate (Lavery 2004:300-1). Ports such as London saw increases in their trade in the Interwar period as they had the facilities to cope with the growing sizes of cargo ships and liners (Friel 2003:268). Many of the larger ferry ports, such as Dover and Harwich, also grew as they were able to handle throughputs of passengers and cargo at appreciable speed (Friel 2003:268). The Thames Estuary region would have thus continued to be subject to a high volume of shipping activity, and of the vessels which passed through the Study Area in this period, a number are expected to have been lost due to natural causes or collision.

6.5.5 The advent of air power brought another dimension to warfare in the 20th century, providing aircraft capable of destroying both military and merchant ships, a strategy which was amplified throughout WWII (Bowyer 2003:26). Boats and ships were a legitimate target for enemy aircraft and the accuracy and effectiveness of the dive-bombing techniques became measurably increased (Whitley 2002:12). Submarines also continued to pose a significant threat to shipping in WWII (Whitley 2002:12). Large scale shipping losses were experienced during WWII. The British Royal Navy alone lost a total of 75 submarines, over 350 major warships and more than 1000 smaller vessels (Friel 2003:248-9).

6.5.6 The volume of hostile activity in the Study Area region during WWII is attested by the Maunsell Sea Forts, small fortified towers which were built in the Thames and Mersey estuaries in order to help defend the United Kingdom. The Sea Forts were intended to deter the German air raids and attempts to lay mines in the estuary.

6.5.7 Maritime activity within the Study Area region throughout the post-war era is multi-faceted. Providing an arena for military, commerce and leisure activities and an environment capable for overseas, coastal and inland voyages, a diverse array of boats and ships continued to enter the archaeological record after 1945. London remains the leading port in the United Kingdom, handling 56 million tonnes of cargo in 1997 (Friel 2003:271). Although ships and boats are less numerous than in preceding years, the overall volume of seafaring activity continues to be very high (Wessex Archaeology 2009:61).

6.5.8 Archaeological material within the Study Area relating to the modern period is characterised by the Outer Thames Estuary REC as relating to intense civilian and military use, predominantly taking the form of numerous wreck sites (Emu *et al.* 2009:53). Due to the intensity of activity within the Study Area during this period, the potential exists for the presence of currently uncharted wreck sites.

6.6 MARITIME ARCHAEOLOGY: SUMMARY

6.6.1 From the above it is thus clear that there is the potential for the remains of vessels which date from at least the Mesolithic period to the present day within the Study Area. The density of marine traffic which has passed through the Study Area since the Mesolithic is immense. Furthermore, by its close proximity to the Continent and its position on the approach to the River Thames, the Study Area would have not only provided access directly to the capital, and other large ports and harbours along the coasts of Suffolk and Essex, but also further afield to Europe and beyond. With this quantity of shipping activity within the region, the potential for the remains of vessels within the Study Area is clearly very high.

6.6.2 This potential is further enhanced by the nature of the seabed topography within the Study Area. The highly mobile and numerous sandbanks which characterise the shallow geology of the region have the ability to swallow shipwrecks of considerable size. An example of this is provided by the *Stirling Castle*, a 152 foot long, 70 gun warship which was lost on the 27th November 1703 and stood 20 feet proud of the seabed when it was discovered within the Goodwin Sands sandbank off Ramsgate in Kent, south-east England (Fenwick and Gale 1998:96). These sandbanks also often provide favourable preservation for shipwrecks. Although in some cases the remains of vessels would not survive due to post-depositional processes, the debris field of a wrecking incident may also be sealed within the sandbanks.

6.6.3 Consideration must also be given to the potential for isolated finds that may have come to be on the seabed having been lost or discarded overboard. Such finds may not only be useful in defining the preferred sea routes within the Study Area throughout the centuries, but may also provide evidence for other maritime activities, such as overseas commerce and naval warfare. A number of finds reported through the English Heritage/British Marine Aggregate Producers Association Protocol for Reporting Finds of archaeological interest (http://www.wessexarch.co.uk/projects/marine/bmapa/index.html) highlight the importance of isolated finds. Since the start of the Protocol in 2005, a number of cannon balls have been found in material dredged from licence area 430, approximately 25km south-east of Southwold on the Suffolk coast. Following an assessment of their calibre, it became apparent that these cannon balls may derive from two 17th century naval battles of the Anglo-Dutch Wars which took place in this vicinity; the Battle of Lowestoft 1665 and the battle of Sole Bay 1672. Their discovery is thus not only important in relating to this significant episode of Britain's maritime history, but also in being indicative of the density of maritime activity within the region during the post-medieval period.

6.7 RECORDED WRECKS

6.7.1 Based on the charted sites listed by SeaZone and the recorded losses listed by the NMR, the baseline data has been used to provide a broad understanding of the nature and density of maritime activity within the Study Area. It is not within the scope of this report to discuss each record contained within the SeaZone and NMR data on an individual basis.

SeaZone

6.7.2 A total of 1537 charted sites were listed in the SeaZone data within the Study Area. Using the 'Feature' attribute listed within the SeaZone data, these records were subdivided into those classified as wrecks and obstructions. An 'obstruction' is defined by SeaZone as 'an object on the seabed of known or unknown source that is neither a wreck nor infrastructure and which may hinder safe passage or other activity'. Despite this definition, through an assessment of the SeaZone obstructions for the Study Area, it became apparent that a number contained references to shipwreck material.

6.7.3 In order to account for this, a further query based on the type of site defined these records once more into categories of 'wrecks' 'aircraft' and 'unspecified' sites. Unspecified sites are UKHO survey contacts which may either be wrecks for which there is limited data, or sites which may or may not be wrecks (i.e. obstructions) and whose nature and origin cannot be defined on the basis of available survey data. The results of these queries are shown in **Table 8** below. A total of 14 aircraft sites were listed within the SeaZone data. These sites are considered in **Section 7** and are thus omitted from **Table 8**.

SeaZone Feature	**Type of Site**		**Total**
	Wrecks	Unspecified	
Wrecks	561	452	1013
Obstructions	83	441	524
Total	644	893	1537

Table 8: SeaZone charted vessels and unspecified sites

6.7.4 In order to provide a broad overview of the density and nature of maritime activity within the Study Area as implied by the SeaZone data, a number of queries were conducted based on the date of the charted wrecks and obstructions. The composite time line for shipwrecks around England, produced by Wessex Archaeology (2008d), was used as a framework in which to sort the dates of these charted sites (see **Section 6.1**). **Table 9** below shows the results of the queries conducted on the SeaZone data based on these date ranges classified within this composite time line. These sites are illustrated in **Figure 12**.

Date	Wrecks	Unspecified	Total
<1508	0	0	0
1509-1815	1	0	1
1816-1913	5	0	5
1914-1945	429	18	447
>1946	106	17	123
Unknown	103	858	961
Total	**644**	**893**	**1537**

Table 9: SeaZone wrecks and unspecified sites queried by date range

6.7.5 In order to identify any distribution patterns associated with vessel wrecking incidents, a 10km² grid square was implemented across the Study Area within ArcView GIS software. Shipwreck sites listed as both Wrecks and Obstruction features within the SeaZone data were joined to the grid by spatial location, ultimately enabling the calculation of the density of wreck sites within each grid square. The wreck site density was sorted into five distinct classifications ranging from grid squares with a nil or low density of wreck sites to those with a relatively high density of wreck sites. Each classification was colour coded using graduated colours, with pale pink representing the lowest density of wreck sites and red representing the highest density of wreck sites within the grid squares. The results of this statistical analysis are illustrated in **Figure 13**.

6.7.6 Overall, the wreck sites are dispersed fairly randomly throughout the Study Area, although distinct areas of concentration have been noted. The highest density of wreck sites occurs at the north of the Study Area off the Suffolk coast, some 10km east of Aldeburgh. The remains of vessels within this area may have foundered on the headland-associated bank known as the Aldeburgh Ridge or the Aldeburgh Napes.

6.7.7 A further concentration of wreck sites has been noted within the centre of the Study Area extending from the Harwich Haven region. As an area of shallow reefs and shoals a large number of vessels are likely to have foundered in this vicinity. The density of wrecks within this region may also reflect a relatively high density of shipping activity in this area.

6.7.8 To the south of the Study Area, concentrations of wreck sites appear to correlate with the Margate Sands to the north of Margate, Kent, and the Maplin Sands east of Foulness Island. This is not surprising, as it is expected that a great number of vessels were lost after foundering on the extensive shallow sand banks such as these which characterise the surface geology of the Study Area.

Shipping Casualties

6.7.9 A total of 2017 recorded losses were listed in the NMR within the Study Area. It is important to note that the positions of recorded losses are often vague and inaccurate and also only represent those loses which were actually recorded.

6.7.10 The recorded losses were sorted into two categories entitled ‘wrecks’ and ‘aircraft’. A total of 126 aircraft were listed in the NMR data and are considered in **Section 7**.

A further query classified the wrecks into the date range discussed above (**Section 6.1**). The results of these queries are presented into **Table 10** below and illustrated in **Figure 14**.

Date	Shipping Casualties
<1508	7
1509-1815	575
1816-1913	1087
1914-1945	213
>1946	8
Unknown	1
Total	**1891**

Table 10: NMR shipping casualties queried by date range

Discussion

6.7.11 The charted sites and shipping casualties should not be regarded as directly representative of the wreck sites that lie on the seabed within the Study Area. Prior to the advent of the Lloyds of London list of shipping casualties in 1741, there was no central record of ship losses and as such the record of shipping casualties is biased towards wrecking incidents which occurred from the mid 18th century onwards. It must also be taken into account that the shipping casualties refer to wrecking incidents for which there are no known positions other than a description of the general area and may consequently lie outside the Study Area.

6.7.12 In addition to the sites known to exist in the Study Area, the discussion of the maritime archaeological potential within the Study Area indicates that there is potential for uncharted and unknown wrecks sites to lie within the Study Area. To demonstrate this potential the results of a number of previous archaeological assessments undertaken by WA within and in the immediate vicinity of the TEDA MAREA Study Area were reviewed (below), as illustrated in **Figure 4**:

Cutline Areas 446 and 447 (Wessex Archaeology 2003)	A desk-based assessment of the potential impact on archaeological remains from the proposed aggregate extraction areas 446 and 447 in the Thames dredging region. A total of 21 geophysical anomalies were identified by the geophysical assessment, 13 of which are thought to represent charted sites. The remaining six anomalies were not thought to represent wreck sites.
Cutline Area 447 (Wessex Archaeology 2008a)	An archaeological assessment of the geophysical data collected from licence area 447. A total of 81 geophysical anomalies were identified in this report, 13 of which are thought to correlate with charted sites. Of the remaining 68 anomalies, 30 are described as having archaeological potential and may thus be wrecks or other anthropogenically derived material.

Bathside Bay (Wessex Archaeology 2003b)	An archaeological interpretation of existing marine geophysical data in the channel of the River Stour. Within the Study Area, a total of 13 anomalies were identified. One anomaly is thought to represent a wreck. A further four irregular anomalies have been described as being human in origin. Six sites have been identified as probable mooring blocks and the remaining two sites are thought to represent debris or rocks.
Felixstowe South Reconfiguration (Wessex Archaeology 2003c)	An archaeological assessment of geophysical data. Within the Study Area, a total of 37 anomalies were identified. One charted wreck was identified and two further anomalies which were thought to represent wreckage from this site. In addition to this, five sites with high archaeological potential were noted, characterised by a correspondence between magnetic and bathymetric anomalies. Sites picked up by magnetometer surveys contain metal elements and are thus often humanly derived. Five sites composed of bathymetric anomalies were considered to be of medium archaeological potential, and the remaining 24 sites were considered to be of low or very low archaeological potential.
Gunfleet Sands (Wessex Archaeology 2002)	As part of an EIA, this report comprised a desk-based assessment of the potential effects on archaeological remains of a proposed wind farm development on an area of seabed off the South Essex coast. The proposed development area lies on and immediately adjacent to a sandbank know as Gunfleet Sands, which lies approximately 6km off the Essex coast to the south-east of Clacton-on-Sea. Within the Study Area, 48 charted sites and 32 geophysical anomalies were identified. Of the geophysical anomalies, a total of five were thought to represent possible uncharted wreck sites.
Gunfleet Sands 1 and 2 (Wessex Archaeology 2008b)	This report was prepared as a Written Scheme of Investigation (WSI) for the construction, operational and de-commissioning phases of the Gunfleet Sands 1 and 2 offshore wind farms. Within this Study Area, 34 geophysical anomalies were identified, three of which are likely to represent wrecks.
London Array Offshore Wind Farm (Wessex Archaeology 2005)	An archaeological desk-based assessment that considered the potential impact on archaeological remains from a proposed wind farm development within the Outer Thames Estuary. The site lies approximately 20km from the Kent and Essex coastlines. Searches were run within two Study Areas; the Wind Farm Study Area (WFSA) and the Cable Route Study Area (CRSA). Of the 277 geophysical anomalies identified within the WFSA, 31 are thought to represent charted wrecks or obstructions and 12 are thought to represent possible uncharted wreck sites. No geophysical data covering any of the wrecks in the CRSA was reviewed by WA.
Thames Estuary Offshore Wind Farm (Wessex Archaeology 2003d)	A summary of the archaeological issues relating to the development of a wind farm facility on the Long Sand and Shingles Bank in the Thames Estuary and provided an initial summary of the known and potential archaeological resource within the vicinity. 59 known wrecks and obstructions were noted within the Study Area, but no geophysical data was assessed to supplement this data.

Thanet Offshore Wind Farm (Wessex Archaeology 2005a, 2006)	Desk-based study to assess the potential impact on archaeological remains from a proposed wind farm development off the north-east Kent Coast. Information was collated from two areas, a marine Study Area (MSA) and a Coastal Study Area (CSA). Within the MSA, 71 known wrecks or obstructions were noted. As part of the same project, an archaeological assessment of the geophysical data was collected in order to inform the environmental assessment for the Thanet Offshore Wind Farm project. A total of 130 anomalies were identified from the geophysical data. Of these, a total of 14 represented charted wrecks and obstructions which were identified and a further five anomalies represented charted wrecks which were situated outside the Study Area for the desk-based assessment (66070.03). A total of three geophysical anomalies were identified which were though to represent uncharted wreck sites.
London Gateway	As part of the channel deepening for the DP World Container Port Development, an archaeological assessment was carried out by WA for the main shipping channel in the Thames. However, the majority of the archaeological investigations for this project were carried out outside the Study Area.

7 AVIATION ARCHAEOLOGY

7.1 INTRODUCTION

7.1.1 Since the advent of powered human flight in the early 20th century, thousands of military and civilian aircraft have been lost around the UK, and aircraft losses at sea span the entire period of aviation history, from the introduction of flight to the post-WWII period. However, although records of aircraft losses at sea are extensive, data regarding their location is limited.

7.1.2 A guidance note published by English Heritage (EH) entitled *Military Aircraft Crash Sites* (English Heritage 2002) outlined a case for recognising the importance of aircraft crash sites, specifically with regards to existing and planned development proposals which may have an impact on such sites. The guidance note argues that aircraft crash sites not only have significance for remembrance and commemoration, but they also have an implicit cultural value as historic artefacts, providing information on the aircraft itself and also the circumstances of its loss (English Heritage 2002:2).

7.1.3 Although the extent of knowledge of air crash sites on the seabed is limited, WA has broadly characterised the resource by drawing out a few generalisations on importance and special interest (Wessex Archaeology 2009:62). It is with regards to the three broad chronological divisions outlined by WA that aviation archaeology will be discussed here:

- **Pre-1939**: The period of intense and rapid development of a new technology, from the advent of powered flight to the outbreak of WWII. Although at least 119 different aircraft models were used by the military in the UK during this period, examples of only 24 survive today anywhere in the world. This, alongside the fragility of the airframes and the relative scarcity of flights over water deem any aircraft remains dating to this period of special interest;
- **1939-1945**: By the onset of WWII, advances in technology had greatly extended the reliability and range of aircraft. Such technological innovation enabled aircraft to increasingly undertake long-range flights, including many flights across the Study Area. This period also saw the highest number of aircraft casualties – and human casualties – in the history of aviation and as such has special significance;
- **Post-1945**: A period characterised by the rapid development of jet propulsion technology and its use in both military and civilian aviation applications.

7.2 AVIATION ARCHAEOLOGY PRE-1939

7.2.1 Fixed wing aviation first began in the early 1900s in the UK, with the first fixed wing flight across the English Channel in 1909 (http://www.rafmuseum.org.uk/milestones-of-flight/british_civil/1909.cfm). The Isle of Sheppey in the Thames Estuary was an important focus of pioneer aviation, and was the home of the first British aerodrome on grounds adjacent to Musswell Manor. In 1909 the first recorded circular mile in Britain was made from the Isle of Sheppey. The Isle of Sheppey was also home to the early design and construction of seaplanes for the Royal Navy and at Sheerness in 1912, the first aircraft in the world to have taken off from a warship was recorded.

7.2.2 The development of military and naval aviation began just prior to the First World War (WWI). Initially, airpower was conceived as an adjunct of the army and navy, and it was the task of the Royal Naval Air Service (RNAS), founded in July 1914, to patrol the east coast of Britain and provide airborne defence and anti-submarine duties (Brown *et al.* 1995:31; English Heritage 2000). During this period aircraft were constructed of canvas covered wooden frames and were extremely fragile. Aviation engineering at this time was relatively basic, and due to their fragile structure a number of aircraft broke up in flight (Wessex Archaeology 2009:64).

7.2.3 The Study Area provided a focus for hostile aircraft activity during WWI. The first air raid on England occurred in December 1914 when a seaplane dropped a single bomb on Dover (Crowe 2008:3). In February 1915, Colchester and Braintree (Essex) were attacked by a seaplane, and later that year Zeppelins dropped bombs on a number of towns in East Anglia and Essex (Crowe 2008:3). From 1915 onwards there a number of offensives whereby Zeppelins targeted London and South East Essex, many of which were subjected to anti-aircraft fire and pursuit and interception by British aircraft.

7.2.4 Anti-aircraft defences were coordinated into anti-aircraft zones, one for the Thames Estuary and another for London (Crowe 2008:36). The defences were so effective against the German daylight raids that the enemy began night raids from August 1917 (Crowe 2008:37). Towards the end of WWI the vast majority of night raids were targeted on London, with the aerial attacks undertaken by Zeppelins, Gotha bombers and Zeppelin-Staaken (Giant) bombers (Crowe 2008:47).

7.2.5 The Royal Flying Corps and the RNAS provided further defence against air raids, and there were a series of Home Defence airfields protecting London (Crowe 2008:37). The increasing threat posed by Zeppelin airships and, from 1917 Gotha bombing planes, flying across the North Sea to London and targets on the East Coast was met by the establishment of 16 squadrons of fighter airfields, 480 anti-aircraft guns and 706 searchlights with a centralised control system around Britain (English Heritage 2000; Lake and Francis 1998:13).

7.2.6 During WWI, the potential of airpower as an independent sector of the armed forces became increasingly clear (Lake and Francis 1998:13). The patrols of the RNAS had pioneered the role of airpower from purely reconnaissance motives to an increasingly strategic role, and by April 1918 the Royal Air Force (RAF) had been established as an independent force (English Heritage 2000a; Lake and Francis 1998:13).

7.2.7 The regular use of aircraft over the battlefields of the Western Front by the end of WWI prompted the mass-production of fixed wing aircraft in large numbers for the first time. This increasing use of aircraft during WWI also spurred technological advances which saw the development of more powerful engines, allowing aircraft to reach speeds up to 130mph (Wessex Archaeology 2009:64). This increased power not only enabled aircraft to travel more than twice the speed of pre-war aircraft, but it also made larger aircraft possible (Wessex Archaeology 2009:65).

7.2.8 A number of aircraft dating to WWI are recorded to have been lost around the UK, some of which are likely to have resulted in crashes in coastal waters. A total of 28 fixed wing aircraft and 15 airships were lost by the German Imperial Air Service and Navy during raids on the UK mainland during WWI (Wessex Archaeology 2009:65). During the same period, 34 aircrew from British Home Defence Squadrons were also lost (Holyoak 2002:659). It is possible that some of these losses occurred at sea.

7.2.9 By the end of WWI it had become apparent that increasing effort would have to be put into defending Britain's airspace at the expense of guarding the coastline (Brown *et al.* 1995:31). After the collapse of the Geneva disarmament talks in 1933, the British government engaged in a massive programme of rearmament and more than 100 permanent airbases were built throughout Britain during the inter-war years (English Heritage 2000; Lake and Francis 1998:13).

7.2.10 There was a rapid progress in the field of aviation during the interwar years. Technological innovation during this period meant that the low-powered wood and cloth biplanes had been replaced by high-powered monoplanes made of aluminium (Wessex Archaeology 2009:65).

7.2.11 With the construction of aircraft designed to carry passengers and cargo, commercial civil aviation significantly increased during the 1920s and 1930s and various cross-channel services to a number of European and worldwide destinations had been established (Wessex Archaeology 2008:16). The Department of Transport's Air Accident Investigation Branch (AAIB) records 20 civil aircraft losses at sea between 1920 and 1939, though this is not regarded as being a comprehensive record (Wessex Archaeology 2009:65).

7.2.12 Pre-1939 aircraft crash sites at sea are likely to be relatively rare, and the lightweight construction of the earlier airframes means they are less likely to survive within the marine environment unless buried within seabed sediments. Any early air crash sites from this period are, however, likely to be very important.

7.3 AVIATION ARCHAEOLOGY: 1939-1945

7.3.1 By the Second World War (WWII) an advance in aeroplane technology enabled flights over water to take place with a much lower level of risk and airpower became increasingly important at a strategic and operational level. The English Channel and the North Sea formed a frontier between the Allies and Axis Europe during this period, becoming a significant focus for this high volume of aviation activity (Wessex Archaeology 2008:16). Hostile aircraft activity was particularly concentrated off the east and south coasts of the UK.

7.3.2 The Thames Estuary was a significant focus for aircraft activity during WWII. In 1940, tactical directives during the Battle of Britain changed on September 7th stating that the main effort of the German Luftwaffe was to be directed at London, and a number of daylight attacks took place on the capital city. This phase of the Battle of Britain became a round-the-clock offensive, with night bombers taking over from daylight raiders until spring 1941 (Bowyer 2003:76; Goss 2005:60). From the 7th September 1940, the Blitz saw the sustained bombing of Britain, beginning with London. The aircraft losses which occurred during this period were considerable. Losses in British aircraft destroyed or written-off due to battle damage amounted to 1,140, and RAF fighter pilots are recorded to have destroyed at least 1,733 German aircraft (Bowyer 2003:79). With aircraft activity focussed on London it is likely that a number of these losses took place in the Study Area.

7.3.3 The loss of aircraft from both sides was immense in WWII. It has been estimated that an average of 5 aircraft crashed every day between 1939 and 1945 somewhere in the British Isles (Bédoyère 2001:8) and many of these casualties would have occurred offshore. Despite this, the known aircraft crash sites which have been identified are few.

7.3.4 In response to the apparent discrepancies between the known and potential aircraft crash sites, Wessex Archaeology was funded by English Heritage through the Aggregates Levy Sustainability Fund to undertake a scoping study entitled *Aircraft*

Crash Sites at Sea (Wessex Archaeology 2008). The study aimed to identify current gaps in data and understanding relating to aircraft crash sites at sea.

7.3.5 One of the most complete sources of information reviewed by WA during the scoping study for the WWII and post-war period was provided by published aviation researcher Ross McNeill. McNeill has recorded 11,090 RAF aircraft losses in the North Atlantic, North Sea, English Channel, Irish Sea and Biscay areas between 1939 and 1990, the majority of which occurred during WWII (Wessex Archaeology 2008:18). Of these aircraft crash sites, 123 are thought to be located off the coast of Essex, while another 73 are thought to be off the coast of Suffolk. A further 380 aircraft crash sites are thought to be located off the coast of Kent. Although WA cannot verify the accuracy of the data supplied by McNeill, it was collated through a systematic study based on both primary and secondary sources and suggests a high volume of potential aircraft crash sites within the Study Area.

7.3.6 A further survey of crash sites in England carried out by EH, in consultation with the Ministry of Defence (MoD) as part of the Monuments Protection Programme (MPP), revealed that WWII losses tended to cluster along the southern and eastern margins of England. For example, some 1,000 losses of British aircraft were noted off the coast of Suffolk (English Heritage 2000; English Heritage 2002:5). Located beneath the various flight paths of enemy bomber formations that were flying to the capital and to targets further inland, the Study Area would have been a focus for air combat during WWII.

7.3.7 A review of maps showing the location of WWII Air/Sea Rescue Operations suggest that over 200 recorded Air/Sea Rescue Operations took place within the Study Area. Although the mapped location of these operations is not necessarily reliable, the locations provide a useful guide to the general distribution and potential density of aircraft crash sites within the Study Area. A review of these operations alongside the known aircraft crash sites highlights the disparity between the known and potential resource with regards to aviation archaeology (**Figure 15**).

7.3.8 Commercial aircraft are also likely to have been lost in this period. Although only two aircraft losses were recorded by the AAIB from 1939-1945, this figure seems unlikely and is possibly a factor of the acknowledged incompleteness of the AAIB records (Wessex Archaeology 2008).

7.4 AVIATION ARCHAEOLOGY: 1945 - PRESENT

7.4.1 Following WWII and until the early 1990s, military aviation activity was dominated by the Cold War. In response to threats posed by the Cold War, military aircraft research, design and development was further increased, much development of which was also applied to commercial aircraft (Wessex Archaeology 2009:67).

7.4.2 Technological innovation during this period saw the refinement of the jet engine, which enabled the production of jet aircraft which catered for both military and commercial pursuits. The jet aircraft was much faster than its propeller-powered predecessors and was able to attain a much greater altitude, providing maximum efficiency over long distances (Jarrett 2000).

7.4.3 Throughout the periods prior to 1945, military activity provided the dominant impetus for aircraft design and development. However, following WWII there was a steady and rapid rise in commercial flights. Initially ex-military aircraft were used to transport people and cargo, with aircraft such as the American B-29 and the British Lancaster converted into commercial aircraft (Wessex Archaeology 2009:68). The first purpose-built commercial jet airliner was the de Havilland Comet, which first flew in 1949 and entered service for the British Overseas Airways Corporation (BOAC) in 1952, between London and Johannesburg. Flight soon became an available means of travel within and around the UK for most people, and the volume of airliner activity across the Study Area is considerable.

7.4.4 Despite the volume of aviation activity across the UK, there have been very few major losses. The AAIB lists 120 civil aircraft losses at sea around the UK between 1946 and 1994, most of which comprise light aircraft or in more recent years helicopters associated with the North Sea oil and gas industry (Wessex Archaeology 2009:68). Unlike in preceding years, the majority of military aircraft losses are due to training accidents rather than combat operations (Wessex Archaeology 2009:66).

7.5 AVIATION ARCHAEOLOGY: SUMMARY

7.5.1 Although aircraft losses are predominantly concentrated within the period between 1939 and 1945, there is the potential for aircraft crash sites which span the entire period of aviation history.

7.5.2 With the potential resource for aircraft crash sites large, and the number of known crash sites relatively small, the potential exists for the presence of a large number of unknown crash sites on the seabed within the Study Area. In providing favourable preservation, the seabed environment further enhances this potential, making the discovery of fairly intact aircraft on the seabed far more likely than for those discovered on land.

7.5.3 Despite this, due to the often ephemeral nature of their remains, aircraft crash sites are not easily distinguishable in standard geophysical survey. Furthermore, the remains of military aircraft which are found receive blanket protection under the Protection of Military Remains Act 1986, whereby no disturbance of a military aircraft wreck is permitted without a licence from the MoD.

7.5.4 Consequently, the potential for the remains of aircraft – especially military aircraft – to be present within the Study Area must be borne in mind during the assessment of any area ahead of seabed development.

7.6 KNOWN AIRCRAFT CRASH SITES

SeaZone

7.6.1 Of the 1551 charted sites listed in the SeaZone data within the Study Area, only 14 contained references to aircraft crash sites. Of the 14 records, four were post 1946 in date while the remaining 10 were of unknown date. The sites are illustrated in **Figure 15**.

7.6.2 Of the 14 records, nine contain no information relating to the type of aircraft, although of these nine records, one is described as being a German aircraft. Of the remaining five sites, two are described as Light Aircraft and one a possible American Voodoo aircraft, all of which post-date 1946. The remaining sites are detailed to be a Lancaster aircraft and a Piper Comanche. The Lancaster was the most successful bomber used by the RAF and the Royal Canadian Air Force (RCAF), and of the 7,377 built, 3,932 were lost in action (http://www .lancastermuseum.ca/lancbomber.html). Lancasters continued in use by the RAF until 1965 and by the RCAF in the 1960s (http://www. Lancastermuseum.ca/ lancbomber.html). As a military aircraft, the remains of the Lancaster would be automatically protected under the Protection of Military Remains Act 1986. The Piper Comanche is a civilian aircraft, a type produced between 1957 and 1972.

7.6.3 The majority of the known aircraft remains are within 10km of the coastline within the Study Area, comprising nine records. Eight of these sites are concentrated in the Blackwater and Stour-Orwell estuary approaches.

Recorded Losses

7.6.4 Of the 2017 recorded losses listed in the NMR within the Study Area, a total of 126 contained references to aircraft crash sites. These sites are illustrated in **Figure 15**. Of these aircraft losses, a total of six predating WWII, spanning from 1921 to 1937. Five of these aircraft are described as British Seaplan, while the remaining aircraft is detailed to be a British Trainer.

7.6.5 In the period between 1939 and 1945, 119 aircraft losses are listed by the NMR within the Study Area, 86 of which are listed to be British. Of these 86 records, 45 are described as Fighters, 14 as Bombers, nine as Heavy Bombers, six as Nightfighters, five as Fighting Bombers, four as Light Bombers, one as a Flying Boat, one as a Glider and one as a British Trainer. The remaining vessels are German, and are listed to comprise ten Messerschmitts, nine Junkers, four Dorniers, three Focke Wulfs and seven Heinkels.

7.6.6 The remaining aircraft crash site was post 1946 in date, and is described as a British Fighter.

Marine Aggregate Industry Protocol

7.6.7 The tailwheel assembly of a Hawker Hurricane (UMD_0194) was reported through the Marine Aggregate Industry Protocol having been recovered during dredging in Licence Area 447.

8 SITE SURVIVAL AND VISIBILITY

8.1 INTRODUCTION

8.1.1 In order to identify the impacts of existing and future dredging operations on the known and potential archaeological resource, the preservation of archaeological material and deposits within the Study Area is a prime consideration. Archaeological sites and material may be covered by metres of sediments which protect them or their preservation may be compromised by exposure. They may also be subject to human disturbance as a result of marine and seabed activities such as aggregate dredging.

8.2 PREHISTORIC ARCHAEOLOGY

8.2.1 The potential for prehistoric archaeological sites within the Study Area has already been discussed in this report (**Sections 5.6, 5.7 and 5.8**). However, the degree to which archaeological material can be expected to survive is a key consideration in the assessment of the submerged prehistoric archaeological potential within the Study Area. Since the earliest evidence for the occupation of the British mainland in *c.*700,000 BP, human and proto-human artefacts may have been deposited in sediments on the Continental shelf whenever the glacial ice sheets caused the floor of the North Sea to be dry and beyond the limits of the ice (Flemming 2006:6).

8.2.2 The critical period of survival for prehistoric archaeological material is the time when the surf zone starts to impact on the site, and the ensuing few hundred years as the sea level rises over the site (Flemming 2006:12). Favourable factors for the survival of prehistoric archaeological material *in situ* in the southern North Sea, outlined by Flemming (2006:12), are as follows:

- Very low beach gradient and offshore gradient so that wave action is attenuated and is constructional in the surf zone;
- Minimum fetch so that wave amplitude is minimum, wavelength is short, and wave action on the seabed is minimum;
- Original deposit to be embedded in peat or packed lagoonal deposits to give resistance and cohesion during marine transgression. Drowned forests and peat are good indicator environments;
- Where deposits are in a cave or rock shelter, roof falls, accumulated debris, concretions, breccia, conglomerate formation, indurated wind-blown sand, all help to secure archaeological strata;
- Local topography contains indentations, re-entrants, bays, rivers, estuaries, beach-bars, lagoons, near-shore islands, or other localised shelter from dominant wind fetch and currents at the time of transgression of the surf zone.

8.2.3 The factors listed above are those which promote the survival of the prehistoric archaeological resource *in situ.* The visibility of the archaeological resource is determined by further factors, outlined by Flemming (2006:13) and listed below:

- Low net modern sediment accumulation rate so that the artefacts are not too deeply buried;
- No fields of sand waves or megaripples over the site;
- A slight change in oceanographic conditions so that the site is being gently eroded to expose deposits, permitting their discovery.

8.2.4 There are a number of prospective locations within the Study Area that may be considered to have favourable site survival and visibility for prehistoric archaeological material. Recorded sites of retrieved prehistoric artefacts in the North Sea are predominantly discovered in some form of depression or low ground, where scour has removed the overlying mobile marine sands (Flemming 2006:18). The depressions and gulleys between the banks and ridges north east of the Essex coast thus provide an environment potentially favourable for prehistoric site survival and visibility.

8.2.5 Prehistoric site survival is also expected to occur within the relict estuaries and river valleys of the Study Area. The gravel terraces laid down by the proto-Thames and its tributaries provide favourable preservation for prehistoric artefacts, which although likely to be concealed within alluvium, may be exposed during dredging operations. The potential also exists for the survival of palaeoenvironmental remains within peat or alluvial deposits. The visibility of such remains may be considered in terms of the methods adopted by geophysical and geotechnical surveys in order to identify such deposits, outlined in **Section 5.5**.

8.2.6 Although this report is primarily concerned with marine and offshore areas, the coastal areas adjacent to the Study Area have a high potential for the survival and visibility of the prehistoric archaeological resource. There is the potential for artefacts to erode out of modern coastlines, such as that in Suffolk, which is composed of relatively unconsolidated material and is subject to extensive erosion. Coastal sediments adjacent to the Study Area, comprising mudflats, marshes and wetlands, also have a high potential for prehistoric site survival and visibility as evidenced by the Hullbridge Survey which describes numerous sites in the marshland, creeks and tidal mudflats of the Essex coast dating from 7,600-3,500 BP (Wilkinson and Murphy 1995).

8.3 MARITIME ARCHAEOLOGY

8.3.1 The ALSF *Navigational Hazards* project (Bournemouth University 2007) attempted to identify areas where a high potential for ship loss coincided with a high potential for preservation of archaeological materials. These areas were referred to as Areas of Maritime Archaeological Potential (AMAPs), and it is with reference to these that the survival and visibility of maritime sites within the Study Area will be considered.

8.3.2 The results of the *Navigational Hazards* project showed a general higher potential for the loss and preservation of vessels on approaches to estuaries inshore and shallow fine-grained sandbanks offshore (Bournemouth University 2007:33). The approaches to the Thames Estuary provided one of the largest AMAPs in which these trends coincided.

8.3.3 The coastal character of the Study Area is that of an exposed coast with numerous offshore sandbanks which run parallel to one another in a NE-SW direction. The area is exposed to prevailing winds from the north east during the winter which increases the risk of vessels being blown on to the shallow sandbanks (Bournemouth University 2007:34).

8.3.4 The survival of shipwrecks or maritime structures depends largely on whether they come to lie on or within the seabed sediments (Gregory 2006:8). Structures which lie exposed within the seawater are at risk of being deteriorated by wood boring or saprotophic organisms (Gregory 2006:8). Those which are engulfed or covered by sediments experience a much slower rate of deterioration due to the absence of dissolved oxygen (Gregory 2006:8).

8.3.5 The sediment types which contain a higher proportion of finer grained sediments and a lower proportion of coarser grains offer the best preservation for archaeological material on the seabed (Gregory 2006:14-15). This is partly due to the fact that such sediments tend to have lower bearing capabilities and thus engulf archaeological material more readily (Gregory 2006:15). Finer grained sediments are also quite mobile and will more easily cover archaeological material, although the obvious drawback of this is that such sediments may be more easily transported away from a site leaving it exposed (Gregory 2006:15). The penetration of oxygen is much lower in finer grained deposits such as sand which also contributes to the preservation of archaeological material (Riedl and Ott 1982).

8.3.6 The seabed within the Study Area is characterised by sand with layers of gravel in between the sandbanks (Bournemouth University 2007:34). The predominance of fine grained sediments suggests that the Study Area thus has a high potential for the preservation of archaeological material, although this may be counteracted to a degree by the mobile nature of the sandbanks (Bournemouth University 2007:37).

8.3.7 The visibility of the maritime archaeological resource predominantly relies on the ability for individual sites to be identified in geophysical and hydrographical surveys, particularly with regards to side scan sonar and magnetometer surveys. The visibility of such sites thus depends on the survival of individual wreck sites and their related material on the seabed, the degree to which they are buried beneath sediment and their construction material.

8.4 AVIATION ARCHAEOLOGY

8.4.1 With regards to aircraft crash sites within the Study Area, site survival and visibility is determined largely by the cause of loss of the aircraft. With a few exceptions, aircraft come to be on the seabed as a result of an in-flight accident or enemy action. Those aircraft which are on the seabed as a result of controlled ditching are likely to be much better preserved than those which exploded in mid-air or hit the water at speed, which are likely to be highly fragmented and widely dispersed.

8.4.2 The factors which determine the survival of an aircraft crash site are not yet fully understood. It is, however, recognised that marine environments generally offer favourable conditions for the preservation of artefacts, enhancing the potential for the survival of aircraft crash sites on the seabed.

8.4.3 The seabed sediments within the Study Area as discussed in **Section 8.3** with regards to the survival of the maritime resource would similarly promote the survival of aircraft crash sites. As with wreck sites, the visibility of aircraft crash sites predominantly relies on their ability to be identified by geophysical survey.

9 IMPACT ASSESSMENT

9.1 INTRODUCTION

9.1.1 This section considers the source and nature of the effects of aggregate dredging and the degree to which archaeological receptors are exposed to and affected by dredging practices within the potential areas of impact and within the MAREA Study Area as a whole. Potential areas of impact are the current dredging licence areas, the application dredging areas and the prospecting areas provided by ERM (**Figure 1**).

9.1.2 For the purposes of this assessment, the archaeological resource is divided into the three themes discussed above: prehistoric archaeology, maritime archaeology and aviation archaeology. Within each of these themes, a number of receptors have been identified. These are:

Prehistoric Archaeology	Maritime Archaeology	Aviation Archaeology
Pleistocene fluvial gravels	Known, charted wreck sites	Known, charted aircraft crash sites
Estuarine alluvium	Shipping casualties / Recorded losses	Recorded aircraft losses
Peat	Unknown, uncharted wreck sites	Isolated aircraft finds
Isolated prehistoric finds	Isolated maritime finds	

9.1.3 The process of assessing the effects of dredging on these archaeological receptors involves predicting the magnitude of the effect, identifying the sensitivity of each receptor to that effect and evaluating the significance of the likely impacts of that effect at a regional scale. Each stage of this process is detailed in turn below.

9.1.4 In the Impact Assessment Criteria compiled by TEDA (2009) an 'impact' is considered to be a change (positive or negative) in the existing baseline for a given receptor that occurs as a consequence of an activity associated with dredging in the Study Area. This impact may be significant in its own right, or when added to existing impacts.

9.2 DREDGING PRODUCTION, PROCESSING AND EFFECTS

Marine Aggregate Production and Processing

9.2.1 Deposits suitable for exploitation as marine aggregate comprise well-defined bodies, more than 0.5m thick, of well-sorted hard rock gravels in the size-range *c.* 2-40mm, without a covering of clay, silt or organic-rich sediments (Wenban-Smith 2002:1). In the Thames estuary, these gravel deposits represent submerged formerly terrestrial deposits which are of Pleistocene fluvial origin, generally preserved in terraces on the flanks of submerged valley systems or filling palaeo-river channels (Wenban-Smith 2002:1).

9.2.2 Two types of dredging technique are employed to extract marine aggregate. The first is known as anchor dredging, and involves a vessel anchoring over a deposit. This technique is often employed when working in thick, localised reserves. The second technique, known as trailer dredging, is employed when working with more widely distributed deposits. Trailer dredging is the technique most commonly used around the UK.

9.2.3 Dredging vessels position themselves relative to the aggregate resource using a satellite navigation system. When in position, the dredge pipe is lowered to the seabed and as the vessel trails it slowly across the seabed powerful pumps are used to extract the aggregate. On large vessels, these pumps are capable of drawing up to 2,600 tonnes of material an hour from water depths of up to 50m (BMAPA 2006:6). The sand and gravel is discharged into the vessel's hold, displacing the seawater which was previously taken in as ballast.

9.2.4 Once fully loaded with aggregate, the vessel returns to a wharf to discharge the sand and gravel. The process of discharging involves bucket wheels, scrapers or wire-hoisted grabs which place the aggregate onto a conveyor system for delivery to the wharf or processing plant (BMAPA 2006:7).

9.2.5 Onshore processing of marine aggregate generally comprises screening, sieving by size and crushing, though the exact process varies from wharf to wharf.

Dredging Effects

9.2.6 A number of existing and potential effects of aggregate extraction are identifiable, including substrate removal, elevated turbidity/suspended sediment concentrations, sand transport and the mobilisation of contaminants and noise.

9.2.7 Of these, substrate removal and elevated turbidity, or sediment plume, are most likely to have an impact on the archaeological record, although the degree of impact will vary according to the effect and from receptor to receptor. Mobilization of contaminants and noise will not affect the archaeological record and are therefore not considered further in this assessment.

9.3 INTERACTION BETWEEN RECEPTORS AND IMPACTS: PREHISTORIC ARCHAEOLOGY

9.3.1 The known archaeological record for submerged prehistoric archaeology and palaeo-landsurfaces in the Study Area is limited. In order to highlight areas of prehistoric archaeological potential in the Study Area deposits which have the potential to contain *in situ* prehistoric archaeological material have been identified from the results of the geotechnical and geophysical investigations (see **Sections 5.6** to **5.8**). In assessing prehistoric archaeology in the context of aggregate dredging this report considers it more meaningful to concentrate on the deposit types in which the archaeological material may be found than to concentrate on archaeological periods to assess potential and impacts. For the purposes of this assessment, therefore, these deposits have been broadly categorised as Pleistocene fluvial gravels, estuarine alluvium and peat. It must be noted, however, that the available geophysical and geotechnical data are limited by their area of survey and cannot be regarded as providing a conclusive understanding of the full extents of these various deposits within the Study Area.

9.3.2 It must also be noted that this assessment has assumed that where alluvium and/or peat overlie a gravel deposit this gravel will not be targeted for extraction (see **9.2.1**. above). Should this assumption not be correct, the effects and impact on the overlying alluvium and/or peat must be assumed to be the same as those suggested below for Pleistocene fluvial gravel.

Pleistocene Fluvial Gravels

9.3.3 Pleistocene fluvial gravels were discussed as sedimentary Unit 2 in the geotechnical assessment of the MAREA. The unit was observed in five vibrocores within current aggregate licence areas within the Study Area:

108/3, 109/1, 113/1	VC4
118/2	VC192/99
239/1	VCO28
327	VCT159/99
	VC46

9.3.4 These Pleistocene fluvial gravels, which are widespread within the Thames estuary region, are the primary target of aggregate dredging. However their full extent across the Study Area is not known and the degree to which the impacts overlap with the location and distribution of this receptor is thus unknown. Given this uncertainty, a precautionary approach has been adopted when considering this receptor and there is likely to be a **large degree of regional interaction** between impacts and receptor in this case.

Estuarine Alluvium

9.3.5 Estuarine alluvium, which overlies the Pleistocene gravels, was identified as sedimentary Unit 3 in the MAREA Stage 1 geotechnical assessment. Twelve vibrocores containing Unit 3 deposits were observed within current aggregate licence areas within the Study Area, with a further vibrocore containing Unit 3 immediately adjacent to another licence area:

108/3, 109/1, 113/1	VC4
	82-SUNK
	VC019
118/2	VCO31
	VCO35A
119/3	VC10
239/1	VCO28
257	VCE4
327	VC44
	VCT159/99
	VC48
	VC49
447	(VCE11 adjacent)

9.3.6 The extent of estuarine alluvium within the Study Area is not known and the degree to which the impacts overlap with the location and distribution of the receptor is thus unknown. Given this uncertainty a precautionary approach has been adopted. However, based on the assumption that the aggregate industry will avoid areas in which estuarine alluvium is present or overlies gravels, it is postulated that there is likely to be a **small degree of regional interaction** between the impact and receptor in this case.

Peat

9.3.7 Fluvial processes during the Late Devensian and Holocene resulted in the formation of peat deposits. These deposits are evidence of temporary minor falls in sea level and contain data that can help reconstruct past environments and provide a greater understanding of the geomorphology of the coastline during these periods. They may also contain *in situ* archaeological material. *Identifying and Protecting Palaeolithic Remains: Archaeological Guidance for Planning Authorities and Developers* (English Heritage 1998) notes that well-preserved indicators of the contemporary environment such as peat are of particular archaeological importance.

9.3.8 Peat was included within sedimentary Unit 3 in the MAREA Stage 1 geotechnical assessment. The vibrocores containing Unit 3 within the licence areas are listed in **Section 9.3.5**.

9.3.9 The occurrence of peat deposits within the Study Area is not fully understood and the degree to which the spatial extent of the impact overlaps with the location and distribution of the receptor is thus unknown. In view of this uncertainty a precautionary approach has been adopted here too. As with alluvium above, however, and based on the assumption that the aggregate industry will avoid areas in which peat is present or overlies gravels, it is likely that there is a **small degree of regional interaction** between the impact and receptor in this case.

Isolated Prehistoric Finds

9.3.10 Marine and glacial transgressions and regressions across the southern North Sea have shaped the sediments of the Study Area over time. These processes will also have resulted in the disturbance, movement and re-distribution of prehistoric artefacts and assemblages from their primary context. There is thus a high potential for derived finds to be present within the potential areas of impact and the MAREA Study Area as whole. However, whilst this potential exists, it is not possible to quantify or predict the volume or distribution of such artefacts. Due to the uncertainty regarding their location, isolated prehistoric finds must be viewed with caution, and as such a **medium degree of regional interaction** between the impact and the receptor is suggested in this case.

9.4 INTERACTION BETWEEN RECEPTORS AND IMPACTS: MARITIME ARCHAEOLOGY

Known, Charted Wreck Sites

9.4.1 There are 1,537 known or charted maritime sites in the Study Area comprising shipwrecks and seabed obstructions. These sites have been charted and their positions are relatively secure. It must be borne in mind that these recorded wrecks show a clear bias towards large iron or steel vessels dating from within the last 150 years. This is largely due to the higher potential for structures of ferrous material to be identified on the seabed through hydrographic and geophysical survey.

9.4.2 Although the density plot of charted wreck sites (**Figure 13**) shows some areas with higher concentrations there is a fairly widespread and general distribution of wrecks across the Study Area. **Figure 12** demonstrates that each of the current licence areas, licence application areas and prospecting areas include at least one charted maritime site within its boundaries.

9.4.3 Although all of the licence areas include charted maritime sites, **Figure 12** also shows that the vast majority of charted sites within the Study Area lie outside the current dredging licence areas, dredging licence application areas and prospecting areas. On this basis, a **small degree of regional interaction** is suggested between dredging impacts and the known, charted wreck sites receptor. At a licence area level, however, there is the potential for a high degree of interaction.

Shipping Casualties / Recorded Losses

9.4.4 There are 2,017 recorded shipping casualties or losses listed within the Study Area. Of this total, only 24 are recorded within current aggregate licence areas, and none within application or prospecting areas. These 24 shipping casualties are located within licence area 108/3 at one Named Location detailed by the NMR as vessels that sank 'off the coast of Essex'. Although these losses are not currently tied to known positions on the seabed they should be expected to survive in some form within the Study Area. Similarly, the potential exists for the remains of shipping casualties at Named Locations which are located outside licence, application and prospecting areas to be present within these potential areas of impact.

9.4.5 The shipping casualties ascribed to a Named Location within a licence area are far outweighed by the total of documented losses listed within the Study Area. However, due to the lack of positional data this receptor must be regarded with a degree of uncertainty and a precautionary approach is adopted accordingly. On this basis, a **medium degree of regional interaction** is suggested between the dredging impacts and shipping casualties as a receptor.

Unknown, Uncharted Wreck Sites

9.4.6 Unknown and uncharted wreck sites are those for which there is no record of loss or position, but whose existence is inferred or likely on the basis of the maritime history of the Study Area. It is not possible to quantify the extent of unknown and uncharted sites within the impact areas.

9.4.7 As an AMAP (See **Section 8.3**), the Thames estuary region is one of the largest areas in the UK in which a high potential for ship loss coincides with a high potential for the preservation of archaeological materials (Bournemouth University 2007). However, it must be noted that the conditions favourable for preservation of archaeological material within the Study Area will be predominantly provided by finer-grained sediments rather than by the coarse gravel deposits targeted by the aggregate industry.

9.4.8 There is a great deal of uncertainty regarding the distribution and extent of unknown, uncharted wreck sites within the potential impact areas and across the Study Area as a whole. Consequently a precautionary approach is adopted and a **medium degree of regional interaction** between the impact and the receptor is anticipated.

Isolated Maritime Finds

9.4.9 Maritime sites comprise not only wrecks of vessels, but also debris which is associated with maritime activities. This can include, for example, artefacts which were accidentally lost or material deliberately thrown overboard from a vessel. While there is the potential for isolated finds of this nature within the potential impact areas and across the Study Area as whole, it is not possible to quantify the volume or distribution of such artefacts. However, the number of known wrecks and documented losses and the inferred potential for unknown and uncharted wreck sites suggests a high potential for such finds to be present on the seabed. Due to the uncertainty regarding their location, isolated maritime finds must be approached with caution, and as such a **medium degree of regional interaction** between the impact and the receptor is suggested in this case.

9.5 INTERACTION BETWEEN RECEPTORS AND IMPACTS: AVIATION ARCHAEOLOGY

Known, Charted Aircraft Crash Sites

9.5.1 Data regarding the physical location of aircraft remains on the seabed is extremely limited. Consequently, known aviation resource alone must not be viewed as indicative of the total number of aircraft crash sites within the Study Area.

9.5.2 The known resource lists only 14 aircraft crash sites within the Study Area, none of which lie within a licence, application or prospecting area. On the basis of the known resource, therefore, **no regional interaction** is expected between the known, charted aircraft receptor and the aggregate extraction impacts.

Recorded Aircraft Losses

9.5.3 In contrast to the small known resource, records of aircraft losses at sea are extensive. For the purpose of this report, recorded aircraft losses are those documented losses listed by the NMR at Named Locations and the records of WWII Air/Sea Rescue Operations. There are a total of 126 documented aircraft losses listed by the NMR within the Study Area. The total number of WWII Air/Sea Rescue Operations within the Study Area was extracted from contemporary maps which are sometimes ambiguous and unclear and thus must be considered with caution. The maps imply, however, that somewhere in the region of 236 Air/Sea Rescue Operations took place within the Study Area.

9.5.4 Of the 126 documented losses, four are recorded within current aggregate licence areas. These four are all linked to a single Named Location (described as ‘off the coast of Essex’) which is located within Area 108/3. Although these losses are not currently tied to known aircraft remains on the seabed such remains should be expected to survive in some form within Area 108/3 or its vicinity. Similarly, there is the potential for the physical remains of aircraft losses listed in other Named Locations to be present within these licence areas.

9.5.5 Most of the licence, application and prospecting areas had WWII Air/Sea Rescue Operations either within them or in reasonably close proximity. Nonetheless, it is clear that the majority of recorded aircraft losses and WWII Air/Sea Rescue Operations in the Study Area lie outside licence, application or prospecting areas.

9.5.6 There is no single definitive list of aircraft losses in UK territorial waters and thus the numbers presented above must not be considered definitive. Additionally, the positional data for the NMR recorded aircraft losses and WWII Air/Sea Rescue Operations is poor. Given these factors, and the automatic protection afforded military aircraft under the Protection of Military Remains Act (1986), a **medium degree of regional interaction** may be suggested between the impacts and the location and distribution of the receptor.

Isolated Aircraft Finds

9.5.7 Isolated finds relating to aviation activity may also be present within the potential areas of impact and the Study Area as a whole. Most aircraft came to be on the seabed as a result of in-flight accident or enemy action. The remains of aircraft that exploded in mid-air or hit the water at speed are likely to be represented by fragmented and widely dispersed artefacts rather than a coherent aircraft wreck. It is not possible to predict the volume and distribution of such artefacts across the Study Area. However, a consideration of the known aircraft crash sites and the documented aircraft losses suggests a high potential for such material in or on the seabed. Due to the uncertainty regarding their location, isolated aircraft finds must be approached with caution and, as such, a **medium degree of regional interaction** between the impact and the receptor is suggested in this case.

9.6 INTERACTION BETWEEN RECEPTORS AND IMPACTS: SUMMARY

9.6.1 **Table 11** presents a summary of the interaction between the various receptors and the potential areas of impact within the Study Area.

Theme	Receptor	Degree of Interaction
Prehistoric Archaeology	Pleistocene Fluvial Gravel	Large
	Estuarine Alluvium	Small
	Peat	Small
	Isolated Prehistoric Finds	Medium
Maritime Archaeology	Known Charted Wreck Sites	Small
	Shipping Casualties	Medium
	Unknown Uncharted Wreck Sites	Medium
	Isolated Maritime Finds	Medium
Aviation Archaeology	Known Charted Aircraft Crash Sites	Small
	Recorded Aircraft Losses	Medium
	Isolated Aircraft Finds	Medium

Table 11: Summary of the interaction between the receptors and impacts

9.7 DREDGING IMPACTS

9.7.1 The process of marine aggregate extraction and the effects of substrate removal and sediment plume may result in the following impacts upon prehistoric, maritime and aviation archaeology:

- **Impact 1**: Direct damage to both *in situ* and derived archaeological material;
- **Impact 2**: Damage and dispersal of *in situ* material resulting in the disturbance of relationships between structures, artefacts and their surroundings or contexts;
- **Impact 3**: Loss of derived prehistoric artefacts and isolated wreck and aircraft artefacts and debris within the volume of aggregate;
- **Impact 4**: Destabilisation of sites through the removal of overlying or adjacent sediments prompting exposure and leading to instability, erosion or corrosion and decay;
- **Impact 5**: Burial of sites due to re-deposited sediment, potentially protecting and promoting the favourable preservation of sites.

Summary

9.7.2 **Table 12** below summarises the nature, type and order of impacts discussed above across all archaeological themes.

Impact	Effect	Nature of Impact	Type and Order of Impact
1	Substrate Removal	Negative	Direct
2	Substrate Removal	Negative	Direct
3	Substrate Removal	Negative	Direct
4	Substrate Removal	Negative	Indirect
5	Sediment Plume	Positive	Indirect

Table 12: Summary of the nature, type and order of impacts

9.7.3 Impacts 1-3 arise from activities associated with marine aggregate extraction and are thus **direct** impacts. Impacts 4-5 follow on as a consequence of the direct impacts and are **indirect**.

9.7.4 Impacts 1-4 result in adverse changes to the archaeological baseline conditions and are thus considered to be **negative** impacts. Due to the finite, non-renewable nature of the archaeological record, archaeological receptors affected by these impacts will by unable to return to their pre-impact state and as such there is no degree of reversibility to these impacts.

9.7.5 Impact 5 may result in the introduction of a potentially desirable factor for the archaeology and is consequently regarded as a **positive** impact.

9.8 MAGNITUDE OF EFFECTS

9.8.1 In order to determine the magnitude of the effects of dredging on the archaeological receptors, the predicted effects are defined in terms of their elevation above background or baseline conditions and assessed against the following variables:

- Extent of effect;
- Duration of effect;
- Frequency of effect.

Elevation above Baseline

9.8.2 The effect of substrate removal upon the existing archaeological baseline will be adverse or negative. The archaeological record is non-renewable and any negative impacts will result in permanent and non-reversible changes to the existing baseline.

9.8.3 WA was supplied with images by ERM which show the pre- and post-dredge bathymetries for all licence areas within the Study Area. The bathymetric data shows the expected areas of seabed lowering from the current situation to the post-dredge situation, 15 years from now. The regional figure demonstrates a maximum lowering of 5m within the licence areas.

9.8.4 The data suggests that most of the seabed in each licence area will be lowered by between approximately 1-3m and that areas in which the maximum depths will be reached are relatively small and localised. However, regardless of depth, any archaeological sites and material within areas of substrate removal will be damaged, destroyed, scattered or destabilised.

9.8.5 The effects of sediment plume on the downstream archaeological baseline are potentially favourable or positive. Sediment plume will produce either no change to the existing baseline, or may produce potentially positive changes by burying exposed archaeological material, thereby promoting its preservation.

Extent of Effect

9.8.6 Because both the direct and indirect impacts (Impacts 1-4) of substrate removal arise as the result of marine aggregate extraction, it is reasonable to propose that the extent of the effect is largely limited to the dredging licence areas.

9.8.7 The impact of the sediment plume (Impact 5) is likely to be largely confined to the dredging licence areas, although the re-deposition of sediment may extend downstream, beyond the boundaries of the areas. The extent of this effect can therefore be considered to be **local**, extending up to one tidal excursion beyond the licence areas.

Duration of Effect

9.8.8 The direct impacts of substrate removal (Impacts 1-3) on archaeological receptors only occur during active dredging. However, the removal of substrate is permanent and thus **long-term** in duration. These impacts non-reversible and their effects upon the archaeological record are permanent.

9.8.9 The effects of the indirect impacts of site destabilisation due to substrate removal and site burial due to sediment deposition (Impacts 4-5) on archaeological receptors are likely to be **short-medium-term** in duration. This is based on the exposure or concealment of archaeological material which results from the process of marine aggregate extraction. Any damage sustained to archaeological material which is exposed on the seabed, however, is non-reversible and permanent.

Frequency of Effect

9.8.10 Substrate removal and sediment plume will occur during all normal dredging operations and are thus **routine**. These effects will not, however, impact upon the archaeological resource each time they occur.

Summary

9.8.11 **Table 13** summarises the extent, duration, frequency and thus, the magnitude of the effects of substrate removal and sediment plume on archaeology.

Effect	Extent	Duration	Frequency	Magnitude
Substrate Removal	Dredging Licence Areas	Long-term	Routine	Small/Medium
Sediment Plume	Local	Short-Medium-Term	Routine	Small/Medium

Table 13: Magnitude of the effects of substrate removal and sediment plume on archaeology

9.8.12 Based on a combination of elevation above baseline and the extent, duration and frequency of the effects of marine aggregate extraction, it is proposed that the effects of substrate removal and sediment plume are of **small** to **medium magnitude**.

9.9 RECEPTOR VALUE AND SENSITIVITY: OVERVIEW

9.9.1 In order to asses the impacts of marine aggregate extraction at a regional scale, the value and sensitivity of each archaeological receptor must be considered. This assessment of value considers whether the receptor is rare, protected or threatened. The sensitivity of each receptor is assessed against the following three criteria:

- **Adaptability**: The ability of the receptor to avoid adverse impacts that arise from a particular effect of dredging;
- **Tolerance**: The extent to which the receptor (at a regional scale) is adversely affected by a particular effect of dredging;
- **Recoverability**. The measure of a receptor's ability to return to a state close to that which existed before the effect caused a change.

9.9.2 The sensitivity of each receptor is determined through a combination of these variables.

9.10 RECEPTOR VALUE AND SENSITIVITY: PREHISTORIC ARCHAEOLOGY

9.10.1 On the basis of their age and the rarity of finds in a marine context, finds of Palaeolithic and Mesolithic sites and material within the Study Area would be of high national and possibly international archaeological importance.

9.10.2 *Identifying and Protecting Palaeolithic Remains: Archaeological Guidance for Planning Authorities and Developers* (English Heritage 1998) notes sites containing certain forms of Palaeolithic material are so rare in Britain that they should be regarded as of national importance and whenever possible should remain undisturbed (see Appendix I).

Pleistocene Fluvial Gravels

9.10.3 The Study Area lay beyond the southern limits of the ice front during the Wolstonian and Devensian glaciations and was thus not subject to the direct effects of the ice on sediments and topography. Moreover, the survival of pre-Anglian land forms suggested by the Outer Thames Estuary REC extends the potential for archaeological material within the Study Area even further back in time. Any *in situ* archaeological material relating to the Lower and Middle Palaeolithic period within the region must be regarded to be of potential national and international importance in understanding Europe's earliest human populations (Austin 1997:5-7), and even confirmed material in secondary contexts would be nationally or regionally significant. If present in the Study Area such material may be expected to found within Pleistocene gravels, which should therefore be regarded as **high value** receptors.

9.10.4 As they are the principal deposits targeted by the marine aggregate industry, Pleistocene fluvial gravels will be unable to tolerate the effects of substrate removal, resulting in a permanent change to the receptor. The adaptability and tolerance of the receptor is **low**.

9.10.5 Similarly, the receptor's recoverability or ability to return to its pre-impact state after substrate removal is **low** and Pleistocene fluvial gravels must therefore be regarded as a receptor of **high sensitivity** to the effects of substrate removal.

9.10.6 With regard to the effects of sediment plume, Pleistocene fluvial gravels are likely to be unaffected or positively affected and are thus regarded as a receptor of **low sensitivity**.

Estuarine Alluvium and Peat

9.10.7 The fluvial processes of the Holocene have resulted in the deposition of alluvial sediments, including peat, within the Study Area. With the gradual rise in sea level which led to the inundation of the Study Area in the Late Mesolithic, some of these sediments will have sealed and buried deposits or landscape features in which Late Devensian and early Holocene *in situ* archaeological material may be present. Estuarine alluvium and peat should thus be regarded as a **high value** receptor.

9.10.8 Alluvial and peat deposits will be unable to tolerate the effects of substrate removal, resulting in a permanent change to the receptors. The adaptability and tolerance of the receptors are **low**.

9.10.9 Similarly, the measure of the receptors' ability to return to their pre-impact state is **low.** With regard to substrate removal, alluvium and peat are therefore receptors of **high sensitivity**. However, on the assumption that alluvial and peat deposits are not targeted by the marine aggregate industry the degree of interaction will be minimal (see **Section 9.6.1**).

9.10.10 With regard to the effects of sediment plume, estuarine alluvium and peat are likely to be unaffected or positively affected and are thus regarded as a receptor of **low sensitivity**.

Isolated Prehistoric Finds

9.10.11 Although archaeological material from secondary contexts is by its nature, derived, recent discoveries have shown that it nevertheless has the potential to provide valuable information on patterns of human land use and demography in a field of study which is still little understood and rapidly evolving (Hosfield and Chambers 2004). Isolated prehistoric finds should thus be regarded as **moderate value** receptors.

9.10.12 The adaptability and tolerance of isolated prehistoric finds to substrate removal is **low**. This is because while derived material is still susceptible to direct damage and the potential for the loss of artefacts within the volume of aggregate remains, damage and dispersal resulting in the loss of the relationship between the artefact and its archaeological context has already occurred to artefacts that are in a secondary context.

9.10.13 For the same reasons, the exposure of derived material is not of the same degree of concern as *in situ*, primary context archaeological deposits. However, isolated archaeological material will be unable to tolerate the effects of substrate removal, resulting in a permanent change to the receptor.

9.10.14 The receptor's ability to return to its pre-impact state after substrate removal is **low**. Given their moderate archaeological value, however, isolated prehistoric finds can be regarded as receptors of **moderate sensitivity** to the effects of substrate removal.

9.10.15 With regards to the effects of sediment plume, isolated prehistoric finds are likely to be unaffected or positively affected, and are thus regarded as a receptor of **low sensitivity**.

Summary

9.10.16 **Table 14** summarises the value and sensitivity for each prehistoric receptor with regards to substrate removal and sediment plume.

Receptor	Value	Sensitivity	
		Substrate Removal	Sediment Plume
Pleistocene Fluvial Gravels	High	High	Low
Alluvium	High	High	Low
Peat	High	High	Low
Isolated Prehistoric Finds	Moderate	Moderate	Low

Table 14: Summary of the value and sensitivity for each prehistoric receptor

9.11 RECEPTOR VALUE AND SENSITIVITY: MARITIME ARCHAEOLOGY

9.11.1 The value assigned to a wreck site is to a large degree case specific. A vessel may have historical importance at a local, national or international level as a result of its association with a historical event or figure. Wartime losses or a vessel whose sinking was associated with a loss of life may have a level of importance directly associated with that loss of life. Vessels which are key to or representative of specific periods of maritime development may also be regarded as important. Alternatively a vessel may have a level of archaeological importance based on the rarity of its representation within the maritime archaeological record and/or its cargo. Wrecks which are regarded to be of special interest may be designated under the Protection of Wrecks Act 1973 or the Protection of Military Remains Act 1986.

9.11.2 The differing levels of importance assigned to wrecks are not necessarily dictated by age. However, in an attempt to provide a few generalisations regarding the age and special interest of vessels, a composite timeline (Wessex Archaeology 2008d) was consulted throughout this assessment which takes into account the broad chronology of shipbuilding and employment (**Section 6.1**). The known and potential maritime archaeological resource in the Study Area was queried by the periods presented in this timeline, the results of which were presented in **Section 6.7**.

Known, Charted Wrecks

9.11.3 The relative potential importance of the various periods into which the known, charted wrecks within the Study Area fall has been discussed already. Although this will vary from wreck to wreck, all of the known wrecks in the Study Area will have a greater or lesser degree have archaeological potential and value. Due to this variability at a regional scale, known charted wreck sites must be regarded as a **high value** receptor.

9.11.4 Particularly where substrate removal results in a direct impact to the archaeological record known, charted wreck sites will be unable to tolerate the effects, resulting in a permanent change in the receptor. The adaptability and tolerance of the receptor is **low** and it is therefore a **high sensitivity** receptor.

9.11.5 However, because the extent and distribution of this receptor is fairly accurately known and the marine aggregate industry avoids seabed structures and obstructions such as wrecks, the interaction between known charted wrecks and substrate removal will be small (see **Section 9.4**).

9.11.6 With regard to the effects of sediment plume, known charted wrecks are likely to be unaffected or positively affected and are thus regarded as a receptor of **low sensitivity**.

Shipping Casualties / Recorded Losses

9.11.7 The relative potential importance of the various periods into which the recorded shipping casualties within the Study Area fall has been discussed already. The recorded losses in the Study Area will each have a greater or lesser degree of archaeological potential and value should they be located on the seabed. Due to this variability at a regional scale, recorded shipping casualties must be regarded as a **high value** receptor.

9.11.8 Particularly where substrate removal results in a direct impact to the archaeological record the physical remains of recorded shipping casualties will be unable to tolerate the effects, resulting in a permanent change in the receptor. The adaptability, tolerance and the measure of the receptor's ability to return to its pre-impact state is low.

9.11.9 Due to the uncertainty of their location and the potential, therefore, for impact from aggregate dredging recorded shipping casualties should be regarded as a receptor of **high sensitivity**.

9.11.10 With regard to the effects of sediment plume, the remains of shipping casualties are likely to be unaffected or positively affected and are thus regarded as a receptor of **low sensitivity**.

Unknown, Uncharted Wreck Sites

9.11.11 The biases in of the records of both charted wrecks and documented shipping casualties towards vessels lost from the mid-18th century onwards have already been discussed, as has the potential for the presence within the Study Area of unknown watercraft and vessels dating from the Mesolithic period to the modern day. A significant proportion of unknown, uncharted wreck sites will pre-date the consistent keeping of casualty records and on that basis (i.e. their age and rarity) unknown, uncharted wrecks as a group can be considered to be of special archaeological interest and should be regarded as a **high value** receptor.

9.11.12 Particularly where substrate removal results in a direct impact to the archaeological record the remains of unknown, uncharted wrecks would be unable to tolerate the effects, resulting in a permanent change in the receptor. As such, the adaptability, tolerance and the measure of the receptor's ability to return to its pre-impact state is **low**.

9.11.13 Due to a lack of any certainty as to their numbers and location, and the consequent potential for them to be impacted by aggregate dredging unknown, uncharted wrecks should be regarded as a receptor of **high sensitivity**.

9.11.14 With regard to the effects of sediment plume, the remains of shipping casualties are likely to be unaffected or positively affected and are thus regarded as a receptor of **low sensitivity**.

Isolated Maritime Finds

9.11.15 Isolated maritime finds are isolated or derived artefacts which are likely to be of limited archaeological importance. However the occurrence of a number of seemingly isolated artefacts within a particular area can indicate historical shipping routes or maritime battlegrounds, for example, or may suggest the presence of a hitherto unknown wreck site. On this basis, isolated maritime finds are regarded as a **moderate value** receptor.

9.11.16 The adaptability and tolerance of isolated maritime finds to substrate removal is **low**. Although this receptor is scattered and ephemeral in nature if adversely affected by substrate removal, it will be unable to recover, resulting in permanent change. As such the measure of the receptor's ability to return to its pre-impact state is **low**. It is suggested that isolated maritime finds be regarded as a receptor of **moderate sensitivity**.

9.11.17 With regard to the effects of sediment plume, isolated maritime finds are likely to be unaffected or positively affected and are thus regarded as a receptor of **low sensitivity**.

Summary

9.11.18 **Table 15** summarises the value and sensitivity for each maritime receptor with regards to substrate removal and sediment plume.

Receptor	Value	Sensitivity	
		Substrate Removal	Sediment Plume
Known Charted Wreck Sites	High	High	Low
Shipping Casualties / Recorded Losses	High	High	Low
Unknown Uncharted Wreck Sites	High	High	Low
Isolated Maritime Finds	Moderate	Moderate	Low

Table 15: Summary of the value and sensitivity for each maritime receptor

9.12 RECEPTOR VALUE AND SENSITIVITY: AVIATION ARCHAEOLOGY

9.12.1 The importance of aircraft crash sites is outlined in *Military Aircraft Crash Sites* (English Heritage 2002) as discussed above. They not only have significance for remembrance and commemoration, but also have an implicit heritage value as historic artefacts, providing information on the aircraft itself and also the circumstances of its use and loss (English Heritage 2002:2).

Known, Charted Aircraft Crash Sites

9.12.2 Within the Study Area there are 14 charted sites known to be aircraft wrecks, all of which are automatically protected by the Protection of Military Remains Act 1986.

On this basis, known, charted aircraft crash sites are considered to be **high value** receptors.

9.12.3 Known, charted aircraft crash sites will be unable to tolerate the effects of substrate removal resulting in a permanent change in the receptor. As such, the adaptability, tolerance and the measure of the receptor's ability to return to its pre-impact state is **low** and it is therefore a **high sensitivity** receptor.

9.12.4 However, because the extent and distribution of this receptor is fairly accurately known and the marine aggregate industry avoids seabed structures and obstructions such as wrecks, the interaction between known aircraft crash sites and substrate removal will be minimal (see **Section 9.5**).

9.12.5 With regard to the effects of sediment plume, known aircraft crash sites are likely to be unaffected or positively affected, and are thus regarded as a receptor of **low sensitivity**.

Recorded Aircraft Losses

9.12.6 There are 126 recorded losses listed by the NMR within the Study Area, six of which predate WWII. The remaining sites date predominantly to the period between 1939 and 1945. One post-dates 1946. In addition, over 200 WWII Air/Sea Rescue Operations are recorded to have taken place in the Study Area.

9.12.7 The location, distribution of the physical remains of these recorded aircraft losses on the seabed is poorly understood. However, these sites are likely to be of special archaeological interest, and will be automatically protected by the Protection of Military Remains Act 1986 should they be located. Consequently at a regional scale recorded aircraft losses must be considered as a **high value** receptor.

9.12.8 Particularly where substrate removal results in a direct impact to the archaeological record the physical remains of recorded aircraft losses would be unable to tolerate the effects, resulting in a permanent change in the receptor. As such, the adaptability, tolerance and the measure of the receptor's ability to return to its pre-impact state is **low**. Although the positions of these sites are not known, the relatively short span of time since they were deposited on the seabed suggests that wreckage should be expected to survive in some form within the Study Area. Due to the uncertainty regarding their precise location and the potential, therefore, for impact from aggregate dredging recorded aircraft losses should be regarded as a receptor of **high sensitivity**.

9.12.9 With regard to the effects of sediment plume, the remains of recorded aircraft losses are likely to be unaffected or positively affected and are thus regarded as a receptor of **low sensitivity**.

Isolated Aircraft Finds

9.12.10 Isolated aircraft finds will consist of derived, aircraft-related artefacts which may be of limited archaeological importance as isolated objects. However the occurrence of a number of seemingly isolated artefacts within a particular area can give insights into patterns of historical aviation across the Study Area or may indicate the presence of a recorded but uncharted aircraft crash site. On this basis, isolated aircraft finds are regarded as a **moderate value** receptor.

9.12.11 The adaptability and tolerance of isolated aircraft finds to substrate removal is **low**. Although this receptor is scattered and ephemeral in nature if adversely affected by substrate removal, it will be unable to recover, resulting in permanent change. As such the measure of the receptor's ability to return to its pre-impact state is **low**. It is thus that isolated maritime finds be regarded as a receptor of **moderate sensitivity**.

9.12.12 With regard to the effects of sediment plume, isolated aircraft finds are likely to be unaffected or positively affected and are thus regarded as a receptor of **low sensitivity**.

Summary

9.12.13 **Table 16** summarises the value and sensitivity for each maritime receptor with regards to substrate removal and sediment plume.

Receptor	Value	Sensitivity	
		Substrate Removal	Sediment Plume
Known Charted Aircraft Crash Sites	High	High	Low
Recorded Aircraft Losses	High	High	Low
Isolated Aircraft Finds	Moderate	Moderate	Low

Table 16: Summary of the value and sensitivity for each aviation receptor

9.13 SIGNIFICANCE OF LIKELY IMPACTS: OVERVIEW

9.13.1 The significance of likely impacts arises from the combination of several variables, including the degree to which the receptor and the impact interact, the magnitude of the effect in terms of the extent, duration and frequency of the impact and the sensitivity of the receptor to the effect of impact. The significance of impacts are defined as 'not significant' or of 'minor', 'moderate' or 'high' significance.

9.14 SIGNIFICANCE OF LIKELY IMPACTS: PREHISTORIC ARCHAEOLOGY

9.14.1 **Tables 17** and **18** provide a summary of the results of the impact assessment for prehistoric archaeology receptors against the effects of substrate removal and sediment plume carried out above.

Substrate Removal				
Impact Assessment Criteria	**Prehistoric Archaeology Receptors**			
	Pleistocene Fluvial Gravels	**Estuarine Alluvium**	**Peat**	**Isolated Prehistoric Finds**
Interaction between Effects and Receptors	Large	Small	Small	Medium
Magnitude of Effect	Small/ Medium	Small/Medium	Small/Medium	Small/Medium
Value of Receptor	High	High	High	Moderate
Sensitivity of Receptor	High	High	High	Moderate

Substrate Removal				
Impact Assessment Criteria	Prehistoric Archaeology Receptors			
	Pleistocene Fluvial Gravels	Estuarine Alluvium	Peat	Isolated Prehistoric Finds
Significance of Impact	**Major**	**Minor/ Moderate**	**Minor/ Moderate**	**Moderate**

Table 17: Summary of variables assessed with regards to substrate removal and prehistoric archaeology

Sediment Plume				
Impact Assessment Criteria	Prehistoric Archaeology Receptors			
	Pleistocene Fluvial Gravels	Estuarine Alluvium	Peat	Isolated Prehistoric Finds
Interaction between Effects and Receptors	Large	Small	Small	Medium
Magnitude of Effect	Small/ Medium	Small/ Medium	Small/ Medium	Small/ Medium
Value of Receptor	High	High	High	Moderate
Sensitivity of Receptor	Low	Low	Low	Low
Significance of Impact	**Moderate**	**Minor/ Moderate**	**Minor/ Moderate**	**Moderate/ Minor**

Table 18: Summary of variables assessed with regards to sediment plume and prehistoric archaeology

9.15 SIGNIFICANCE OF LIKELY IMPACTS: MARITIME ARCHAEOLOGY

9.15.1 **Tables 19** and **20** provide a summary of the results of the impact assessment for maritime archaeology receptors against the effects of substrate removal and sediment plume accordingly carried out above.

Substrate Removal				
Impact Assessment Criteria	Maritime Archaeology Receptors			
	Known Charted Wreck Sites	Shipping Casualties / Recorded Losses	Unknown Uncharted Wreck Sites	Isolated Maritime Finds
Interaction between Effects and Receptors	Small	Medium	Medium	Medium
Magnitude of Effect	Small/ Medium	Small/ Medium	Small/ Medium	Small/ Medium
Value of Receptor	High	High	High	Moderate
Sensitivity of Receptor	High	High	High	Moderate
Significance of Impact	**Minor / Moderate**	**Moderate / Major**	**Moderate / Major**	**Moderate**

Table 19: Summary of variables assessed with regards to substrate removal and maritime archaeology

Sediment Plume				
Impact Assessment Criteria	Maritime Archaeology Receptors			
	Known Charted Wreck Sites	Shipping Casualties / Recorded Losses	Unknown Uncharted Wreck Sites	Isolated Maritime Finds
Interaction between Effects and Receptors	Small	Medium	Medium	Medium
Magnitude of Effect	Small/ Medium	Small/ Medium	Small/ Medium	Small/ Medium
Value of Receptor	High	High	High	Moderate
Sensitivity of Receptor	Low	Low	Low	Low
Significance of Impact	**Minor / Moderate**	**Moderate**	**Moderate**	**Minor / Moderate**

Table 20: Summary of variables assessed with regards to sediment plume and maritime archaeology

9.16 SIGNIFICANCE OF LIKELY IMPACTS: AVIATION ARCHAEOLOGY

9.16.1 **Tables 21** and **22** provide a summary of the results of the impact assessment for aviation archaeology receptors against the effects of substrate removal and sediment plume accordingly carried out above.

Substrate Removal			
Impact Assessment Criteria	Aviation Archaeology Receptors		
	Known Charted Aircraft Crash Sites	Recorded Aircraft Losses	Isolated Aircraft Finds
Interaction between Effects and Receptors	Small	Medium	Medium
Magnitude of Effect	Small/ Medium	Small/ Medium	Small/ Medium
Value of Receptor	High	High	Moderate
Sensitivity of Receptor	High	High	Moderate
Significance of Impact	**Minor / Moderate**	**Moderate / Major**	**Moderate**

Table 21: Summary of variables assessed with regards to substrate removal and aviation archaeology

Sediment Plume			
Impact Assessment Criteria	Aviation Archaeology Receptors		
	Known Charted Aircraft Crash Sites	Recorded Aircraft Losses	Isolated Aircraft Finds
Interaction between Effects and Receptors	Small	Medium	Medium

Sediment Plume			
Impact Assessment Criteria	**Aviation Archaeology Receptors**		
	Known Charted Aircraft Crash Sites	**Recorded Aircraft Losses**	**Isolated Aircraft Finds**
Magnitude of Effect	Small/ Medium	Small/ Medium	Small/ Medium
Value of Receptor	High	High	Moderate
Sensitivity of Receptor	Low	Low	Low
Significance of Impact	**Minor / Moderate**	**Moderate**	**Minor / Moderate**

Table 22: Summary of variables assessed with regards to sediment plume and aviation archaeology

9.17 SENSITIVITY OF INDIVIDUAL LICENCE AREAS AND IMPLICATIONS FOR FUTURE LICENCE APPLICATIONS

Introduction

9.17.1 The coincidence of individual Licence Areas and historic environment receptors has been summarised in **Table 23**. The actual presence of evidence within or in close proximity to Licence Areas has been noted; absence of evidence does not necessarily mean that the receptor is not present, not least because of the regional–scale of the datasets used and acknowledged biases in third-party records. Equally, the presence of receptor types such as isolated finds or unknown uncharted wrecks is, by definition, not knowable until they are encountered.

9.17.2 The coincidence of Licence Areas and receptors summarised in **Table 23** is such that none of the Licence Areas can be regarded as 'clear' of interactions with any of the historic environment receptors that have been assessed.

Prehistoric Archaeology

9.17.3 All the Licence Areas fall in Geophysical Zone 2 –characterised by cut and fill features generally in London Clay – or Geophysical Zone 3 – characterised by the presence of large scale channel features. Regional geophysical surveys (REC and REA) have demonstrated the presence of geophysical features of archaeological interest in a number of the Licence Areas (108/3; 327; 452 A; North Falls). Given the overall characterisation of the zones, such features are also likely to be revealed by site-specific geophysical survey in the other Licence Areas. Indeed, Estuarine Alluvium and Peat (Unit 3) has been shown to be present in almost all of the Licence Areas where vibrocore surveys have been carried out; with Fluvial Gravels (Unit 2) also been shown to be present in four Licence Areas. Oxidised bedrock (Unit 1) indicating the presence of a former landsurface is apparent in a core from 108/1. The possibility for isolated prehistoric finds to be discovered in the course of dredging has been demonstrated by Cemex_0201 – a fragment of mammoth tusk – in area 447.

Maritime Archaeology

9.17.4 There are known charted wrecks in all of the Licence Areas, with Areas 108/1, 118/2, 257 and 447 lying in areas characterised as having a high level of known losses. Whilst only Licence Areas 108/3 and North Falls have shipping casualties / recorded losses within or in close proximity to them, the distribution of records is a function of the NMR's policy of attributing casualties to a named location. The potential for the remains of shipping casualties to be present in each Licence Area is highlighted by the identification of the entire Thames Estuary as an Area of Marine Archaeological Potential (AMAP) by the ALSF Navigational Hazards Project (Bournemouth University 2007). Both the presence in each Licence Area of known charted wrecks and the overall potential for shipping casualties suggest that each Licence Area has the potential to contain as yet unknown, uncharted wrecks. This potential extends to include the possible presence of isolated maritime finds in each Licence Area, though no such finds have been reported through the Marine Aggregate Industry Protocol to date.

Aviation Archaeology

9.17.5 None of the Licence Areas contain known, charted air crash sites. However, more than half of the Licence Areas encompass reported aircraft losses. Again, difficulties in identifying and recording air crash sites and aircraft losses – combined with the high level of aviation activity in the region during World War II – suggest that each Licence Area has the potential to contain isolated aircraft finds, and possibly entire crash sites. The recovery during dredging of a Hurrican tailwheel from Area 447, reported through the Marine Aggregate Industry Protocol (UMD 0194), underlines the potential for aircraft remains to be present.

Table 23: Sensitivity of Individual Licence Areas

			Prehistoric Archaeology			Maritime Archaeology				Aviation Archaeology		
Licence Area	Geophysical Zone	Geophysical Features	Fluvial Gravels (Unit 2)	Estuarine Alluvium and Peat (Unit 3) ◊	Isolated Prehistoric Finds	Known Charted Wrecks◊	Shipping Casualties / Recorded Losses	Unknown Uncharted Wrecks	Isolated Maritime Finds	Known Charted Air Crash Sites◊	Recorded Aircraft Losses	Isolated Aircraft Finds
Significance of Impact (substrate removal)			Major	Minor / Moderate	Moderate	Minor / Moderate	Moderate / Major	Moderate / Major	Moderate	Minor / Moderate	Moderate / Major	Moderate
108/1	2			*		**Y(H)**					**Y**	
108/3, 109/1, 113/1	2	**Y**	**Y**	**Y**		**Y**	**Y**				**Y**	
118/2	2		**Y**	**Y**		**Y(H)**					**Y**	
119/3	2			**Y**		**Y**						
239/1	2		**Y**	**Y**		**Y**						
257	3			**Y**		**Y(H)**					**Y**	
327	2	**Y**	**Y**	**Y**		**Y**						
447	2			**Y**	**Y****	**Y(H)**						**Y‡**
452 A-E	2	**Y**				**Y**					**Y**	
North Inner Gabbard	2					**Y**						
North Falls	3	**Y**				**Y**	**Y**				**Y**	

* oxidised bedrock
** Cemex_0201 Fragment of Mammoth Tusk
‡ UMD_0194 Hurricane Tailwheel
◊ (H) indicates high density of charted wreck sites (see Fig. 13)
NB Where the position of receptors is known their sensitivity is lowered by virtue of being avoidable, hence known charted wrecks and air crash sites are of Minor/Moderate sensitivity. Equally aggregate dredgers will avoid known areas of alluvium and peat because they present a contamination risk.

Implications for Future Licence Applications

9.17.6 This report has addressed the general baseline for the historic environment of the Thames Estuary region in considerable detail, combining both desk-based sources and regional geophysical and geotechnical data. The regional overview provided here is sufficient to inform each future licence application in the region. That is to say, this report obviates the need to provide additional regional context in the baseline for each Licence Area EIA, except insofar as significant additional regional data becomes available.

9.17.7 EIA for future licence applications can, therefore, concentrate directly on the historic environment baseline for the individual Licence Area and its immediate environs, referring back to this report for regional context as necessary.

9.17.8 This regional assessment has demonstrated that each of the historic environment themes may present an issue for each Licence Area, with each Licence Area containing known material of archaeological interest and demonstrable potential for as yet unknown material. The Significance of Impact on historic environment receptors is generally Moderate or Major. However, the Significance of Impact is Minor when such receptors can be avoided because their presence, position and extent have been established. Prehistoric archaeology is likely to be an issue in every Licence Area, though industry will itself avoid Estuarine Alluvium and Peat because of its potential to contaminate aggregate cargoes. Maritime Archaeology is also an issue in each Licence Area, with some Licence Areas lying in areas characterised as having high densities of known wrecks, which might also indicate higher potential for the presence of other shipping casualties and isolated finds. Whilst known charted air crash sites are relatively sparse, evidence of aircraft losses is present for more than half of the Licence Areas and the potential for as yet unknown air crash sites and isolated finds is widespread. Air crash sites are automatically protected from interference by the Protection of Military Remains Act 1986.

9.17.9 In conducting EIAs for individual Licence Areas, it will continue to be necessary for historic environment data to be sought for the Licence Area and its immediate vicinity from the principal third-party records. Specifically, it will be necessary to check if any existing records have been altered or new records added as these third-party records are continually being updated. The third-party sources of most direct relevance are the UKHO (known sites of maritime and aviation archaeology interest, plus obstructions etc. that may represent as yet unrecognised sites) and NMR (known prehistoric, maritime and aviation sites; shipping casualties; and aircraft losses). Local Historic Environment Records (HERs) should also be consulted where a Licence Area falls within a HER's territorial extent, predominantly for known prehistoric, maritime and aviation sites within the Licence Area. Reports received through the Marine Aggregate Industry Protocol are passed to third-party records including the NMR and HERs, but as there may be a lag in such reports being incorporated into records it may be advisable to consult such reports directly.

9.17.10 Previous practice has been to search the NMR and/or HERs for records of known prehistoric sites from coastlines adjacent to Licence Areas as a means of gauging potential. This REA – drawing on such records and on the direct evidence of geophysical and geotechnical data – has already established this potential at a regional scale. Consequently, the general practice of searching records of adjacent coastlines is no longer advocated for Licence Areas in the Study Area.

9.17.11 Notwithstanding, consultation of NMR/HERs for adjacent coastlines may be warranted where geophysical/geotechnical data from the Licence Area itself suggests the presence of palaeo-channels that can be correlated with rivers onshore. In such cases, inferences about prehistoric archaeological potential in the Licence Area might be obtained by considering palaeo-catchments as a whole. Consultation of NMR/HERs may also indicate event records that point to relevant published or grey literature reports.

9.17.12 Insofar as EIAs informed by the Thames Estuary MAREA can focus on the Licence Areas and their immediate environs rather than regional context, then geophysical and geotechnical data from the Licence Area itself will continue to grow as the most important sources for assessing the historic environment. As already recognised in TEDA members' best practice, adequate EIA can be achieved through the archaeological assessment of existing geophysical and geotechnical data. Where additional geophysical/geotechnical surveying is planned, it is advantageous to incorporate archaeological advice arising out of the regional geoarchaeological characterisation presented in this MAREA to inform the survey specification. Specifically, provision for conserving core material is to be encouraged, to facilitate archaeological logging and sub-sampling if subsequently required. As with existing geophysical/geotechnical data, provision should be made for archaeological assessment of survey results.

9.17.13 This MAREA has not included a review of regional-scale sidescan and magnetometer datasets. Consequently, no comment has been made on the relation between recorded maritime/aviation sites and the actual presence of features and anomalies on the seabed, or on regional patterning in the visibility of features/anomalies (whether attributable to seabed sediments, bedform movement or other factors). In the absence of field data to temper conclusions, there appears to be high potential for as yet unknown maritime/aviation sites and isolated finds. As already recognised in TEDA members' best practice, adequate EIA requires archaeological assessment of high resolution sidescan survey from the Licence Area. Evaluation of archaeological features and anomalies from sidescan data will be enhanced by the availability of magnetometer and/or multibeam data.

9.17.14 Looking at the levels of effort required for individual Licence Area EIAs, the work relating to searches of third party records is likely to be common for each Licence Area. Variations in the overall level of effort in respect of the historic environment will largely be related to the acquisition (where necessary) of geophysical / geotechnical data, and the archaeological interpretation of existing/new geophysics and geotechnical results. The level of effort in conducting EIAs will be less for Licence Areas where appropriate geophysical and geotechnical data is already available and can be incorporated archaeologically at the start of the assessment. A greater level of effort will be required in conducting EIAs if existing data is inadequate. Where new surveys are to be carried out it will be advisable to obtain advice to ensure that the results are capable of addressing archaeological issues.

9.17.15 For individual EIAs, this MAREA has removed the need for preparing regional overviews and (generally) for conducting searches of records of adjacent coastlines. This should facilitate EIAs that are more tightly focussed on specific historic environment issues in the Licence Area itself, resulting in more succinct documents that can be prepared more rapidly. As acknowledged above, the MAREA places considerable emphasis on the detailed consideration of geophysical and geotechnical data for each Licence Area EIA. In turn, archaeological interpretation of geophysical and geotechnical data can be expected to reduce uncertainty and – by allowing features or anomalies to be avoided – reduce thereby the significance of impacts, which will ease the licensing process, reassure stakeholders, and facilitate the drafting of conditions. Geophysical and geotechnical surveys that are informed by this MAREA will have the effect of increasing what is known, and decreasing the scope within which previously unknown sites might potentially be found. Impacts on known sites and features can be mitigated through the existing practice of establishing Archaeological Exclusion Zones to enforce avoidance. This reduced, residual potential can be expected to fall within the operational capabilities of the Marine Aggregate Industry Protocol, which has already been demonstrated to be effective in the Thames Region.

9.17.16 This MAREA has increased certainty and provided a clearer focus on specific historic environment issues within Licence Areas. This MAREA can equally be expected to facilitate the development of more tightly-focussed monitoring programmes with respect to historic environment, so that monitoring is limited only to those areas/issues that are likely to be sensitive to aggregate dredging. Smarter monitoring of the historic environment is likely to be more efficient, whilst continuing to provide an effective safeguard.

9.17.17 The historic environment sections of the Thames Estuary MAREA will warrant review in due course, especially in the light of the current pace of marine archaeological research arising from ALSF projects and development-led investigations in the region. The Marine Aggregate Industry Protocol is likely to continue to provide directly relevant data, which should also be used to update the MAREA in the course of review.

In-combination Impacts

9.17.18 The impacts of marine aggregate dredging in combination with other forms of marine development has been assessed in the light of known or proposed schemes for channel dredging and offshore wind farm construction, including installation of export cables.

9.17.19 Like marine aggregate licensing, consents for these other forms of marine development are normally accompanied by EIA. As well as requiring an adequate level of assessment of effects on the archaeological heritage, EIAs for these other schemes include mitigation measures that can be enforced through conditions on consent. As with marine aggregates, mitigation generally comprises avoidance (through the use of exclusion zones), protocols for archaeological discoveries, and offsetting impacts on deposits of prehistoric interest by providing for assessment, scientific dating and analysis of significant horizons.

9.17.20 For the Study Area's archaeological heritage, with adequate assessment informing consent, the in-combination residual ('with mitigation') impact of marine aggregates and other schemes is likely to be low.

9.17.21 The low level of in-combination impact is also attributable to the fact that marine aggregate dredging and other forms of development have different implications for the main archaeological receptors.

9.17.22 Channel dredging for navigation is intense but localised, especially where (as in the Outer Thames) the majority of the channel is already at depth and no further excavation is required. Whilst some sites are avoided by changing channel design and navigational infrastructure, other sites can require demolition ('clearance') and are subject to specific mitigation measures. Aggregate dredging tends to be more extensive and diffuse and there is greater scope for sites to be avoided.

Consequently the in-combination impact of marine aggregate dredging and navigational channel dredging on the archaeological heritage is considered to be low.

9.17.23 Offshore windfarms generally have two main physical impacts relevant to the archaeological heritage: installation (and protection) of turbine foundations; and installation of inter-array and export cabling. Foundation impacts tend to be restricted horizontally but they may be very deep – which is a concern for buried deposits of prehistoric interest – in contrast to generally shallow aggregate dredging. Vertical impacts from windfarms arising from turbine foundations have tended to be offset by carrying out detailed assessment, scientific dating and analysis of suitable recovered material. The impact of turbines offset by geoarchaeological investigation of deep sequences, together with geophysics-based results for marine aggregates that are extensive, is probably resulting in a positive in-combination impact on the prehistoric archaeological heritage through the research dividend being created for future management.

9.17.24 Windfarm cables are laterally extensive but physical impacts are limited in width and depth. Moreover, cables are routed around known sites to avoid jeopardising both the cables and the installation gear. As the physical impacts of cabling are limited and in both sectors developers seek to avoid known sites, the in-combination impact of windfarm cabling and marine aggregates in the Study Area is considered to be low.

9.17.25 In conclusion, due to the different characteristics of impacts on the archaeological heritage arising from marine aggregates compared with other scheme types, and subject to the archaeological heritage being adequately assessed and appropriately mitigated across all scheme types, in-combination impacts in the Study Area are unlikely to compromise the historic environment at a regional scale.

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APPENDIX I: LEGISLATION

Introduction

This section outlines the legal framework that applies to the maritime heritage in the MAREA Study Area. The Study Area encompasses waters administered by England and those of the United Kingdom Continental Shelf (beyond the 12 nautical mile (nm) limit). The maritime heritage within England's territorial waters is covered by legislation and guidance for England and the United Kingdom. The maritime heritage on the Continental Shelf is predominantly covered by international legislation and guidance, although in some cases policies from England and the United Kingdom apply.

Protection of Wrecks Act 1973

Under the 1973 Act, wrecks and wreckage of historical, archaeological or artistic importance can be protected by way of designation. It is an offence to carry out certain activities in a defined area surrounding a wreck that has been designated, unless a licence for those activities has been obtained from the Government. Generally, the relevant Secretary of State must consult appropriate advisors prior to designation, though it is also possible to designate a wreck in an emergency without first seeking advice.

Under Section One of the Act, wrecks and wreckage of historical, archaeological or artistic importance can be protected by way of designation. Section Two of the Act provides protection for wrecks that are designated as dangerous due to their contents and is administered by the Maritime and Coastguard Agency (MCA) through the Receiver of Wreck (RoW).

The are currently two sites designated under Section One of the Protection of Wrecks Act 1973 within the Study Area: the Dunwich Bank wreck and the South Edinburgh Channel wreck. However, if any important wreck or ship borne artefact is discovered during dredging operations, the emergency designation of an area around the find remains a possibility.

Merchant Shipping Act 1995

This Act sets out the procedures for determining the ownership of underwater finds that turn out to be 'wreck'. Within the context of the Merchant Shipping Act 1995, 'wreck' refers to items defined as flotsam, jetsam, derelict and lagan found in or on the shores of the sea or any tidal water. It includes a ship, aircraft or hovercraft, parts of these, their cargo or equipment.

If any such finds are brought ashore the salvor is required to give notice to the RoW that he has found or taken possession of it and, as directed by the RoW, either hold it to the Receiver's order or deliver it to the Receiver. This applies whether material has been recovered from within or outside UK Territorial Waters, unless the salvor can prove that title to the property has been vested in him (e.g. by assignment to him of rights devolving from the owner of the vessel or its contents at the time of loss). Even if ownership can be proved the salvor is still required to notify the RoW.

The Crown makes no claim on a wreck found outside UK Territorial Waters which remains unclaimed at the end of the statutory one-year and the property is returned to the salvor. Ownership of unclaimed wreck from within Territorial Waters lies in the Crown or in a person to whom rights of wreck have been granted.

The RoW has a duty to ensure that finders who report their finds as required receive an appropriate salvage payment. In the case of material considered being of historic or archaeological importance, a suitable museum is asked to buy the material at the current valuation and the finder receives the net proceeds of the sale as a salvage payment. If the right to, or the amount of, salvage cannot be agreed, either between owner and finder or between competing salvors, the RoW will hold the wreck until the matter is settled, either through amicable agreement or by court judgement.

Protection of Military Remains Act 1986

Under the Protection of Military Remains Act 1986, all aircraft that have crashed in military service are protected, and the Ministry of Defence (MoD) has powers to protect vessels that were in military service when they were wrecked. The MoD can designate named vessels as ‘protected places’ even if the position of the wreck is not known. In addition, the MoD can designate ‘controlled sites’ around wrecks whose position is known. In the case of ‘protected places’, the vessel must have been lost after 4 August 1914, whereas in the case of a wreck protected as a ‘controlled site’ no more than 200 years must have elapsed since loss.

Diving is not prohibited at a ‘protected place’ but it is an offence to tamper with, damage, move or remove sensitive remains. However, diving, salvage and excavation are all prohibited on ‘controlled sites’, though licences for restricted activities can be sought from the MoD. Additionally, it is an offence to carry out unauthorised excavations for the purpose of discovering whether any place in UK waters comprises any remains of an aircraft or vessel which has crashed, sunk or been stranded while in military service.

In November 2001, the MoD reported on the Public Consultation on Military Maritime Graves and the Protection of Military Remains Act 1986. The report recommended that a rolling programme of identification and assessment of vessels against the criteria be established to designate all other British vessels in military service when lost, as Protected Places. There have been three tranches since November 2001 which occurred in 2002, 2006 and 2008. Under the third tranche, the type of vessel that can be protected under the Act has been substantially widened.

The records of vessels lost during both World Wars whilst on active service do not always give an exact location. Given the volume of activity which occurred throughout WWI and WWII in the general area of the Thames estuary and within the Study Area in particular, there is high potential for finding shipwrecks for which there are currently no known remains.

Ancient Monuments and Archaeological Areas Act 1979

This act is primarily land based, but in recent years it has also been used to provide some level of protection for underwater sites.

The Act provides for the scheduling of monuments, which encompasses buildings, structures or work, cave or excavation, vehicle, vessel, aircraft or other moveable structure. In order to be eligible for scheduling, a monument must be of national importance. Sites range from standing stones to deserted medieval villages, and include more recent structures such as collieries and wartime pillboxes. Scheduled Monuments and Areas of Archaeological Importance (AAIs) are afforded statutory protection by the Secretary of State, and consent is required for any major works. The law is administered by English Heritage (EH) and the Department of Culture, Media and Sport (DCMS).

In relation to maritime scheduled monuments, it would be an offence to demolish, destroy, alter or repair a scheduled wreck without *scheduled monument consent*.

PPG16: Planning Policy Guidance: Archaeology and Planning

PPG16 only applies to local authority regions, which, as a general rule, extends only to the low water mark. However, local councils can apply this to sub-tidal archaeological remains in order to ensure best practice.

PPG16 sets out the Secretary of State's policy on archaeological remains. It acknowledges the potentially fragile and finite or irreplaceable nature of such remains (para. 6), and states that the desirability of preservation of archaeological remains and their setting is a material consideration within the planning process (para. 18). PPG 16 provides that there is a presumption in favour of the physical preservation of nationally important archaeological remains (para. 8), and that where preservation *in situ* is not justified it is reasonable for planning authorities to require the developer to make appropriate and satisfactory provision for excavation and recording of remains (para. 25).

Paragraph 19 of PPG 16 suggests that it is in developers' own interests to include an initial assessment of whether the site is known or likely to contain archaeological remains as part of their research into the development potential of a site. Paragraph 22 adds: 'Local planning authorities can expect developers to provide the results of such assessments ... as part of their application for sites where there is good reason to believe there are remains of archaeological importance'. PPG 16 also notes that in spite of the best pre-planning application research, there may be occasions when the presence of archaeological remains only becomes apparent once development has commenced (para. 31).

PPG20: Planning Policy Guidance: Coastal Planning

PPG20 sets out the importance of the coast as a national resource. Paragraph 2.8 states that the coastal zone also has a rich heritage both above and below the low water mark. This includes buildings and areas of architectural or historic interest, industrial archaeology, scheduled and other ancient monuments and other archaeological sites. As a consequence, it is recommended that policies should encourage conserving and restoring structures of special historic, architectural or archaeological interest (para. 3.6).

Code of Practice for Seabed Developers, Joint Nautical Archaeology Policy Committee 2006 (JNAPC)

The *JNAPC Code of Practice for Seabed Developers* provides a framework for seabed developers similar to the principles found in current policy and practice on land. Thr aim of the Code is to ensure a best practice model for seabed development. The Code offers guidance to developers on issues such as risk management and legislative implications.

England's Coastal Heritage: A statement on the management of coastal archaeology 1996

This statement sets out a number of principles for managing coastal archaeology. These include the promotion of preservation *in situ,* that finds should be managed in accordance with the principles which apply to terrestrial archaeological remains, that marine and terrestrial remains must be considered seamlessly, that a precautionary approach should be adopted and that PPG16 should be applied to the treatment of sub-tidal archaeological remains in order to secure best practice.

European Landscape Convention (ELC) 2000

The ELC (2000) became binding on the UK from 1 March 2007. Its principal clauses require the Government to protect and manage landscapes and to integrate landscape into regional and town planning policies including its cultural, environmental, agricultural, social and economic policies. The ELC applies to the entire territory of the UK and includes land, inland water and marine areas. However, the Convention is not regarded as applying to sea areas regulated by the UK that lie beyond territorial waters.

Identifying and Protecting Palaeolithic Remains

Identifying and Protecting Palaeolithic Remains; Archaeological Guidance for Planning Authorities and Developers (English Heritage 1998) draws attention to the importance of Palaeolithic remains and states that they must be considered in line with PPG 16 when potentially affected by development proposals. Palaeolithic archaeological sites are defined as any land where artefacts or traces of a human presence of Pleistocene date have been found. The document notes that Palaeolithic remains have particular importance if:

- any human bone is present in relevant deposits;
- the remains are in an undisturbed, primary context;
- the remains belong to a period or geographic area where evidence of a human presence is particularly rare or was unknown;
- organic artefacts are present;
- well-preserved indicators of the contemporary environment (floral, faunal, sedimentological) can be directly related to the remains;
- there is evidence of lifestyle (such as interference with animal remains);
- one deposit containing Palaeolithic remains has a clear stratigraphic relationship with another;
- any artistic representation, no matter how simple, is present;
- any structure, such as a hearth, shelter, floor, securing device etc. survives;
- the site can be related to the exploitation of a resource, such as a raw material;
- artefacts are abundant.

The document goes on to note that sites containing any of these features are so rare in Britain that they should be regarded as of national importance and whenever possible should remain undisturbed.

The advice offered to developers and planning officers includes the following:

- It is advisable for prospective developers to research the archaeological potential of their sites (including that for Palaeolithic remains) at an early stage;
- It is the responsibility of developers to supply the relevant planning authority on the archaeology of their sites, with proposals for the way in which this will be accommodated within the development scheme, so that an informed planning decision can be reached. Information on the Palaeolithic remains or the potential for such remains within a certain site may be acquired from a desk-based assessment but when this is inadequate it may be necessary to obtain further information from a limited field evaluation by suitably qualified archaeologists;

- Planning authorities may apply a condition to a consent which prohibits the start of development until the applicant has ensured appropriate provision has been made for an adequate record of the site's archaeological remains.

Military Aircraft Crash Sites (EH 2002)

This provides archaeological guidance regarding the significance and future management of military aircraft crash sites. It outlines the importance of aircraft crash sites and indicates that they should be considered where they are affected by development proposals and planning and development bodies.

MARITIME ARCHAEOLOGY ON THE CONTINENTAL SHELF

The mandate for regulating the maritime heritage beyond the 12 nm territorial limit is less direct. In some cases, the archaeological resource is covered by the provisions of the legislation and guidance discussed above. For example, the provisions of the Protection of military Remains Act 1986 regarding Controlled Sites are applicable in international waters, though they are only enforceable with respect to British-controlled ships, British citizens and British companies.

Archaeological material on the Continental shelf is also covered by international laws and conventions. While wrecks are not currently regarded to form part of the natural resources of the Continental shelf which are regulated by coastal states, some indirect regulation arises from the environmental controls placed on the regulated exploitation of natural resources. In particular, insofar as Continental Shelf activities are subject to Environmental Impact Assessment under European Directives (85/337/EEC and 97/11/EC), the effects of those activities on the archaeological heritage have to be addressed and mitigation proposed. Similarly, the effects on the archaeological heritage of Continental Shelf activities have to be assessed by virtue of the Strategic Environmental Assessment Directive (2001/42/EC).

United Nations Convention on the Law of the Sea (UNCLOS) 1982

UNCLOS 1982 was ratified by the UK in 1997. Article 303 stipulates that 'states have the duty to protect objects of an archaeological and historical nature found at sea and shall co-operate for this purpose'. Article 303 also provides for coastal states to exert a degree of control over the archaeological heritage to 24 nautical miles, though the UK has not introduced any measures to implement this right.

European Convention on the Protection of the Archaeological Heritage 1992 (Revised) (The Valletta Convention)

The Valletta Convention was ratified by the UK Government in 2000 and came into force in 2001. The convention binds the UK to implement protective measures for the archaeological heritage within the jurisdiction of each party, including sea areas. Insofar as the UK exerts jurisdiction over the Continental Shelf, then it would appear that the provisions of the Valletta Convention apply to that jurisdiction.

UNESCO Convention on the Protection of the Underwater Cultural Heritage 2001 (CPUCH)

The UNESCO Convention (CPUCH) concluded in 2001, and is a comprehensive attempt to codify the law internationally with regards to underwater archaeological heritage. The UK abstained in the vote on the final draft of the Convention, however, it has stated that it has adopted the Annex of the Convention, which governs the conduct of archaeological investigations, as best practice for archaeology. In addition, although the UK is not a signatory, the convention was carried forward on 2nd January 2009 as it has now been signed or ratified by 20 member states.

International Council of Monuments and Sites (ICOMOS) Charter on the Protection and Management of Underwater Cultural heritage 1996 (The Sofia Charter)

The Charter includes a series of statements regarding best practice, intending 'to ensure that all investigations are explicit in their aims, methodology and anticipated results so that the intention of each project is transparent to all'. The UK is a member of ICOMOS.

APPENDIX II: RELATIONSHIP BETWEEN SIGNIFICANT ARCHAEOLOGICAL PERIODS AND RELATIVE SEA LEVEL STANDS

Relative Sea Level	Approximate Age	Oxygen Isotope Stage	Chronozone/ Biozone	Archaeology
0m+ to -10m+	5,500 BP 7,200 BP	-	Atlantic pollen zone	Late Mesolithic to Early Neolithic
-15m+	- 8,500 BP	-	Boreal pollen zone	Beginning of Late Mesolithic, land-bridge to the Continent finally removed
-30m+	- 9,500 BP	-	Boreal pollen zone	Early Mesolithic
-40m+	- 10,000 BP	-	Preboreal pollen zone	Beginning of Early Mesolithic
-50m+	- 11,000 BP	1	Loch Lomond stadial	Final Upper Palaeolithic
-60m+	- 13,500 BP	2	Windermere interstadial/ Late glacial	Late to Final Upper Palaeolithic, Re-colonisation of Britain from *c.* 12,500 BP; Creswellian cave sites and 'straight-backed blade' open air sites at Brockhill and Hengistbury Head
-80 to -100m+	- 18,000 BP	2	Dimlington stadial/ Late Devensian glaciation	Mid to Late Upper Palaeolithic, Britain probably not occupied
-120m+	- 40,000 BP	2	Devensian glacial maximum *c.* 18,000 BP	Early to Mid Upper Palaeolithic, appearance of modern humans in Europe *c.* 40-30,000 BP; Britain probably not occupied from *c.* 22,000 BP
-60 to -90m+	- 110,000 BP	3-5a-d	Devensian glaciation, Upton Warren/Chelford interstadials	Late Middle Palaeolithic; Kempton Park/East Tilbury gravel terraces deposited; Britain probably not occupied until 60,000 BP

Relative Sea Level	Approximate Age	Oxygen Isotope Stage	Chronozone/ Biozone	Archaeology
0m+	- 130,000 BP	5e	Ipswichian interglacial	Early Middle Palaeolithic; Britain is an island and probably not occupied; raised beach deposits, e.g. Pagham
-120m+	- 186,000 BP	6	Wolstonian glaciation	Taplow/Mucking gravel terraces deposited; Britain probably not occupied from 180,000 BP
0m+	- 245,000 BP	7	(Aveley) interglacial	Pontnewydd (Homo neanderthalensis); Britain is an island; Norton raised beach
-120m+	- 303,000 BP	8	Wolstonian glaciation	Lynch Hill/Corbets Tey gravel terraces deposited – possibly related to the particularly artefact rich Taddiford Farm Gravel of the Solent; Levallois technology appears
0m+	- 339,000 BP	9	(Purfleet) interglacial	Sparsity of sites; Britain probably an island for at least part of this stage
-120m+	- 380,000 BP	10	Wolstonian glaciation	Boyn Hill/Orset Heath gravel terraces deposited; many Lower Palaeolithic sites
0m+	- 423,000 BP	11	Hoxnian interglacial	Swanscombe (Homo heidelbergensis); Aldingbourne raised beach (? possibly early OIS 7); Britain is an island during late Hoxnian
-130m+	- 478,000 BP	12	Anglian glaciation	Sea level probably at its lowest recorded level around the British Isles; first breach of Continental land-bridge during late Anglian
+/-0m	- 528,000 BP	13	Cromerian Complex, including Cromer Forest-bed formation (possibly confined to OIS 17-19) and Happisburgh glaciation (OIS 16?)	Boxgrove (Homo heidelbergensis); Slindon raised beach
-50m	- 568,000 BP	14		
+/-0m	- 621,000 BP	15		
-90m	- 659,000 BP	16		
-10m	- 712,000 BP	17		Happisburgh artefacts

Relative Sea Level	Approximate Age	Oxygen Isotope Stage	Chronozone/ Biozone	Archaeology
-80m	- 760,000 BP	18		
-?m	- ?	19		Pakefield freshwater deposits and artefacts (OIS 17 or 19?)
+/-0m	- 787,000 BP			Pakefield estuarine deposits and artefacts (OIS 17 or 19?)

10.1.1

10.1.2 The table above presents information derived from several references. The Oxygen Isotope Stages are from Wymer's projection in *The Lower Palaeolithic Occupation of Britain* (1999:4) and from compilations by Dix and Westley (2004:95) and the Ancient Human Occupation of Britain (AHOB) project (AHOB 2006; e.g. Barton 2005:18). Oxygen Isotope Stages (OIS) refer to periods alternating between temperate and cold climates. These periods have been deduced from oxygen isotope data reflecting temperature curves derived from deep sea core samples.

10.1.3 The sea levels from the Pleistocene period shown in **Appendix II** are drawn from discussions by Funnel (1995:4), Dix and Westley (2004:67-80) and Lee *et al.* (2006:173-176). More data is available for the sea levels during the Holocene, particularly with regards to the east and the south coasts. However, it must be noted that as sea level fluctuations are the result of numerous factors, projected sea level curves must be regarded as projections of general tendencies rather than representations of exact figures. A comprehensive account of these Holocene sea levels can be found in Shennan *et al.* (2000:278) and Dix and Westley (2004).