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HOO PENINSULA, NORTH KENT COAST, THAMES ESTUARY
A PALAEOENVIRONMENTAL REVIEW OF THE DEVELOPMENT OF THE HOO PENINSULA

ENVIRONMENTAL STUDIES REPORT

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ARCHAEOLOGICAL SCIENCE

ENGLISH HERITAGE

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Hoo Peninsula
North Kent coast
Thames Estuary

A palaeoenvironmental review of the development of the Hoo Peninsula

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SUMMARY
This report forms part of the output of the 'Hoo Peninsula Historic Landscape Project' (5733), reviewing and describing the Quaternary palaeoenvironmental development and associated deposits of the region; in particular those of fluvial- (deriving from the migrating Rivers Medway and Thames) and marine- (deposits associated with fluctuating sea levels) origin. Within these contexts, archaeological deposits and remains have been discussed where present. The studies on which this review is based result from a combination of academic- and development-led research across a variety of disciplines. Sites from which palaeoenvironmental proxies (ie sub-fossils) have been recovered and/or analysed are summarised and recorded as a layer within the project's GIS output.

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ARCHIVE LOCATION
This will form part of the Hoo project archive at the National Monuments Record Centre (NMRC).

DATE OF RESEARCH
2010-2011

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Cover image: Aerial photograph looking westwards across the Hoo Peninsula, with the Isle of Grain in the foreground (© English Heritage, NMR 26477/050).

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INTRODUCTION

The over-arching aim of the multi-disciplinary 'Hoo Peninsula Historic Landscape Project' (5733) is to investigate and understand the diverse aspects of the region's historic environment – its longterm development and current assets – in order that it can be appropriately managed and protected. This is particularly pertinent given the increasing development pressures being placed on the area, such as the proposed Lower Thames Crossing and Hoo airport.

As part of Phase 1, a desk-based palaeoenvironmental review (mostly based on published and grey literature) was undertaken, synthesising the multidisciplinary research that has been carried out; its products comprise this document and an accompanying Access database that is incorporated as a layer into the project's GIS output. By collating and synthesising information already available for the region, priority areas of future investigation have been identified.

CURRENT GEOGRAPHICAL AND GEOLOGICAL SETTING

Geographical setting

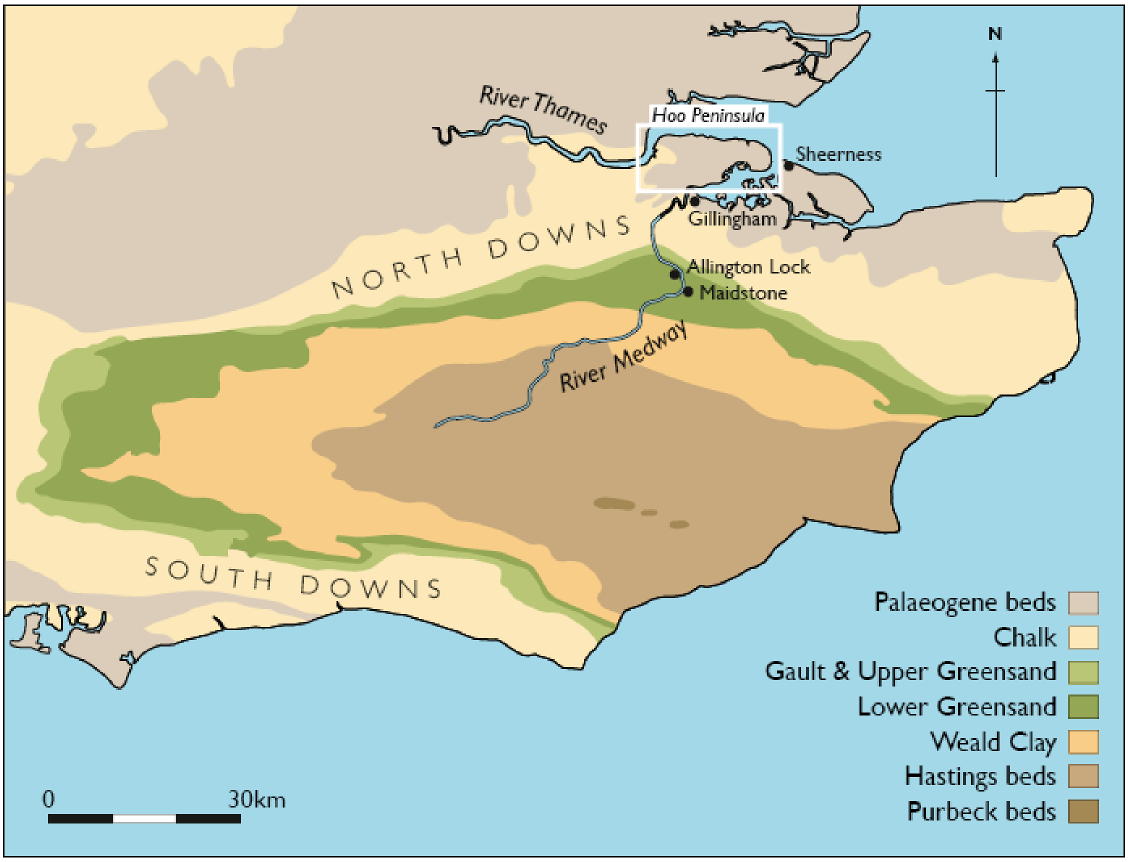
The Hoo Peninsula promontory on the north Kent coast extends northwards from the southern bank of the Greater Thames Estuary. It is located within the London Basin syncline; a depression between the chalk Chiltern Hills of Essex to the north, and the chalk North Downs of Kent to the south (part of the Wealden anticline) (see Figure 1). The latter escarpment trends west-north-west to east-south-east, and gently slopes down to the lower-lying land to its north-east (Dines *et al* 1954), which includes the areas of the Hoo Peninsula, the Isle of Sheppey and the Medway and Swale Estuaries. The River Medway – the largest tributary of the Thames – has its source in Ashdown Forest, West Sussex, on the Hastings Beds of the High Weald (WessexArchaeology 1993). It is thought to have come into existence during the geological period known as the Palaeogene[1] (at a time when the London Basin was a marine embayment) when tectonic movements resulted in the upward movement of the chalk deposits (Bridgland 2003).

From its source, the River Medway flows generally north-eastwards until Maidstone, where it changes direction to take a more northerly route (Figure 1). It crosses the North Downs chalk mass near Burham, flowing within a narrow, steep-sided incised gorge (the Medway Gap). At Gillingham it becomes a meandering channel crossing a broad, flat-floored valley, finally joining the Thames at Sheerness (Kirby 1969). It becomes tidal at Allington Lock (Hutchings 1925 ; Kirby 1969); the Medway estuary is macrotidal with a

[1] See Table A1 for the geological time period divisions relevant to this text.

spring tidal range varying between 4.9m at its mouth (Sheerness) to 3.4m at Allington Lock (Anon 2007).

Figure 1. Map showing the geological setting of southeast England, including the location of the Hoo Peninsula on the north Kent coast and the current routes of the Rivers Thames and Medway (after Bridgland 2003).



The Hoo Peninsula is joined to the mainland along its south-western edge; its south-eastern and eastern margins are on the River Medway's estuary, and the northern edge borders the easterly flowing River Thames. The peninsula has a ridge of relatively high land running south-west to north-east, from Allhallows to High Halstow (James 2006), referred to as the 'Hundred of Hoo Hills' by Evans (1953).

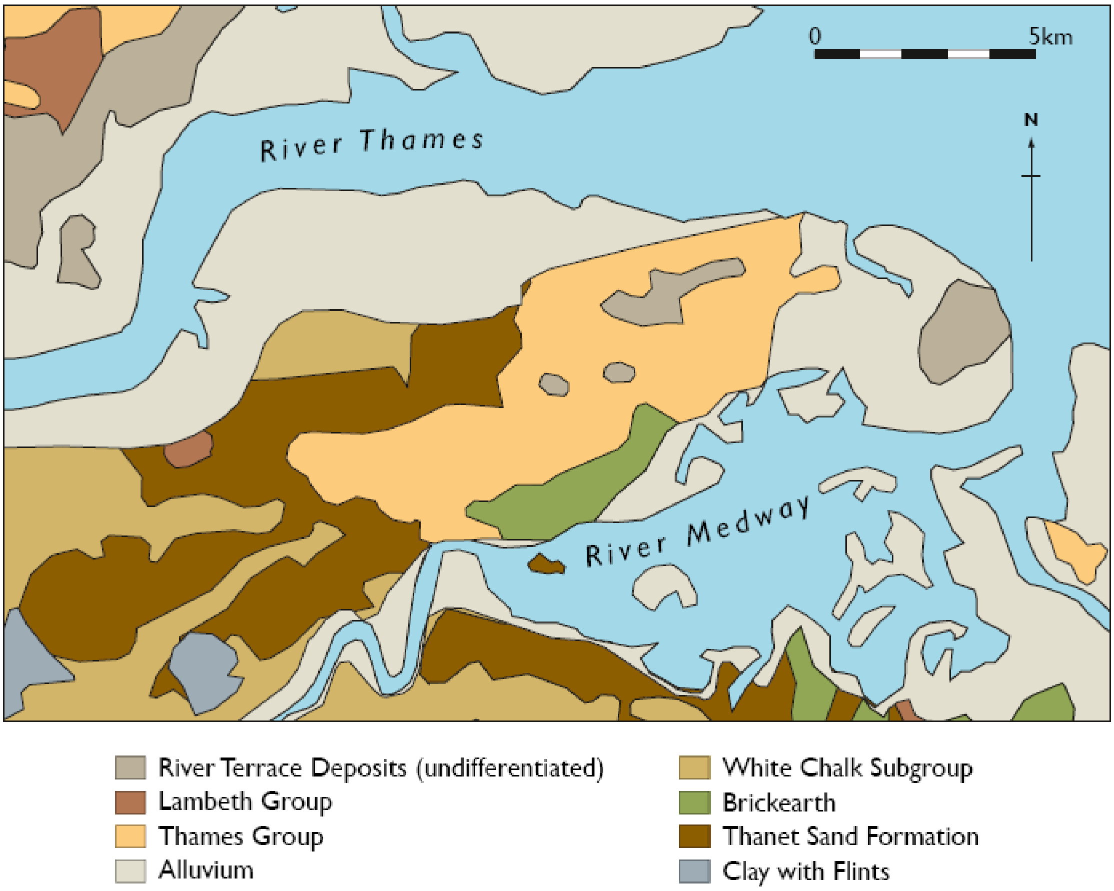
Around the peninsula's coast, to the north and south of the ridge, are extensive, low-lying marshes with a history of reclamation since the Roman period (Barham *et al* 1995). Early maps show the Isle of Grain to be an island, yet it now forms part of the Hoo Peninsula, joined as a result of land reclamation. During the13-15th centuries, flood defences were built on the Hoo, along the Medway River, facilitating a landuse shift from pasture to agriculture.

The saltmarshes of the River Medway are characteristically broad in area, but tend to be highly dissected by creeks (Burd 1992). Kirby (1990) calculated a net sediment budget deficit for Stoke Marshes (on the south-eastern edge of the peninsula). This is supported by a saltmarsh survey (Burd 1992) showing that between 1973 and 1988, 21 per cent of the River Medway marshes had eroded; Stoke Saltings was mentioned particularly as having lost complete small patches of marsh (although some gains of marsh had also been experienced due to colonisation of the grass *Spartina*) (Burd 1992). The saltmarshes along the Kentish Thames coast (that is, the northern coast of the Hoo Peninsula) are smaller and less dissected, and experienced slightly less erosion (18 per cent) (but a total loss of 23 per cent). Most loss was from the extreme seaward edge of the marshes; notably at Cliffe Fleet and Allhallows-on-Sea (Burd 1992). Exposed peat layers are visible in the intertidal zone as a result of the erosion (see WessexArchaeology 2005, 2006).

Geological setting

The geology of the region (Figure 2) is dominated by the clay and silt London Clay Formation (part of the Thames Group) laid down in the Eocene under marine conditions. It is prevalent on the eastern Hoo Peninsula as the underlying bedrock; in particular, forming the peninsula's ridge of hills – the Hundred of Hoo Hills – (some of which is overlain by head or river terrace deposits) and underlying the superficial alluvial marsh deposits. The oldest deposits on the Hoo Peninsula belong to the Cretaceous White Chalk Subgroup, and consist of chalk with flints; its main (albeit small, at 2 square miles) outcrop is at Cliffe in western central Hoo (Whitaker *et al* 1872a ; Dines *et al* 1954).

Figure 2. Geological map of the Hoo Peninsula and adjacent regions (redrawn based upon the 1:625 000 scale geology map, with the permission of the British Geological Survey).



Other significant geological constituents of the peninsula are:

i) sand/silt/clay of the early Palaeocene **Thanet Sand Formation** bedrock, found mainly in the west-central, north-west and south-west regions of the peninsula

ii) sand/silt/clay of the **Lambeth Group**, from the later Palaeocene (and found in similar areas as the Thanet Sand Formation)

iii) Quaternary silt/clay **Brickearth**[2] in the south, clay/silt/sand/gravel **Head**[3] along the Hoo's ridge and sand/gravel **River terrace** deposits along the ridge and in the far east on the Isle of Grain (where Grain Gravel over 5m thick lies on London Clay (Bridgland 2003))

iv) more-recent Holocene **alluvium**[4] that covers extensive areas of land on the low-lying marshes of the eastern and north-western Hoo Peninsula (Dines *et al* 1954), either side of the elevated ridge. It is mainly silt and clay, but with some sand, gravel and peat seams. Biological remains are commonly

[2] 'Brickearth' forms under dry, cold conditions and takes its name from its main use; brick-making.
[3] 'Head' is the term given to describe deposits of non-fluvial origin (eg by solifluction, hillcreep, wind action), hence is a wide group.
[4] 'Alluvium' refers to waterlain deposits eg silts deposited by flooding.

preserved, including ostracods, molluscs, insects, mammal bones and teeth, wood and pollen (Sumbler *et al* 1996).

As the dominant deposit of the region, the London Clay has a large influence on the characteristics of the resultant Head deposits. It is quite distinctive from the gravel deposits that have originated in the Chalk bedrock of the North Downs (Wenban-Smith *et al* 2007); the gravels usually lack fossil material although they can contain lithic artefacts, and the Head often yields fossil animal and plant remains.

Relative to the river terrace mapping studies of the River Thames, the River Medway has received much less attention. Prior to the work of Bridgland, the only work to have given the Hoo Peninsula gravels specific attention was that of Dines *et al* (1954). They recognised four river terraces trending roughly from north-west to south-east across the peninsula.

Subsequently, Bridgland (1983) and Bridgland and Harding (1985) (onwards) have revised these categories, realising at least nine separate gravel deposits on the Hoo and Isle of Grain (Bridgland 2003) (see below). More recent investigations also indicate that Dines *et al*'s (1954) geological mapping of the Hoo Peninsula to be an oversimplification; for example, boreholes taken by Bates *et al* (2002) at Allhallows in western Hoo, show there to be Pleistocene deposits overlying what had previously been mapped purely as London Clay.

GEOMORPHOLOGICAL DEVELOPMENT

The Hoo Peninsula's geomorphological development has involved a complex interaction between glacially-driven isostatic (land) adjustments, changing (eustatic) sea-levels and migrating river systems. Evidence of the environmental changes associated with different depositional environments is inferred from their associated sediments preserved within the stratigraphy. The most recent, and best evident, developments have occurred within the Quaternary period, characterised by a series of alternating glacial (cold) and interglacial (warm) conditions. In the British Isles, the most recent of the most extensive (ie most southerly-reaching) periods of ice cover occurred during the Anglian glaciation; marine oxygen isotope stage (MOIS) 12[5]. The most recent glaciation (the Devensian; MOISs 2-5d) did not reach as far south as the ice advance of the Anglian, and so the Kent area was subjected to periglacial, tundra-like conditions. Although periglacial conditions and processes have in places altered the characteristics of some deposits (thereby hindering their interpretation), the fact that the region was not ice-covered has resulted in the preservation of older deposits, for example, river terraces and interglacial deposits that often contain important biological palaeoenvironmental indicators (Bridgland 2000).

[5] See Table A2 for the stage names, ages and equivalent MOISs and archaeological periods.

River terrace formation

Due to the combination of i) land uplift, ii) the downward cutting processes of flowing rivers and iii) a lack of ice cover (that would otherwise have removed earlier deposits), older river sediments (characteristically sands and gravels) are preserved at progressively higher altitudes, as suites/staircases of 'river terraces'. These terraces are formed during a river's downcutting phase, occurring at the transition from a glacial to interglacial (see Bridgland (2000) for an overview of the six-phase model of formation). Preservation of terraces is highly dependent on the nature of the bedrock (Bridgland 1985: 29); hard rock geologies, for example chalk, prevent rivers meandering, resulting in the reworking of sediments; softer geologies, for example clays, facilitate a river's lateral migration and therefore preservation of previous terrace deposits.

The River Medway once flowed from south-west to north-east across the Hoo Peninsula, and so, as a result of this, in the central peninsula, near High Halstow, is the best preserved suite of terraces found so far for this river (Bridgland 2003: 25, 33). However, the peninsula is thought to lack the very oldest (highest) river's sediments, as they are likely to have been eroded through mass movement and surface runoff (Bridgland 1985: 30). For example, the highest remaining terrace on the peninsula is not, in fact, the oldest gravel deposit associated with the early River Medway (which is the Cobham Park Gravel found on the North Downs), but that of the Lodge Hill Gravel, at Lodge Hill (+73m OD) (Bridgland 2003).

By mapping the river gravels it has been possible to infer the rivers' previous courses, for example, Gibbard (1999) and Bridgland (2003) show former routes of the Rivers Thames and Medway; clast lithological analysis – identifying and determining proportions of rock types within a particular river gravel – is used in conjunction with geological maps to identify source/provenance regions and characterise a particular river's associated sediments (for example, Bridgland (1999)).

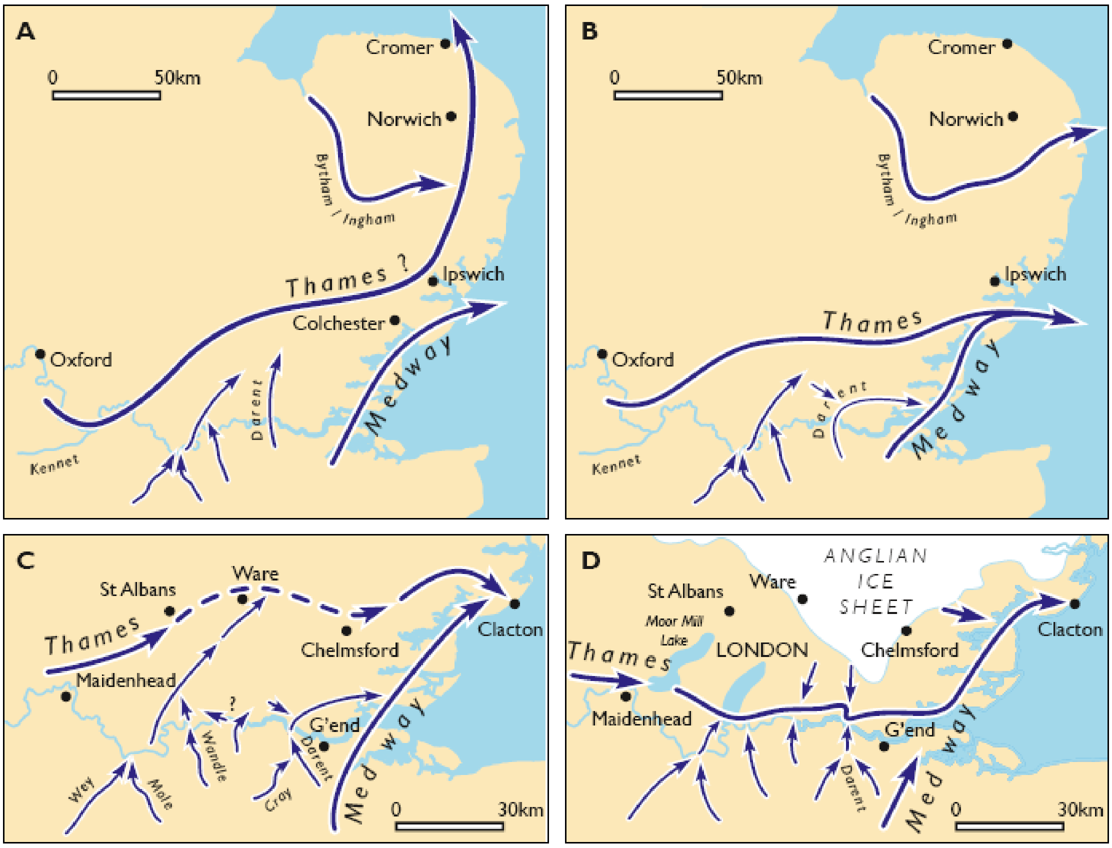
By using a combination of their altitudes, biostratigraphy and archaeological (lithic) artefacts found within them (taking into consideration problems of reworking), terrace ages and correlations between terraces can be inferred. For example, a late/post Anglian age (MOIS 11) was assigned to the Shakespeare Gravel from the Clactonian and Acheulian lithics found within it (Bridgland and Harding 1985); and Preece (1995) uses the presence/absence/assemblages as indicators of particular MOISs in Lower River Thames deposits. Increasingly, amino-acid racemisation and optically stimulated luminescence (OSL) methods are being used for dating. For example, OSL dated the important lithic artefact site at Cuxton to MOIS 7 (c 230,000 BP) (Wenban-Smith *et al* 2007). Unfortunately, on the Hoo Peninsula, findings of pre-Devensian deposits with fossil fauna and/or flora associated are scarce. Exceptions are: Upnor (Andrews 1928), Allhallows (Bates *et al* 2002 ; Bates *et al* 2007) and Kingsnorth/Damhead Creek (Bates 1999a).

Pleistocene development

Since early work by Wooldridge (1927) it has been identified that 'belts' of gravels plotting former river courses, trended approximately north to south across East Anglia. It is postulated that during the Early Pleistocene, prior to the Anglian glacial period, the Rivers Thames and Medway followed separate courses (Bridgland 2003) (see Figure 3). The early River Thames followed a north-easterly route; north of London, across what is now the Vale of St Alban's (see Gibbard 1977), and then across Suffolk and north Norfolk, possibly via Norwich, and into the central North Sea region (Bridgland and D'Olier 1995). Over time, its path is thought to have migrated steadily southwards, passing through Ipswich (Bridgland 1988). Meanwhile, the 'Essex Medway' (an early, proto River Medway) flowed from south-west to north-east across eastern Essex, with its path migrating eastwards, perhaps as a result of tectonic land tilting (Coleman 1952). It is thought to have then joined the River Lobourg that drained from the Wealden ridge (now eroded as the Strait of Dover) into the southern North Sea basin (Bridgland and D'Olier 1995).

The River Medway only became a tributary of the River Thames during the early Anglian (early Middle Pleistocene), when the River Thames was forced by the advancing ice to migrate further south to cross central and northern Essex (via Clacton) where it came to occupy the valley of the then Essex Medway. Subsequently, the merged river continued to shift its route further south, settling where we know it today, through London. Former channels, now buried, have been studied by Lake *et al* (1977) and submerged palaeochannels can also be mapped offshore in the Thames Estuary.

Figure 3. Series of maps showing the Quaternary development of the River Thames and its tributaries, including the River Medway (after Bridgland 2003). A: Early Pleistocene – the River Thames flowed northwards across East Anglia, separate from the River Medway that flowed northeastwards across Essex; B: Early Middle Pleistocene – the River Thames migrates southwards, joining the River Medway at Clacton; C: Early Anglian – the River Thames continues to migrate southwards; D: Late Anglian – the River Thames is forced to migrate further south, more-or-less reaching its current location, and truncates the River Medway at the Hoo Peninsula.



In terms of the River Medway, indicative lithologies within its terrace gravels are of a Wealden source; namely Greensand chert (from the northern Weald) and Hastings Beds (typical of the central high Weald). Since the 1890s the former has been recognised north of the current Thames, but systematic work has only been carried out more recently, for example, by Bridgland (1999) who showed that both rock types are common in the High Level and Low Level East Essex Gravels. As well as the southern components, the Low Level East Essex Gravel also contains lithologies identical to those of the lower River Thames gravels; demonstrating that the River Thames took the Medway's course (as a result of the Anglian glaciation) (Bridgland 1999) and thereby resulting in a mix of the two rivers' associated lithologies.

Most of the gravels found on the Hoo Peninsula[6] are classified as belonging to the Hoo Gravel Formation (Bridgland 1983 ; Bridgland and Harding 1985: 42, figure 1). Through clast analysis, the identification of more-local and southern lithological constituents (that is, of the central Weald), suggests that they were laid down by the River Medway. Bridgland (2003) presents detailed lithological clast analysis of these various terrace gravels.

Older (higher elevation), middle Pleistocene deposits include:

- the Dagenham Farm Gravel located in the Allhallows-St Mary Hoo region (Bridgland 2003) (although these desposits had been attributed previously to the River Thames (Gibbard 1979))
- patches of the Shakespeare Gravel seen between Frindsbury, towards the south of the peninsula, to its type site at Shakespeare Farm Pit (St Mary Hoo), and at Allhallows (Bridgland and Harding 1985). It cuts into the London Clay and is thought to represent a braided river system typical of cold climate conditions (Bridgland 1983)
- the Stoke Gravel

and younger (lower elevation), late Pleistocene examples include:

- the Binney Gravel formation (including intermediary Allhallows deposits between an upper and lower Binney gravel). Small exposures of the Binney Gravel are found at Binney Farm and Middle Stoke (the former located between the Isle of Grain and the main peninsula) (Bridgland 2003). It is also suggested that some part of the gravel deposits lying below 'brickearth' at Hoo and Kingsnorth regions could also belong to the Binney Formation
- the Aylesford Gravel formation (including intermediary Kingsnorth deposits between an upper and lower Aylesford gravel), as well as being found in Aylesford itself (outside the project area), is also found at Kingsnorth (Bridgland 2003)
- the Halling Gravel as identified from Halling

These younger River Medway terraces are hard to study, as they are now buried by more recent alluvium, and Holocene deposits. It is therefore problematical to distinguish their exact development.

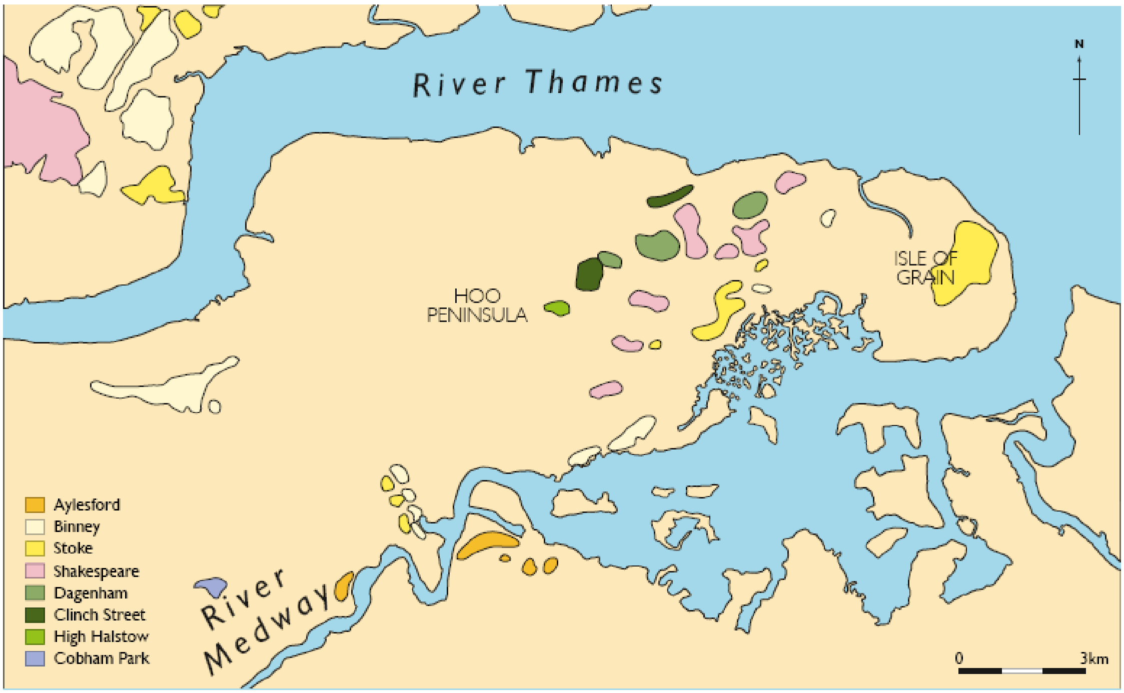
See Table 1 and Figure 4 (below) for information and a map of the River Medway and Hoo Peninsula deposits discussed in the text.

[6] Where Bridgland and Harding (1985) refer to the Hoo Peninsula, they include only the main part of the peninsula, excluding the Isle of Grain, which only became joined after land reclamation.

Table 1. Stratigraphy of deposits on the Hoo Peninsula (including the Isle of Grain) and region, after Bridgland (2003) and Bridgland and Harding (1985). Surface elevations in italics from Bridgland and Harding (1985); non-italicised ones from Bridgland (2003). c=cold, w=warm, ?=unknown, [c/w/c]=climatic conditions from equivalent Thames-Medway terraces in Southend region , *=part of the Low-level East Essex Gravel Formation, **=thought to have originally been at a higher elevation.

Terrace formation/gravel aggradation	River formation	Surface elevation (m OD)	Location	Grid reference	Climatic conditions	Age	MOIS	Terrace number (Dines et al 1954)	Notes
Grain Gravel*	Thames-Medway	13	Isle of Grain	TQ 883 770					Downstream continuation of the Stoke gravel
Tilbury	Lower Thames		Hoo Peninsula (and Tilbury-World's End:	TQ 647 754)	warm	Holocene	1		Alluvium
Halling Gravel	Medway	*(near 0)*	Upstream from Medway towns (Rochester area)		cold	Late Devensian	Late 2	1	Lowest Medway formation
Aylesford Gravel formation	Medway		Hoo Peninsula (and Aylesford:	TQ 727 594)	c/w/c	Late Saalian to Devensian	late 6 to 5d-2		
includes: Kingsnorth deposits	Medway		Hoo Peninsula	TQ 812 728	warm	Ipswichian	5e?		Organic sediments (see Bates et al 2002)
Binney Gravel formation	Medway	8	Hoo Peninsula	TQ 848 774	c/w/c	Intra to late Saalian	late-8 to 6	1	
includes: Allhallows deposits	Medway		Hoo Peninsula		warm		7 (or 9)		Fossiliferous silts (see Bates et al 2002)
Stoke Gravel	Medway	*16*	Hoo Peninsula	TQ 822 748	[c/w/c]	Intra-Saalian	late-10 to 8	2	
Shakespeare Gravel	Medway	*35*	Hoo Peninsula	TQ 815 773	[c/w/c]	Late Anglian to Intra-Saalian	[late-12 to]	3	Palaeolithic artefacts
?Newhall Gravel	Medway	*22*	Hoo Peninsula	TQ 831 769	cold	Anglian	12	2	?Erosional origin
Dagenham Farm Gravel	Medway	*45*	Hoo Peninsula	TQ 828 776	cold	Anglian	12	3	
Clinch Street Gravel	Medway	*50*	Hoo Peninsula	TQ 790 759	c/w/c	Pre Anglian/Anglian	14-12?	4	
High Halstow Gravel	Medway	*60*	Hoo Peninsula	TQ 783 751	c/w/c	Cromerian Complex	?	4	
Lodge Hill Gravel	Medway	73**	Hoo Peninsula	TQ 757 739			?	4	Highest gravel on the Hoo. Residual hill-capping
				HIATUS					
Cobham Park Gravel	Early Medway	(>130)	N.Downs dip-slope, west of Medway Gap	TQ 700 683	?	Lower Pleistocene (possibly c1.85Ma)	?		Oldest Medway deposit

Figure 4. Map of the Hoo Peninsula showing the River Medway's gravel deposits (after Bridgland 2003). As the river migrated eastwards, this is recorded as a sequence of progressively lower and younger deposits in that direction. The gravel on the Isle of Grain is a combination of River Thames and Medway deposits, indicating that it was produced following the rivers joining.



Bridgland and Harding (1985: 42, figure 1) refer to the Isle of Grain (furthest east on the peninsula) separately from the rest of the Hoo Peninsula. The gravels here differ significantly from those on the rest of the Hoo as they contain an exotic (far-travelled) lithological component typical of post-diversion Thames gravels. This Grain Gravel is actually part of the Low Level East Essex Gravel Formation (commonly found north of the current River Thames), thought to have been deposited by the Thames, downstream, beyond its confluence with the Medway (Bridgland 1983); it is a downstream continuation of the Stoke Gravel.

In terms of archaeological remains, the first human occupation of the British Isles is thought to have occurred *c* 700,000 BP ie in the Middle Pleistocene (Parfitt *et al* 1995). An important, but later, site from the west Kent region is at Swanscombe, dating to the Hoxnian interglacial (MOIS 11, c 400,000 BP). Although the sands and gravels excavated for aggregates are commonly important archives for lithic artefacts, on the Hoo Peninsula itself, few prolific Palaeolithic sites have been found (Wymer 1999a: 93; 1999b ; Wenban-Smith *et al* 2007). Interrogation of the National Monuments Record (NMR) 'Archives and Monuments Information, England' (AMIE) database (Newsome, 2011: pers. comm.) tends to support this, showing that the majority of individual Palaeolithic records often consist of only a few artefacts at most and/or of insecure provenance. Wymer (1999a) suggests that this apparent dearth could result from commercial exploitation of the gravels, rather than a real absence.

Holocene development

As relative sea-levels rose at the end of the last glaciation, palaeochannels and terraces of both the early (ie pre-merging) River Medway (dating to the Early and early Middle Pleistocene) and of the merged Thames-Medway rivers became submerged by the Holocene transgression; these can be traced off the Essex coast (D'Olier and Maddrell 1970 ; Bridgland 2003) and out to the southern North Sea area (Bridgland *et al* 1993).

As the lower reaches of the rivers were flooded, the coastline migrated inland, and the gradient of the Thames (that had previously been down-cutting through the glacial deposits) decreased. In short, the lower River Thames region became estuarine, and developed a typical floodplain with alluvial deposition, and estuarine and tidal processes penetrated further upstream.

In the Lower Medway, the transition from Pleistocene gravels to Holocene alluvium occurs at -26m OD at the Isle of Grain (Barham and Bates 1991) and at -10m OD at Chatham (Barham 1993) (both cited from Williamson and Pine (1996: 9)). The Holocene alluvial sediments, that have been little studied compared to the river terrace deposits, increase in thickness down river along the Thames Estuary (Devoy 1979). They are characterised by complex intercalated clay-silts, sands and peat[7] layers, deposited in association with minor sea-level fluctuations and reversals; finer-grained silts-clays-sands are indicative of a sea-level transgression (relative sea-level rise), particularly lower energy mudflat and saltmarsh environments, whereas peat layers suggest a sea-level regression (a relative sea-level fall) to increasingly terrestrial, freshwater conditions.

The organic peat layers were first used by Devoy (1977b, 1977a, 1979) to produce a sea-level curve for the region (although his sea-level models have since been refined), naming peat layers 'Tilbury' stages and minerogenic layers 'Thames' events. These Holocene deposits are commonly referred to generically as the Tilbury Formation. A peat layer from the Medway Tunnel site (thought to represent one of these stages) has since been dated to *c* 7,000 BP (Pine *et al* 1995). Some, more recent peats, have become exposed in areas around the Hoo Peninsula's coast due to changes in sediment regimes that have led to erosion. Examples can be seen in the intertidal zone off Higham and Cliffe (WessexArchaeology 2006 ; Paddenberg and Hession 2008) and on Hoo Flats (WessexArchaeology 2005).

Throughout the Holocene, the Hoo Peninsula has undergone significant change as a result of human activity. The fertile soils have long made the area attractive for settlement; Devoy (1980) suggests that the marsh areas were only really exploited from Roman (that

[7] The term 'peat' is used here in its broad sense, referring to highly organic deposits.

is, historic) times onwards. Rippon (2000) states that there is documentary evidence for drainage in 8th century charters (for example, at Cliffe Marshes and Frindsbury), for arable cultivation and freshwater meadow. In the late Middle Ages (to be investigated in the next phase of the project), sea wall defences were built around most of the peninsula to prevent flooding and protect pastures, and then in the late AD 1800s significant areas were drained in order to create good farmland (MacDougall 1979). At around this time too, extensive saltmarsh was lost due to clay removal for brick and cement industries; this was most intensive in the late 1800s, but, from maps, saltmarsh loss is seen to have been naturally occurring since the 1700s (Kirby 1990).

PALAEOENVIRONMENTAL AND PALAEOLANDSCAPE STUDIES

Whilst understanding its regional setting is vital for discussing Hoo's longer term geological development (ie considering the wider area beyond the project area's boundaries), only detailed palaeoenvironmental case studies from within the project area have been presented here.

A variety of environmental indicators are frequently used as 'proxies' for palaeoenvironmental and palaeoclimatic conditions; based on our current understanding of their ecological preferences and tolerances, it is possible to make inferences concerning past landscapes where their subfossil/fossil remains are present. These methods include floral (pollen, plant macrofossils, waterlogged and charcoal wood remains, diatoms) and faunal (mammals, ostracods, foraminifera, molluscs) remains. These are interpreted together with the geoarchaeology. For the region, there are, in fact, relatively few studies that present detailed data of this sort; Bridgland (2003) notes that until Bates *et al*s (2002) study, no interglacial pollen or molluscan data had been recovered from the Lower Medway.

Main sites and records

This section describes in more detail the main Quaternary geological/geoarchaeological and palaeoenvironmental records from the Hoo Peninsula region (Figure 5). They have been grouped into an alphabetical listing of civil parish (CP) boundary areas. Much of the work is focussed in a few main areas; often associated with industrial developments, such as power stations and water treatment works.

Figure 5. Map of the Hoo Peninsula showing the project boundary, and the locations of sites mentioned in the text (○) and also included in the GIS layer (●). Locations are general site locations, and so the original publications should be consulted for precise sample locations.

Allhallows CP

Multiple investigations have been carried out at the proximal sites of Allhallows, Allhallows golf course, and Binney Farm, as well as at Kingsmead Park and Dagenham Farm.

At Allhallows golf course, Pleistocene deposits rest on London Clay (Bates *et al* 2002). These more-detailed investigations, following on from Bates (1997), show fluvial deposits intercalated with interglacial deposits. In combination, mollusc and ostracod analyses suggest either an OIS 7 or 9 age (late Middle Pleistocene), and amino-acid dating suggests OIS 9 (Bates *et al* 2002). However, Bridgland (2003) favours MOIS 7 based on correlations of the Binney Formation with equivalent River Thames deposits. Some archaeological excavation was carried out, and found evidence of later prehistoric occupation on site, with Neolithic and Late Bronze Age/Early Iron Age (LBA/EIA) pottery and LBA/EIA cremation deposits (evident as un-urned burnt bone and charcoal) (Greatorex 2005).

In the Allhallows-Binney Farm vicinity, electrical section profiles in conjunction with ground-truthing boreholes were used to investigate the deposits (Bates *et al* 2007). Near-surface (3-4m) fine-grained alluvial deposits (possible Holocene palaeochannels) narrow to the south-west of the study area, as more-resistant deposits become more common.

In the south-east of the sites, resistant deposits are common near the surface, and are thought to represent sands/gravels. Biostratigraphical (microfaunal) indicators analysed from Borehole 5 suggest a change from predominantly freshwater, through brackish to tidal conditions, upwards throughout the core.

As part of the Medway Valley Palaeolithic Project (MVPP), in addition to evaluating already existing borehole records, new field work was carried out. Cores were retrieved at Binney Farm (BFM_05) and Kingsmead Park (KMP_05) (Wenban-Smith *et al* 2007). At Kingsmead Park, separate cores were used for microfaunal assessment and OSL dating; Preece (in Wenban-Smith *et al* 2007: appendix 8) reported two samples, dominated by the hydrobiid snails *Heleobia* sp. and with ostracods also recorded as present; the OSL age was reported in Schwenninger *et al* (in Wenban-Smith *et al* 2007: Appendix 6) as 77.23±4.47ka (X2566). The preservation of subfossils shows clear potential for further detailed palaeoenvironmental reconstructions.

As part of the same project, at Dagenham Farm (the site after which the Dagenham Farm Gravel was named), Wenban-Smith *et al* (2007) retrieved five cores, of which one (at TQ 83313 77688) was OSL dated to 183.92±14.94ka (X2589). Generally, these cores consisted of a basal London Clay, overlain by sands and then silts.

Cliffe and Cliffe Woods CP

Devoy (1979: figure 28a) includes a core stratigraphy from Cliffe (Marshes) (TQ 711 780), suggesting the presence of Holocene intercalated terrestrial and marine deposits, typical of his Tilbury and Thames model, all of which rest on gravels at c -12m OD.

Frindsbury Extra CP

At Upnor, a skeleton of *Palaeoloxodon* (formerly *Elephas*) *antiquus* (straight-tusked elephant) was reported by Andrews (1915, 1928), initially having been discovered within clay deposits during military groundworks. However, its stratigraphical context remains unclear, and it is of little interpretive value, as this fauna was characteristic of every post-Anglian interglacial of the British Isles (Bridgland 2003). More recently, eight flint flakes were recovered from the same level in which the elephant was found (WessexArchaeology 1993: 131-132).

The Medway Tunnel scheme spans the River Medway from near Gundulph Pool on the west bank, to Chatham Dockyards on the east. Early work at Chatham Dockyard (St Mary's Island) by Whitaker (1908) (reported in Hutchings (1925)) records the presence of peat deposits (at -2ft (-0.6m) and -17ft (-5.2m) OD) within alluvium, all resting on gravel. More recently, Barham *et al* (1995), Bates *et al* (2000) and Bates and Bates (2000) present borehole investigations carried out as part of the Medway Tunnel scheme, following work by Barham (1993) and Pine *et al* (1994). The stratigraphy of the east margins of the tunnel shows a chalk bedrock, with overlying gravel layers (an upper and lower) thought to date from the early Holocene. On this were Holocene deposits of sands, then silts and finally made-ground. Three discrete peat layers were also present and are indicative of wetland development. They were subjected to radiocarbon dating (Barham *et al* 1995: table 32, page 348); a lower layer (c -10m OD), immediately above the Lower Gravel, was identified as Mesolithic (6,930±70 BP (Beta-66456) and 7,290±80 BP (Beta-66457)), a Neolithic/Bronze Age date was assigned to a shallower peat (c -4-5m OD) (4,820±70 BP (Beta-64509) and 4,710±70 BP (Beta-66455)) and the shallowest peat (c +1m OD) was dated to 3,530±60 (Beta-81728) and 2,600±70 BP (Beta-81729) (dates conventional and $^{12}C/^{13}C$ corrected). The peat deposits are of high palaeoenvironmental potential; faunal and botanical remains were recovered.

Gravesham District

The Gravesend Wastewater Treatment Works (WTW) are located on Denton Marshes, east of Gravesend. Harker (1978) reports the presence of Roman pottery encountered in association with an occupation site sealed between alluvial clay deposits. More recently, archaeological investigations were carried our prior to enhancements of the existing complex. Three borehole descriptions recorded peat deposits and organic matter, within clays, all resting upon flint gravel (McDowellsLtd 1996) and peat layers were also seen in boreholes and test pits by Gravesham Borough Council in 1994 (both reported in WessexArchaeology 1996). Subsequent investigations included a further eight boreholes plus trenches (WessexArchaeology 1998 ; Firth 2000). Detailed pollen analysis was carried out by Scaife (2001) on Auger hole 8, who interpreted the sequence as a transition from i) freshwater grass-sedge fen, with woodland (oak, lime and hazel) and expanding sedge-reed swamp, through ii) increasingly saline conditions due to sea-level transgression, resulting in vegetated saltmarsh. Samples for radiocarbon dating and for the analysis of the foraminifera were also taken but the results were not available at the time of writing.

High Halstow CP

Eastwards around the coast from Cliffe Marshes, in St Mary's Bay (TQ 788 794), Devoy (1979: figure 28a) presents a core stratigraphy very similar to that of Cliffe Marshes.

Hoo St Werburgh CP

Here, the main works have been associated with Kingsnorth power station and the immediately adjacent site of Damhead Creek power station, to the north. All investigations have been carried out in advance of works related to their development. Commonly-encountered Holocene alluvial sediments have been recorded at both sites.

Geotechnical investigations in advance of Kingsnorth Power Station Units 5 and 6, have identified a continuation of the palaeochannel inferred from investigations to the north at Damhead Creek (Waters 2007 ; ParsonsBrinckerhoff 2009). Sediments consist of London Clay bedrock, on top of which sits a variable series of sands-gravels-silts, followed by alluvium (Waters 2007 ; ParsonsBrinckerhoff 2009). Faunal remains (possibly mollusc fragments) have been found in Borehole 1 (BH1), within bedded silts resting between two gravel layers.

Williamson and Pine (1996) undertook geotechnical investigations in advance of Damhead Creek power station works. They recorded the London Clay bedrock as having a gently undulating upper surface, located between c -5 and -6.5m OD. Above this were Pleistocene (possibly Devensian) gravels, with an upper contact between -2.7 and -4.5m OD. Above this, the stratigraphy was complex and sediments were variable across the site. The borehole records from the northern, north-eastern and eastern margins of the investigated area were dominated by coarse-grained deposits (sands and gravels; indicative of higher energy environments eg tidal sand flats) and those from the southern, south-western and western sections were dominated by fine-grained sediments (silts and clays; indicative of lower energy environments eg upper tidal flat, saltmarsh). The latter cores were also characterised by organic inclusions (notably wood and plant macrofossils) and peat layers. In terms of archaeological potential, the finer grained sediments are of increased potential as they represent marsh environments that would have been favourable for occupation; their waterlogged nature also encourages good organic preservation.

The west-east trending pattern of the fluvial substrate deposits is also replicated from excavated trenches by Johnson (1998), who notes the whole area as being overlain with Holocene silts and alluvial clays. From the excavations by Johnson (1998) the majority of trenches lacked archaeological features; this is in contrast to James (2001) and Griffin (2002) who detailed evidence of ditches, gullies and postholes, together with a Roman clay extraction pit, found within trenches excavated in the very east of the same area.

Subsequently, work was carried out by Bates (1997, 1999a) and presented, together with excavation results (Bates in Griffin 2004). The stratigraphy has been recorded as London Clay (Unit 1), overlain by a basal gravel (Unit 2), then a clay-silt complex (Unit 3), flint gravels (Unit 4) and further clay-silts (Unit 5). Only Unit 3 yielded palaeoenvironmental remains, and a combination of the ostracod, mollusc, plant macrofossils and pollen evidence, suggests a shift from freshwater-derived sediments to brackish conditions. Unit 2 is thought to represent a periglacial, high energy braided fluvial environment (MOIS 6), Unit 3 the ameliorating Ipswichian interglacial (MOIS 5e) climate with a large river floodplain replaced with brackish marshland as sea-level rose, Unit 4 a Devensian high energy braided fluvial environment, and Unit 5 a post 6,000 BP (Holocene) floodplain (saltmarsh-mudflat). Bridgland (2003) has assigned the intermediary interglacial deposit to the Aylesford Gravel Formation (between the Binney and the Halling gravels).

More-recently, borehole investigations prior to the construction of Damhead Creek 2 have found London Clay bedrock with a late Pleistocene (Holocene) palaeochannel cut into it, in turn filled with a complex clay-silt-organic sequence. It is considered of high palaeoenvironmental potential, on a regional scale (Bates and BartonWillmore 1997 ; ParsonsBrinckerhoff 2009: 297).

Isle of Grain CP

In this region, the underlying bedrock geology is London Clay. Sands and gravels are commonly found, overlain by Holocene sediments (themselves complex intercalations of clay-silts, sands and peats eg Evans (1953)), which are typical of the lower Medway Valley. In spite of their common presence, a soil profile examined by Marsland (1986: 238) at Tank Farm, BP Refinery (the exact location of which is not specified) does not show organic deposits, but clays resting on interbedded clay/sand/silt layers.

An early well section record from this area (at the Isle of Grain Fort, immediately north-east of Grain village) reports 300ft (91.4m) of blue London Clay, resting on 20ft (6.1m) of sands (some of which contained 'dark grains' and pieces of shell) assigned to the Oldhaven and Woolwich Beds (Whitaker *et al* 1872b: 466).

Investigations by Barham and Bates (1991) (cited from (Williamson and Pine 1996)) also reached the London Clay. The clay was overlain by gravels, and then by a peat and/or organic rich layer at the base of the subsequent Holocene deposit at -26m OD. What is thought to be an equivalent of this peat layer has been dated at the Medway Tunnel to c 7,000 BP (Pine and Williamson 1994) (cited from (Williamson and Pine 1996)). A peat deposit at a similar depth to that of Barham and Bates (1991) had also been recorded on the Isle of Grain by Devoy (1979), although this was dated earlier, to c 8,500 BP (see below).

Devoy (1979) presents a series of boreholes taken around Cockleshell Hard (on the south-east corner of the Isle of Grain) and extending across the River Medway, showing basal deposits of London Clay, and the presence of buried channels. One core SB2/135 (TQ 8884 7440) was analysed in detail. In contrast with his other Hoo borehole sites further west (at Cliffe (Marshes) and St Mary's Bay) there is only one clear organic layer (assigned to Tilbury I) and the height of this, as with the height of the gravel surface, is considerably deeper (both c -26m OD). Pollen analysis was carried out on the highly organic deposits and showed a shift from dominant aquatics and herbs, to grass and arboreal habitats (Devoy 1979: page 40 and figure 27). A radiocarbon date was determined to 8,510±110 BP (Q-1286).

Other dating of sediments in this area comes from two cores retrieved at Clubb's Pit (at TQ 88030 76162 and TQ 88040 76165) by Wenban-Smith *et al* (2007), comprised of basal gravel layers (at 2m depth) with varying sands/gravels on top. The OSL ages

(147.52±13.78ka (X2557) and 196.10±14.14ka (X2553)) of the lower sediments correspond with the early Quaternary.

Multiple investigations have been carried out in connection with Grain power station and its transmission pipeline. This includes Bates (2006) on borehole interpretations from locations immediately north of Cockleshell Hard, and test-pitting (Bates 2008) along the line of the transmission pipeline. The former work (Bates 2006) reports a complex stratigraphy and site development including a) evidence of three separate river terraces (sand and gravel deposits separated by erosional events), the lowest of which contains possible evidence of fine-grained channel fill deposits, b) a shift within the stratigraphy from estuarine mudflats to sand banks, and c) common organic-rich silt layers. From this site it is inferred that fully estuarine conditions would have been in place by the Neolithic. Bates (2008) assessed 24 test-pit stratigraphies along transects associated with the pipeline (although detailed locational data was not included, this route actually extends between the Isle of Grain and Chalk, on the eastern edge of Gravesend ie the length of the Hoo Peninsula). Sediments are dominated by extensive fluvial deposits (sands and gravels, indicative of multiple terrace features) and/or by slope deposits (suggesting reworking), of varying palaeoenvironmental, archaeological and OSL potential.

Stoke CP

As part of the MVPP (Wenban-Smith *et al* 2007) three boreholes were taken at Court Lodge Farm, Stoke (around TQ 82300 74870). All rested on clay; at two of the three sites this was identified as London Clay bedrock. The main stratigraphy consisted of mixed gravel/sand/clay layers.

At Middle Stoke, archaeological investigations (uncovering Bronze Age features) carried out here in advance of a road-building scheme (Greatorex 1995 ; James 1999, 2006) included only a brief interpretation of the geology and geological development of the area covered (Bates in James 1998); the area of the excavation contains river gravels laid down under periglacial conditions, covered by hillwash deposits. Some environmental samples were recovered, but for archaeoenvironmental purposes; they included some marine molluscs (oysters), charcoal and poorly preserved cereal grains.

At Hoo Fort, on the south-eastern edge of Hoo Saltmarsh, Whitaker (1872b: 466) reports a well section record consisting of ‘a great depth’ of chalk from 110ft (33.5m) depth. At West Hoo Creek, on the western margins of Hoo Flats, records by Whitaker (1908) and reported in Hutchings (1925) indicate two thin peat layers within a 22.5ft (6.9m) thick alluvium deposit, on top of gravel.

Archaeological surveys

During 2004-5, Wessex Archaeology carried out an assessment of the archaeological and palaeoenvironmental (eg peats, submerged forest) remains preserved within the intertidal zone of the North Kent coast. Sites are summarised and highlighted in Paddenberg and Hession (2008); although numerous throughout the study region, sites on the Hoo Peninsula itself are fewer, most notably the occupation site at Hoo Flats (WessexArchaeology 2005) and intertidal peats at Higham Saltings, Cliffe Creek and Eastcourt Marshes (WessexArchaeology 2006).

Hoo Flats (TQ 79800 71600; TQ 79883 71662) is an intertidal, prehistoric site (found by the Upchurch Archaeological Research Group (UARG) and subsequently observed and recorded by Wessex Archaeology during their 2004 field season). It is a middle-to-late Neolithic occupation site (WessexArchaeology 2005: 11) consisting of extensive organic clay deposits resting on alluvium, and adjacent to London Clay. Finds included pottery, bone, lithics (flint flake scatters; burnt flints) and timbers described as 'fragmentary roundwood alignments' (possible trackway/s), as well as ditches and possible pits.

Extra-area investigations of note

It should be noted that extensive geotechnical work (eg Bates (1995, 1999b)) was carried out before construction of the Channel Tunnel Rail Link (CTRL) across Kent; whilst it enhances the broader understanding of the lower Thames region, the route did not overlap with this project's geographical boundaries, so is not included in detail here.

Firth (2000) also reports work (including pollen analysis by Scaife (2001)) of two sites proximal to the Hoo Peninsula; Motney Hill (on the southern margins of the Medway estuary) and Queenborough to the east (on the Isle of Sheppey). Firth's (2000) summary of the earlier investigations at Motney Hill (TQ 83000 68500) (a waste water treatment works), together with a new series of boreholes and trenches, showed the deposits to consist of mainly Woolwich Bed sands on Thanet Beds, and with peat/organic layers within the marsh deposits. Pollen analysis was carried out by Scaife (2001) on Borehole 13 (BH13, of an unspecified location). At the base of the core was a possible Neolithic occupation surface (identified from the presence of lithics). Together, the pollen and sediments (peat and minerogenic layers) suggested a fluctuating sea level throughout the core. Prior to the radiocarbon dating of any samples[8], a late prehistoric/Late Bronze Age date was inferred from the palynostratigraphy; abundant lime pollen at the base of the profile (Scaife 2001).

At Queenborough waste water treatment works (TQ 90800 70500) the geology consists of London Clay overlain by alluvium (Firth 2000). A lower and an upper section of a core

[8] It is understood that since these publications, radiocarbon dating has been carried out (by Wessex Archaeology) but not yet published; obtaining these results will help clarify the timing of the site's development.

were analysed for pollen (Scaife 2001). Halophytic (salt-tolerant) plants were common within both sections, suggesting dominant estuarine/brackish conditions. The absence of lime pollen implied that the deposits post-dated the Late Bronze Age lime decline (Scaife 2001).

Also near Queenborough, research associated with the A249 road improvement scheme (Pratt *et al* 2003) produced diatom, foraminifera, ostracod and pollen assessment data (plant debris, charcoal, a fish tooth and insect remains were also recorded as present in samples from trenches). A series of trenches were excavated, the majority of which reached London Clay; in places, the undulating surface of this clay could represent palaeochannels. Borehole B (TQ 91780 69970) was analysed in detail; it was 11.8m long, reached a depth of -10.1m OD and consisted of horizontally-bedded silts and fine sands. Diatoms suggested shallow marine and coastal environments, exclusively; together, the foraminifera and ostracods also recorded coastal environmental conditions (with some runoff-derived freshwater ostracods), with a shift from brackish/near-shore (?creek) indicators in the lower core, to a possible saltmarsh environment in the upper core; pollen results show a mix of both wetland (from alder woodland and saltmarsh) and dryland (varying proportions of oak, elm, lime and hazel) vegetation, but only possible indirect indicators of human activity.

Also on the Isle of Sheppey, pollen from ditch fills of the Neolithic causewayed enclosure at Kingsborough (TQ 9770 7200) were analysed (Scaife 2004/5); pollen was absent in the basal sample, but where present in the remaining samples, it was dominated by grasses and grassland herbs, suggesting a largely open landscape. The presence of lime suggests a pre late Neolithic/EBA date (Scaife 2004/5).

At Lower Halstow [c TQ 86776 68590], some limited pollen analysis was undertaken by Dr G Erdtman on various organic-rich layers overlying what was termed an "epi-Palaeolithic" factory site (the "northern floor") (Burchell 1925-1927: page 296). The factory site itself rested on a gravel layer (3ft (0.91m) thick) and then on redeposited London Clay, and was covered by a 2ft (0.61m) thick peat layer, and then 6ft (1.83m) of marsh deposits. Pollen sample from the peat layer immediately overlying the archaeological deposit contained *Tilia* (lime) and no *Pinus* (pine), therefore interpreted as being of the 'Atlantic' period[9] (ie early to mid-Holocene).

At Cuxton (TQ 7112 6655) (south-east of Strood, on the west bank of the River Medway) some palaeoenvironmental investigations were carried out on sand and gravel sediments from this Palaeolithic site. Unfortunately, preliminary pollen analysis by Hubbard (in Cruse 1987: 78-81) demonstrated low pollen concentrations and poor (differential) preservation, typical of such coarse, waterlain deposits; Cruse (1987: 74) highlights the need to consider possible sourcing through inwashing and reworking. The environmental indications from the animal bones recovered were not precise enough to facilitate a

[9] Following the Scandinavian-based Blytt/Sernander scheme (of late Devensian and Holocene climatic phases) derived during the late 1800s to early 1900s.

secure age and thermoluminescence dating attempts at the time (on the redeposited sandy-loam overlying the gravel deposits) were only able to set a lower limit (ie minimum) of 100,000 BP (Debenham and Bowman in Cruse 1987: 76-78). However, recent work has dated the site by OSL to MOIS 7 (c 230,000 BP) (from borehole TP_2 at TQ 71095 66523; 232.64±13.75ka (X2561)) (Wenban-Smith *et al* 2007).

At Strood [c TQ 74025 69608], north-west of Cuxton, Dines *et al* (1954: 117) briefly mention the presence of molluscs within the middle of a brickearth deposit that rested on chalk and was overlain by loam.

Further south, on the east bank of the River Medway, near Wouldham, pollen analysis was carried out at Peter's Pit (c TQ 717 628) by Scaife (2007) on a 5.5m Holocene profile, consisting of intercalated peat and clay layers. Towards the top of the profile, wetter conditions developed, and indications of arable cultivation are present in the form of cereal grains and agriculturally-associated herbs (weeds). There is a possibility of sediment mixing as there is an anomalous pine-dominated layer within the core, but overall, the pollen spectra seem to suggest a mid to late Holocene age.

THE PALAEOENVIRONMENTAL GIS LAYER

In association with this document, a GIS layer was produced plotting sites with palaeoenvironmental information; specifically, these are only sites that have included an assessment or analysis of one or more biological proxies (such as pollen, ostracods). Given the lack of such detailed data from the project area, studies from immediately adjacent areas have also been included. Any diagrams and tables of results have been reproduced for inclusion in the GIS as a hyperlink.

The data was first compiled and stored in an Access database. In order to follow historic environment data standards, the fields and categories of the GIS layer were selected – as far as possible – from MIDAS (2007). The terms used to complete the fields, were taken from English Heritage's National Monuments Record Thesauri (EnglishHeritage 1999), particularly the Archaeological Sciences thesaurus. The fields and their criteria are described below (Table 2); not all fields are complete for every record.

Table 2. Field name list and description of the palaeoenvironmental GIS layer.

Field name	Description
Primary reference number (data)	A unique reference number identification
Administrative area name	Full name of the administrative area
Civil Parish	Name of civil parish
X coordinate	Easting (6 figure if possible)
Y coordinate	Northing (6 figure if possible)
Grid reference	OS reference
Locality	Named specific area
Map sheet	OS map sheet
Directions	A description of the location relative to fixed landmarks (where appropriate)
Characterisation statement (geology)	Description of the geology/stratigraphy
Characterisation statement (historic)	Description of the historic environment
Scientific date method	Method for dating eg radiocarbon, OSL, dendrochronology
Scientific date	Age eg 5656 years BP
Period name	Name eg Holocene, Bronze Age
Microfossils analysed?	Yes/No
Subject	General topic
Activity/event type	Methods and techniques employed eg palynology, geophysical survey
Material type	Main sediment components
Recovery method	How the remains/samples were recovered eg augering
Ecofact	Types of biological proxies examined
Description (synopsis)	Description of the palaeoecological and/or geoarchaeological remains
Description (interpretation)	Interpretation of the palaeoenvironmental conditions
Associated goods	Any associated materials or manufactured material eg worked flints
Potential (note)	Statement of potential for further research (if applicable)
NMR AMIE number	NMR number if available
Kent CC HER number	HER number if available
Archive/source reference	Date, author, title, pages, publisher etc
Archive/source type	Journal/book/unpublished report/website
Notes	Any further information of relevance

Only sites for which their original reports were obtained, were entered into the database, so as to ensure detailed, accurate reporting of the original data; the advantage of a GIS is that additional records can be added at any time. Those included in the database are outlined in Table 3; only eight are located with the actual project area.

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Table 3 (part). Summary information of sites with palaeoenvironmental (palaeoecological) data included in the GIS. The ID number is the unique database reference identifier. (Laboratory code for Cockleshell Hard taken from Devoy (1982)).

ID no.	Site name	Grid reference	Palaeodata	Within project area?	Age/s	Laboratory code/s	Reference/s
2	Allhallows	TQ 84530 77620	Plant macrofossils, insects, cladocera, foraminifera, ostracods, molluscs	Yes	Possibly MOIS 9		(Bates *et al* 2007)
7	Allhallows, golf course	TQ 84300 78100	Molluscs, ostracods	Yes	MOIS 9 (or 7)		(Bates *et al* 2002 ; Bridgland 2003 ; Greatorex 2005)
12	Allhallows, Kingsmead Park	TQ 84420 77855	Molluscs, ostracods	Yes	77.23±4.47ka	X2566	(Wenban-Smith *et al* 2007)
6	Cockleshell Hard	TQ 88840 74400	Pollen	Yes	8,510±110 BP	Q-1286	(Devoy 1979)
34	Cuxton	TQ 71120 66550	Pollen, vertebrate bones	No	232.64±13.75ka, MOIS 7	X2561	(Cruse 1987 ; Wenban-Smith *et al* 2007)
9	Damhead Creek	TQ 81300 72800	Ostracods, molluscs, plant macrofossils, pollen	Yes			(Bates 1997, 1999a ; Griffin 2004)
4	Denton Marshes, Gravesend WTW	TQ 66600 74000	Pollen, foraminifera	Yes			(WessexArchaeology 1998 ; Firth 2000 ; Scaife 2001)
37	Kingsborough	TQ 97700 72000	Pollen	No			(Scaife 2004/5)
24	Kingsnorth, power station	TQ 81200 72600	Molluscs	Yes			(Waters 2007 ; ParsonsBrinckerhoff 2009)

Table 3 (continued). Summary information of sites with palaeoenvironmental (palaeoecological) data included in the GIS. The ID number is the unique database reference identifier.

ID no.	Site name	Grid reference	Palaeodata	Within project area?	Age/s	Laboratory code/s	Reference/s
38	Lower Halstow	TQ 86776 68590	Pollen	No	Epi-Palaeolithic		(Burchell 1925-1927)
17	Medway Tunnel, eastern approach	TQ 75900 69880	Molluscs, foraminifera, insects	No	6,930±70 & 7,290±80 BP; 4,820±70 & 4,710±70 BP	Beta-66456 & Beta-66457; Beta-64509 & Beta-66455	(Barham 1993 ; Barham *et al* 1995)
35	Motney Hill	TQ 83000 68500	Pollen	No			(Firth 2000 ; Scaife 2001)
36	Queenborough	TQ 90800 70500	Pollen	No			(Firth 2000 ; Scaife 2001)
33	Queenborough, A249 road improvement scheme	TQ 91780 69970	Diatoms, foraminifera, ostracods, pollen	No	6750±40 BP	Beta-176168	(Pratt *et al* 2003)
3	Strood	TQ 74025 69608	Molluscs	No			(Dines *et al* 1954)
1	Upnor	TQ 75500 70500	Vertebrate bones	Yes			(Andrews 1915, 1928 ; WessexArchaeology 1993)
32	Wouldham, Peter's Pit	TQ 71700 62800	Pollen	No			(Scaife 2007)

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

The lower Thames valley includes some of the oldest archaeological, human occupation sites within the country (such as Swanscombe), yet in spite of this and the Hoo Peninsula's own potential, the Hoo has, until very recently, largely been overlooked in terms of geoarchaeological and palaeoenvironmental studies. Traditionally, work in the region has focussed on the sediments (mostly river terraces) and the development of the River Thames – rather than those of the River Medway – and by their nature these represent older Quaternary sequences rather than more recent Holocene remains.

Since the mid 1990s these imbalances have started to be redressed, partly through Professor D Bridgland's extensive work on the River Medway's terraces, but also through developer-funded projects (in particular that by Bates and colleagues). As a result of these investigations, the geology and stratigraphy of the region is now recognised as being far more complex than early mapping suggested. These studies have also recorded complex stratigraphies that highlight the need for further research in the area to develop more accurate models of landscape development.

In spite of the recent increase in the number of site investigations, they have some limitations. Particularly in the case of developer-funded projects, the geographical spread of these studies is uneven; dictated by the location of the development. In the case of power stations and water treatment works (WTWs), these have tended to be in flat, low-lying, coastal locations, on alluvial reclaimed marshland (such as at Kingsnorth power station and at Gravesend WTW on Denton Marshes).

Depending on the nature and importance of a site – and therefore the amount of time and money allocated – the detail of investigations related, in particular, to development works can be limited; often money is only available for the assessment stages of sample investigation, and this can be as basic as presence/absence information. Despite their retrieval, such samples are not subsequently analysed fully, even if they are found to be of high potential. To address this, funding should first be directed to the best already-obtained samples and sites, to carry out a full suite of analysis (ie multi-proxy indicators; pollen, plant macrofossil remains, ostracods, diatoms, foraminifera, molluscs) and dating (^{14}C, dendrochronology, OSL) on the sediments. Where cores still exist, further samples should then be obtained to increase the resolution and detail of the studies. All this will enhance the understanding of the environmental and habitat changes and developments over time, particularly in context with early human occupations.

Once the full potential of already-obtained samples has been explored, new areas should be targeted for study. The combination of fine-grained alluvium (preserving organic remains) and sand/gravel deposits (lacking abundant biological remains, but suitable for OSL dating) makes the Hoo Peninsula ideal for detailed palaeoenvironmental investigations. The need for targeted OSL dating has been identified as vital in developing and refining the region's chronological framework (Wenban-Smith *et al* 2007 ; Bates

2008). In particular, Wenban-Smith *et al* (2007) recommend targeting the Anglian and pre-Anglian terraces (such as the Dagenham and Clinch Street gravels).

Technological developments (eg in geophysical survey techniques) are making deposits that might not have been found previously, more easily and cheaply accessible. In particular, extensive deposits noted as being of high archaeological and palaeoenvironmental potential, are fine-grained channel fill sediments (palaeochannels) (such as the former estuarine channels preserved at depth on terrestrial sites (Bates, 1999; Bates *et al* 2002) and organic peat layers; substantial peat deposits in otherwise silt/clay-dominated floodplain sediments, have been identified of research importance in the Ebbsfleet Valley (east of this project area) by Bates and Barham (1995); if comparable deposits could be found in the region of study, these should be targeted. Burchell (1957) describes a "sunk channel" palaeochannel in the Medway Estuary between Lower Halstow to Hoo, up to 70ft (*c* 21m) deep, that contains a basal gravel, with alluvium resting above which contains peaty silt horizon/s, that could also proffer important palaeoenvironmental information.

Other palaeochannels of potential interest are those located between the main section of the Hoo Peninsula and the Isle of Grain. These were reclaimed in more recent history, and, if they contain deposits of continuous sedimentation from the time of their reclamation, they potentially could provide an uninterrupted late Holocene palaeoenvironmental record.

Many unpublished reports from work in the region, particularly carried out by (or on behalf of) consultancies, are often hard to obtain, demonstrating the necessity for them to be made readily available. Ideally they should be obtained in digital format and incorporated into this project's archives. It is apparent that Dr M Bates has a significant amount of unreported data and work in progress from the region; when it becomes available, it would be most advantageous to have this compiled eg within the GIS.

To further understand the history of sea-level changes in the area, recording and analysing the intertidal peats commonly exposed in the intertidal area around the Hoo Peninsula would be invaluable. The preliminary study by English Heritage's Aerial Survey Team that is attempting to map the peat exposures as seen on aerial photographs, could be used as a starting point, particularly for their potential (or not) based on ground-truthing the mapped deposits. This would link in with the intertidal archaeological site at Hoo Flats (monitored by the Upchurch Archaeological Research Group) where there are also intertidal peat exposures; by putting the record of human settlement and activity into its palaeoenvironmental context. In particular, areas of elevated erosion rates eg Stoke Saltings, as identified by surveys such as Burd (1992), should be targeted for study before the deposits of interest are lost.

APPENDIX A

Table A1. The geological timescale since the start of the Palaeogene, following the IUGS 2009 ratified version in Gibbard *et al* (2010). Terms highlighted in bold are those referred to in this report.

Era	Period	Epoch and Subepoch		Age	Age (Ma) (lower limit)	Years BP
Cenozoic	**Quaternary**	**Holocene**			0.012	12,000
		Pleistocene	Late	Tarantian	0.126	
			Middle	Ionian	0.781	
			Early	Calabrian	1.806	
				Gelasian	2.588	2,588,000
	Neogene	Pliocene		Piacenzian	3.600	
				Zanclean	5.332	
		Miocene		Messinian	7.246	
				Tortonian	11.608	
				Serravalian	13.65	
				Langhian	15.97	
				Burdigalian	20.43	
				Aquitanian	23.03	23,030,000
	Palaeogene	Oligocene		Chattian	28.4	
				Rupelian	33.9	
		Eocene		Priabonian	37.2	
				Bartonian	40.4	
				Lutetian	48.6	
				Ypresian	55.8	
		Palaeocene		**Thanetian**	58.7	
				Selandian	61.7	
				Danian	65.5	65,500,000

Table A2. The main stratigraphical divisions of the British Quaternary period, showing their equivalent marine oxygen isotope stages (MOIS) and archaeological periods, derived from a combination of Wenban-Smith *et al* (2007: tables 2 and 3) and AHOB (2009). The stages between 10 to 5e were previously grouped together as the Wolstonian Complex; but since the identification of discrete stages within that timeframe, the name has become redundant. * indicates timing of Swanscombe site.

Epoch	Stage	Main climate characteristics	MOIS equivalent	Approximate start (1,000 years BP)	Archaeological divisions (approximate start; 1,000 years BP)
Holocene	Holocene/ Flandrian	Warm	1	10	Mesolithic to modern (10)
Late Pleistocene	Devensian	Mainly cold	4-2	70	Upper Palaeolithic (40)
		Temperate	5d-a	110	
	Ipswichian	Warm	5e	120	
Middle Pleistocene		Cold	6	190	
	Aveley	Warm	7	240	Middle Palaeolithic (250)
		Cold	8	300	
	Purfleet	Warm	9	340	
		Cold	10	380	
	Hoxnian*	Warm	11	425	
	Anglian	Cold	12	480	
	Cromerian complex; Beestonian glaciation	Cold and warm cycles	19-13	780	
Early Pleistocene		Cool and warm cycles	64-20	1,800	Lower Palaeolithic

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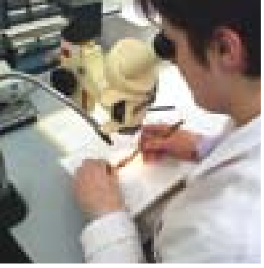
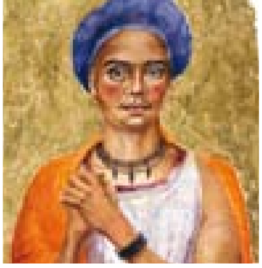



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