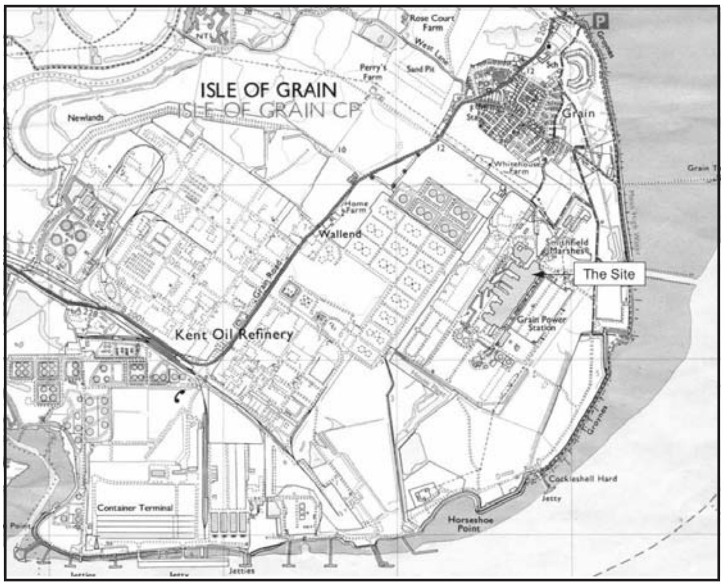
Archaeology South-East

ASE

Geoarchaeological Desk-Based Assessment in Advance of the Construction of a New Power Station on the Isle of Grain, Kent

NGR 588444 174940
ASE Project No. 2524



By Martin Bates

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Summary

Archaeology South East were commissioned to undertake a geoarchaeological desk-based assessment in advance of the construction of a new power station on the Isle of Grain, Kent. The evidence suggests that a complex history of sequence generation exists within the vicinity of the study site, with three possible distinct sequences of fluvial sand and gravel aggradation. Upper Palaeolithic archaeology may well exist in association with these gravels and a channel sequence identified is likely to preserve palaeoenvironmental remains.

Only Mesolithic or late Upper Palaeolithic artefacts may occur on the topographic template between the gravels and overlying clay-silt sediments. By the Neolithic period the entire site area would have been transformed into an estuarine situation. However, the nature of the sediments recorded in the stratigraphic stack suggests shifts in the nature of that landscape from estuarine mudflats (clay-silts) to sand banks (sands). The presence of organic rich horizons in some boreholes also suggest periodic emergence of the landscape from the estuary and the possibility that semi dry habitats may have temporarily existed at times. These may have been targets for human activity.

Archaeology South-East

Archaeology South-East is a division of the Field Archaeology Unit, University College London, one of the largest groupings of academic archaeologists in the country. Consequently, Archaeology South-East has access to the conservation, computing and environmental backup of the college, as well as a range of other archaeological services.

The Field Archaeology Unit and South Eastern Archaeological Services (which became Archaeology South-East in 1996) were established in 1974 and 1991 respectively. Although field projects have been conducted world-wide, the Field Archaeology Unit retains a special interest in south-east England with the majority of our contract and consultancy work concentrated in Hampshire, Surrey, Sussex, Kent, Greater London and Essex.

Based in the local community, the Field Archaeology Unit sees an important part of its work as explaining the results to the broader public. Public lectures, open days, training courses and liaison with local archaeological societies are aspects of its community-based approach.

Drawing on experience of the countryside and towns of the south east of England the Unit can give advice and carry out surveys at an early stage in the planning process. By working closely with developers and planning authorities it is possible to incorporate archaeological work into developments with little inconvenience.

Archaeology South-East, as part of the Field Archaeology Unit, is a registered organisation with the Institute of Field Archaeologists and, as such, is required to meet IFA standards.

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APPENDIX

FIGURES

1.0 Introduction

1.1 Archaeology South-East (ASE), a division of University College London Field Archaeology Unit (UCLFAU), was commissioned by E. ON UK plc. to undertake a geoarchaeological desk-based assessment in advance of the construction of a new power station on the Isle of Grain, Kent. (NGR 588444 174940, Fig. 1).

1.2 The Heritage Conservation Group at Kent County Council advised Medway Council that a condition securing a programme of archaeological works be attached to any consent for the development. Consequently, the Heritage Conservation Group produced a specification for the work, the information from which is reproduced here with due acknowledgement. Medway Council's reference for the development is MC2005/2434.

1.3 This report covers the initial stage of the geoarchaeological assessment of the site in advance of development. The objectives of the work are to contribute to an understanding of the sedimentological and palaeo-environmental history of this area of Medway Valley. In particular this initial stage is to review existing data and inform and develop a programme of targeted sampling and analysis work.

1.4 The work was carried out by Martin Bates in accordance with the specification. The project was managed by Neil Griffin (Project Manager).

2.0 Background

2.1 Prehistoric peat horizons are known in coastal exposures close to the power station and prehistoric remains are known from the nearby Kent Oil Refinery site. A major Iron Age occupation site is known from the higher land at Grain. Roman and medieval remains have also been located at the nearby refinery site. Based on our general understanding of the archaeology of this area of the Medway it is very likely that the alluvial deposits in this area contain a good potential for encountering prehistoric to medieval remains as has been found to the south at Kingsnorth. In addition there will be evidence of the post medieval reclamation of the marshlands and remains relating to the environmental and sedimentological history of this area of the Medway contained within the alluvial sequence.

2.2 Today the study area of the Isle of Grain lies between the two major drainage networks of the Thames to the north and the Medway to the east. It has been the interaction of these two rives, depositing sands and gravels in cold periods and finer grained sediments during warmer interglacial periods that has defined the patterns of sedimentation throughout the region. The river Medway has been active throughout the Pleistocene (Bridgland, 2003) (Table 1) and rises in Ashurst Forest, in the centre of the Weald from where it flows northwards through Kent and the Chalk escarpment of the North Downs to join the easterly flowing Thames at Sheerness. The modern river Thames was created as a river within the Middle Pleistocene, about 0.5 million years ago. Prior to this the pattern of river drainage across the area now occupied by the Thames Estuary was very different where the Thames had a more northerly route, and the Medway flowed across south-eastern Essex before reaching its confluence with the Thames (Bridgland, 2003). Today substantial tracts of sand/gravel aggregate deposits exist in the vicinity of the Hoo Peninsula that document these former courses.

2.3 Basement geology and geomorphology

2.3.1 The study area lies at the margins of a basin known as the London Basin that is bounded to the north by the Chalk escarpment forming the Chiltern Hills and to the south by the Chalk of the North Downs. Younger Eocene sediments occur within a synclinal feature between the Chilterns and the North Downs (Sumbler, 1996; Ellison, 2004). This structure defines the distribution of the local basement geology of the study area which consists of Thames Group sediments (London Clay). The nature of the bedrock geology has important implications for the nature of the overlying superficial geologies in terms of both the nature of sedimentary sequences and the preservational potential of the deposits. For example, the Thames Group sediments (London Clay) contribute significantly to the formation of Head deposits throughout the study area. This contrasts with the gravel bodies that are largely derived from the Chalk bedrock of the North Downs. Within this area typically gravel bodies are sterile of fossiliferous material while in places the ‘Head’ deposits may contain fossil plant and animal remains such as those reported at Allhallows Golf Course (Bates *et al*., 2002) and Kingsnorth (Bates, 1999).

2.3.2 Today the estuaries of the Thames and Medway are classified as tide dominated estuaries (sensu Dalrymple *et al*., 1992). These contain major sand bars within the outer estuary area (marine dominated zone) and tidal meanders in an inner mixed energy zone. Upstream of the Medway Marshes and the Hoo Peninsula the river funnels into a narrow gorge like feature through the north Downs.

2.4 Pleistocene sediments and Palaeolithic archaeology

2.4.1 Pleistocene sediments throughout the study area (Table 2) broadly consist of material from two systems associated with the River Thames and the River Medway. Until c.500,000 years ago the Medway, that had been in existence for over 2,000,000 years, drained northward from the centre of the Weald and was confluent with the Thames in eastern Essex (Bridgland, 2003) (Table 1). Consequently the landscape of southern England was substantially different to the present day. This geography was modified by the advance of ice to London in the Anglian period around 500,000 BP when the course of the Thames was diverted further south (Table 1). The new course of the Thames joined with the Medway north of the Hoo Peninsula, and the combined river flowed across southeast Essex to enter the North Sea at Clacton (Bridgland, 2003, 2006).

2.4.2 Today evidence for these earliest courses of the Medway exist as bands of sediments distributed along the spine and eastern side of the Hoo Peninsula while Thames deposits are present along the northern margins of the peninsula (Table 2). Gravel covering the Isle of Grain (Grain Gravel) has been shown to belong not to the Medway drainage but to the Thames system (Bridgland, 2003). Geological mapping and a substantial body of Quaternary research (Lake *et al.,* 1977; Bates *et al.,* 2002; Bridgland, 2003) have provided a basic understanding of the distribution of fluvial sands and gravels as well as other Pleistocene deposits of relevance to the Lower/Middle Palaeolithic within the Hoo area. However, considerable difficulties in identifying and correlating deposits close to the marsh surface and beneath the modern marsh are encountered. Recent work by Bates (1999) and unpublished information held by the author indicate that substantial bodies of Pleistocene sediments (including both fine grained clays and silts as well as coarse sands and gravels) are buried beneath the marsh surface but remain to be adequately dated and correlated. Some investigations (Lake *et al*., 1977) have established that the area also contains deeply buried channels while Bates (1999) and Bates *et al*. (2002) have shown that these sediments may contain fossiliferous material in places.

2.4.3 The sand and gravel aggregate deposits in these areas have also produced Palaeolithic archaeological material that have been recently summarised in the surveys of the Southern Rivers Palaeolithic Project (Wessex Archaeology, 1993). While a few key sites within the general vicinity of the study area have produced large quantities of finds, eg. Cuxton and Aylesford, most sites are find-spots of much more limited numbers of implements, often only single handaxes. For example, a handaxe was recovered *in situ* in the Shakespeare Farm Pit (Bridgland and Harding 1984), in one of the higher terraces attributed to *c.* 400,000 BP (MIS 11), shortly after the Anglian glaciation, making it one of the earliest sites in the study region.

2.5 Holocene alluvium and later Prehistoric archaeology

2.5.1 Our current understanding of the Holocene sedimentary sequences of the area are derived from work undertaken by Devoy (1977, 1979) who previously considered the main sediment sequences present within our study area. Holocene sediments are part of a continuum forming a wedge thickening downstream to reach a maximum thickness of at least 25m in the vicinity of Grain (Devoy, 1977, 1979,

1982) while the BGS mapping (British Geological Survey, 1997) indicates a maximum depth of Holocene sediments south of our study area of 28.4m. In contrast to the relatively well known sequences of Pleistocene age (Bridgland, 2003) the nature of the Holocene sediments resting on bedrock or pre-Holocene sand and gravel deposits are poorly understood and have only, with few exceptions, been described superficially (Devoy, 1977, 1979). The original basis for subdivision of these deposits was established by Devoy during the early 1970's (1979, 1982) using borehole stratigraphies integrated with biostratigraphic studies to infer successive phases of marine transgressions (typified by clay-silt deposition) and regressions (typified by peat formation). Devoy's work has resulted in a view of sediment accumulation being controlled within the area by a combination of factors dominated by sea-level change and tectonic depression of southern England. Most recently regional models for sequence development have been described by Long *et al*. (2000), Sidell (2003) and Bates and Whittaker (2004) which begin to address the range of factors responsible for sequence accumulation. Within the Medway Barham *et al.* (1995) have described the Holocene sediments encountered during the excavation of the groundworks for the Medway Tunnel.

2.5.2 Typically the Holocene sediments of the estuary area have been grouped by Gibbard (1994) into the Tilbury Member and consist of intercalated peats and clay-silts in the inner estuary. These sediments intercalate with marine sands near the Isle of Grain and at Yantlet Channel and Sea Reach south of Canvey Island. Within the Medway Estuary Barham et al. (1995) have described a sequence of peat units intercalated with estuarine clay-silts resting on Late Pleistocene gravels at the Medway Tunnel Site. Here close to the dry ground extensive evidence for later Prehistoric occupation was also recorded Allen et al. (1995).

2.5.3 In order to fully understand the distribution of likely archaeological sites in the lower estuary area and the reasons behind major changes in settlement patterns in the past it is necessary to understand the changing nature of the estuary. These changes have been summarised recently by Bates and Whittaker (2004) for the inner estuary but presently little is known of the nature and significance of the deeper areas close to the inland edge of the outer estuary.

3.0 Buried sequences and Prehistoric resource potential of the study area

3.1 Our present understanding of the nature of the geological record and the associated archaeological material from the region suggests the following:

1. Pleistocene sediments including sands and gravels associated with Thames/Medway rivers developed during cold stages are likely to exist beneath the marsh surface (Figures 1 and 2). The age of these deposits is not well known but may span more than 300,000 years.

2. Interglacial sediments including freshwater and estuarine channels may overlie the coarser sands and gravels (Figure 1). These may be cut into or lie directly on the older coarse gravels. From work elsewhere in the study area these may contain fossil material suitable for palaeoenvironmental reconstruction and correlation/dating.

3. Palaeolithic archaeological material is well documented in the Medway gravels in a wide variety of contexts. Typically in southern England Palaeolithic material is common in the older Middle Pleistocene deposits and rarer or absent in those sediments ascribed to the later Middle Pleistocene and Upper Pleistocene. Although little is documented in the area the presence of Palaeolithic material should be anticipated in suitable sediments within the region beneath the marsh.

4. Holocene sediments resting on the older Pleistocene deposits will typically consist of clay, silts and sands with organic silts or peats at the base. Sands are likely to represent sub-tidal sand bars; finer grained clays and silts probably represent inter-tidal or sub-tidal mudflats (occasionally saltmarsh surfaces).

5. The on set of sedimentation in the Holocene was a result primarily of sea level rise and flooding of the pre-existing Late Pleistocene topography (the topographic template sensu Bates, 1998; Bates and Whittaker, 2004). Progressive flooding of this landscape, with deposition of sediments on the old topography, occurred during progressively later time periods at higher elevations.

6. Prehistoric archaeological sites formed in dryland situations may be encountered in the study zone at variable depth beneath the marsh surface. Beneath the marsh surface the dryland sites will rest on the topographic template (sensu Bates and Whittaker, 2004) and the age and nature of the sites will be controlled by sea level change and flooding of the topographic template (i.e. Mesolithic sites may be present resting on much of the gravel surface topographic template but Neolithic sites are only going to be present on that part of the topographic template still above contemporary marsh surface created as a result or rising sea levels and changing wetland boundaries).

7. There appears to be a relationship between the dryland/wetland boundary and the distribution of archaeological remains in the region. Although only relatively restricted programs of investigation have attempted to examine these issues previous work in East London along the line of the A13 (Gifford and Partners, 2000, 2001a, 2001b) and on the CTRL at the Thames River Crossing (Bates *et al*., in

prep.). Furthermore the absence of predictable activity within the floodplain away from the dry ground/wet ground interface has also been addressed in the CTRL Thames River Crossing study where detailed monitoring of nearly 1km of continuous profile through the alluvium failed to reveal any archaeology in such situations.

8. The presence of organic remains associated with human activity can be demonstrated within the wetland region or with wetland adjacent to dry ground situations. Good examples are known from the East London area (Meddens, 1996) as well as the Ebbsfleet area (in prep.).

4.0 A geoarchaeological framework model for the study area

4.1 The basis for understanding the nature and distribution of sediments within the study area is based on a geoarchaeological perspective linking observations on regional and local geomorphology, regional geological development and climate history to human activity and a knowledge of areas of preferred human activity in the past. Consequently it is important to understand the history of fluvial activity of the river Thames and Medway as well as changes in local and regional sea levels.

4.2 Reported publications (see above) indicate the main sediment types to be encountered within the area is likely to be:

1. Pleistocene fluvial sands and gravels representing buried terraces inundated during Holocene marine transgression.

2. Pleistocene solifluction, head and colluvium at the inner margins of the terraces buried sea level rise.

3. Pleistocene silts and clays representing interglacial sequences cut into or resting on the terrace surfaces beneath the Holocene marsh.

4. Clays, silts and peats of Holocene date formed immediately prior to or following marine transgression.

4.3 Sequences similar to those predicted to be present within the study area have previously been investigated by Bates *et al.* (2002) at Allhallows to the north and Kingsnorth to the south of the current study area. Under ideal conditions (based on patterns recognised throughout southern England) sediments associated with river terrace sequences consist of a number of elements (Bridgland, 2006) including cold climate flint gravels, fine grained interglacial sands and silt and colluvium. These are illustrated in Figure 3. In valleys such as the Thames and Medway these are often arranged staircase-like down the valley side with the oldest at highest elevations and the youngest at the lowest elevations or buried beneath the floodplain. This is shown in the context of the topography of the floodplain in Figure 3.

5.0 Sequences of the site area: a geoarchaeological assessment

5.1 The data used to assess the nature of the stratigraphy present at the study site is based on a sequence of historical borehole records for which ground surface elevations were available and for which Ordnance Survey grid coordinates could be calculated. In addition to this data other, more recent, borehole records and Cone Penetration Data were consulted but due to an absence of xyz data for these surveys it is not currently possible to integrate the different sets of data.

5.2 The distribution of data points used for investigating the stratigraphy are illustrated in Figure 4 along with the location of 3 transects (Figures 6 – 8) constructed through the borehole data. On the basis of the information from the lithological descriptions provided in the borehole records the following points were observed:

1. Rockhead elevations (Figure 5) declined from north to south across the site from elevations of c.-11m O.D. in the north to below -24.5m O.D. in the south. It was noticeable that an area of relatively gently sloping topography existed between -18m and -20.5m in the central area of the site.

2. Gravel surface topography (i.e. the Holocene topographic template on which Holocene sedimentation has occurred) broadly reflects the pattern of the underlying bedrock topography. Cross sections prepared from the borehole logs (Figures 6 - 8) clearly distinguish the distribution of gravels bounded by the surfaces mapped in Figure 5 and these have been grouped into those at higher elevations (High terrace), intermediate levels (Intermediate terrace) and those at lowest elevations (Low terrace). This pattern has the appearance of 3 distinct fluvial sequences separated by erosion events that lead to terrace formation (comparable with that predicted – see Figure 3).

3. An interesting sequence of deposits has been noted to occur in boreholes 22, 371 and 372 where 2 sets of gravel deposits are separated by clays (Figure 6). These are potentially sediments associated with filling of a channel associated with the gravel sequence.

4. Holocene sediments primarily consist of clay silts or sands. The distribution of the sands appears to suggest the probability that sands disappear towards the north and west. Organic sediments are also present (e.g. 32, 213, 351, 369, and 371). These organic silts occur within the sequence, often beneath the sand bodies. There is no apparent spatial pattern to the distribution of the organic sediments.

6.0 Discussion

6.1 The evidence presented here suggests that a complex history of sequence generation is recorded within the vicinity of the study site. Three possible distinct sequences of fluvial sand and gravel aggradation exist beneath the site. The possible boundaries of these terraces are shown in Figure 9. On the basis of our current knowledge for the area it is likely that the High terrace is the oldest and the Low terrace the youngest. Typically the lowest terraces within the valley date to the very final episode of the Devensian it is likely that the Low terrace can be dated to post 20,000 B.P. and equated to the Shepperton (Table 2). If correct then the Intermediate and High terraces may be of early Devensian or earlier date (equivalent to the East Tilbury Marshes terrace).

6.2 While both the High and Intermediate terraces exhibit relatively simple internal structure the Low terrace appears to exhibit a complex internal structure and fine grained deposits, perhaps indicative of a channel fill sequence, are present.

6.3 On the basis of our current knowledge the potential of any of the terraces to yield *in situ* Lower and Middle Palaeolithic archaeology are low. Upper Palaeolithic archaeology may well exist in association with these gravels and the presence of a channel, perhaps dating to the very late Pleistocene, may have been an attractive place for returning Upper Palaeolithic populations to visit. Palaeoenvironmental material is likely to be minimal in the gravel deposits but the channel sequence identified is likely to preserve palaeoenvironmental remains.

6.4 The surface described by the gravel surface topography (Figure 9) represents the best guess for the shape and distribution of the early Holocene landscape on which the earliest Mesolithic populations would have lived.

6.5 On set of sediment accumulation associated with Holocene sea level rise and transgression of the sea across the former land surface probably began sometime before 8.5ka B.P. based on age estimates from the Lower Thames (Figure 10). This model predicts flooding across this surface began before 9,000 B.P. and that inundation of the -13m O.D. contour was likely around 8,000 B.P. Total transformation of this landscape from a dryland one to an estuarine landscape would have been complete well before 7,000 B.P. Thus only Mesolithic or late Upper Palaeolithic artefacts will occur on the topographic template between the gravels and overlying clay-silt sediments. By the Neolithic period the entire site area would have been transformed into an estuarine situation.

6.6 Although variation in the Holocene stratigraphic sequence is recorded in the boreholes this information provides only basic descriptions that are difficult to interpret in terms of the precise nature of the sequences and associated environments of deposition. Thus although peats are noted in some places (e.g. borehole 351) the nature of the peats are not well defined. Peats are associated with semi-emergent landscapes and thus of potential archaeological relevance although on the basis of the available borehole records these do not appear to define readily mapable associations. For example peat occurs above the high terrace in borehole 351 but not 359. Peat occurs beneath sands above the intermediate terrace in 359 and 32 but not in 176. These peat deposits vary in depth from c.6m below ground surface in 351 to greater than 12m above the intermediate terrace.

6.7 Although flooding of the area commenced early the nature of the sediments recorded in the stratigraphic stack suggest shifts in the nature of that landscape from estuarine mudflats (clay-silts) to sand banks (sands). The presence of organic rich horizons in some boreholes also suggest period emergence of the landscape from the estuary and the possibility that semi dry habitats may have temporarily existed at times. These may have been targets for human activity.

6.8 The area of the site modeled on the basis of the available, and useable, borehole data apparently lies some distance from the edge of the mapped higher ground of the Isle of Grain (i.e. the edge of the modern floodplain). However, areas of the northern part of the site, particularly the 'construction and accommodation laydown area' is likely to straddle that boundary and within this corridor earlier Holocene sediments are likely to lie close to the ground surface. In such situations valley marginal activity from a variety of periods may lie close to the modern ground surface.

7.0 Conclusions

7.1 The site investigation has provided a model for sequence development that may span a considerable time. The history of sedimentation has varied from cold climate to temperate and a range of different environments of deposition are represented. At present age estimates are based on previous work which is based on limited surveys and inadequate data sets. Consequently it is important to verify the conclusions drawn in this study through the recovery of samples for palaeoenvironmental assessment and dating. In order to achieve the testing of the model it would be necessary to undertake a programme of intrusive fieldwork. This could be achieved by targeted trial trenching in the area where construction is likely to have the greatest impact (i.e. within the southern corner of the site) and the drilling of 3 boreholes. In order to examine the channel and the Low terrace a borehole would be required adjacent to 371. The Intermediate terrace and overlying organic sequences beneath the sand bank should be examined through a borehole close to 213. Finally the High terrace and overlying organic sequences should be examined close to 351. In all cases provision for dating the sediments should be made.

References

Allen, T., Macpherson-Grant, N., McNabb, J., Savage, A. and Wilson, T. 1995 **Archaeological works on the eastern approach of the Medway Tunnel: a re-assessment.** Canterbury Archaeological Trust. Unpublished Report.

Barham, A.J., Bates, M.R., Pine, C.A. and Williamson, V.D. 1995 Holocene development of the Lower Medway Valley and Prehistoric occupation of the floodplain area. 339 - 350. In: Bridgland, D.R., Allen, P. and Haggart, B.A. (eds.) **The Quaternary of the Lower Reaches of the Thames. Field Guide**. Quaternary Research Association: Cambridge.

Bates, M.R. 1998 Locating and evaluating archaeology below the alluvium: the role of sub-surface stratigraphical modelling. **Lithics 19**, 4 – 18.

Bates, M.R. 1999. **A geoarchaeological assessment of a borehole from the Kingsnorth Power Station site, Hoo St. Werburgh, Rochester-upon-Medway**. Unpublished report. S. & M.R. Bates.

Bates, M.R., Keen, D.H., Whittaker, J.E., Merry, J.S. & Wenban-Smith, F.F. 2002. Middle Pleistocene molluscan and ostracod faunas from Allhallows, Kent, UK. **Proceedings of the Geologists' Association 113**,: 223–236.

Bates, M.R. and Whittaker, K. 2004 Landscape evolution in the Lower Thames Valley: implications for the archaeology of the earlier Holocene period. 50 – 70. In: Cotton, J. and Field, D. (eds.) **Towards a New Stone Age. Aspects of the Neolithic in south-east England.** CBA Research Report series RR 137. Council for British Archaeology: York.

Bridgland, D.R. 2003. The evolution of the River Medway, SE England, in the context of Quaternary palaeoclimate and the Palaeolithic occupation of NW Europe. **Proceedings of the Geologists' Association 114**, 23–48.

Bridgland, D.R. 2006 The Middle and Upper Pleistocene sequence in the Lower Thames: a record of Milankovitch climatic fluctuation and early human occupation of southern Britain. **Proceedings of the Geologists' Association 117**, 281 – 306.

Bridgland, D.R. and Harding, P. 1984 Palaeolithic artifacts from gravels of the Hoo Peninsula. **Archaeological Cantiana 191**, 41 – 56.

British Geological Survey 1997 **Inner Thames Estuary. England and Wales. Part of Sheets 257, 258, 259, 271, 272, 273. Pre-Quaternary Geology and Quaternary Geology. 1:50 000.** British Geological Survey: Keyworth.

Dalrymple, R.W., Zaitlin, B.A. and Boyd, R. 1992 Estuarine facies models conceptual, basis and stratigraphic implications. **Journal of Sedimentary Petrology 62**, 1130 - 1146.

Devoy, R.J.N. 1977 Flandrian sea-level changes in the Thames Estuary and the implications for land subsidence in England and Wales. **Nature 220**, 712-715.

Devoy, R.J.N**.** 1979 Flandrian sea-level changes and vegetational history of the Lower Thames Estuary. **Philosophical Transactions of the Royal Society of London B285**, 355-407.

Devoy, R.J.N. 1982 Analysis of the geological evidence for Holocene sea level movements in Southeast England. **Proceedings of the Geologists' Association 93**, 65-

90.

Ellison, R.A. 2004 **Geology of London. Special Memoir for 1:50,000 Geological Sheets 256 (North London), 257 (Romford), 270 (South London) and 271 (Dartford) (England and Wales).** British Geological Survey: Keyworth.

Gibbard, P.L. 1994 **Pleistocene history of the Lower Thames Valley**. Cambridge University Press: Cambridge.

Gifford and Partners Ltd. 2000 **A13 Thames Gateway Preliminary Archaeological Investigations: Roding Bridge and Ironbridge-Canning Town Further Archaeological Works Report.** Gifford Report B3295.RO8. Gifford and Partners: London

Gifford and Partners Ltd. 2001a **A13 Thames Gateway Preliminary Archaeological Investigations: Woolwich Manor Way Further Archaeological Works Report.** Report No. B3295.RO10. Gifford and Partners: London

Gifford and Partners Ltd. 2001b **A13 Thames Gateway Preliminary Archaeological Investigations: Movers Lane Further Archaeological Works Report.** Report No. B3295.RO9. Gifford and Partners: London.

Lake, R.D., Ellison, R.A., Hollyer, S.E. & Simmons, M. 1977. Buried channel deposits in the southeast Essex area: their bearing on Pleistocene palaeogeography. **Report of the Institute of Geological Sciences***,* 77/21.

Long, A.J., Scaife, R.G. and Edwards, R.J. 2000 Stratigraphic architecture, relative sea-levels, and models of estuary development in southern England: new data from Southampton Water. In: Pye, K. and Allen, J.R.L.(eds.) **Coastal and Estuarine Environments: sedimentology, geomorphology and geoarchaeology**. Geological Society, London, Special Publications, 175, 253-279.

Meddens, F. 1996 Sites from the Thames estuary wetlands, England and their Bronze Age use. **Antiquity 70**, 325 – 334.

Sidell, E.J. 2003 **Holocene sea level change and archaeology in the inner Thames estuary, London, UK.** Unpublished PhD. Thesis. University of Durham. 2 vols.

Sumbler, M.G. 1996 **London and the Thames Valley**. British Regional Geology. 4th Edition. British Geological Survey: Keyworth.

Wessex Archaeology. 1993. **The Southern Rivers Palaeolithic Project, Report No. 2 — The South West and South of the Thames**. Wessex Archaeology, Salisbury.

Epoch	Age ka BP	MI Stage	Traditional stage (Britain)	Climate	Archaeological period	Key palaeogeographic events
Holocene	Present–10,000	1	Flandrian	Warm — full interglacial		
Late Pleistocene	25,000	2	Devensian	Mainly cold; coldest in MI Stage 2 when Britain depopulated and maximum advance of Devensian ice sheets; occasional short-lived periods of relative warmth ("interstadials"), and more prolonged warmth in MI Stage 3.	Upper Palaeolithic	
	50,000	3				
	70,000	4			Middle Palaeolithic	
	110,000	5a–d				
	125,000	5e	Ipswichian	Warm — full interglacial		
Middle Pleistocene	190,000	6	Wolstonian complex	Alternating periods of cold and warmth; recently recognised that this period includes more than one glacial–interglacial cycle; changes in faunal evolution and assemblage associations through the period help distinguish its different stages.		
	240,000	7				
	300,000	8			Lower Palaeolithic	
	340,000	9				Confluence established in vicinity of Isle of Grain.
	380,000	10				
	425,000	11	Hoxnian	Warm — full interglacial		Medway drains into Thames NE of current estuary mouth
	480,000	12	Anglian	Cold — maximum extent southward of glacial ice in Britain; may incorporate interstadials that have been confused with Cromerian complex interglacials		Major ice advance to London and south Essex. Former course of Thames blocked and creation of modern Thames Valley
	620,000	13–16	Cromerian complex and Beestonian glaciation	Cycles of cold and warmth; still poorly understood due to obliteration of sediments by subsequent events		Thames flowing north of current course through Vale of St. Albans. Medway draining across current Thames estuary, confluent with Thames north of Clacton
	780,000	17–19				
Early Pleistocene	1,800,000	20–64		Cycles of cool and warn, but generally not sufficiently cold for glaciation in Britain		

Table 1. Quaternary epochs, the Marine Isotope Stage framework and key palaeogeographic events for SE England

Terrace formation: Medway	Interglacial deposits (channels)	Terrace formation: Thames	Members: Lower Thames	Age	Climate	MI Stage
Tilbury		Tilbury	Tilbury	Holocene	warm	1
Halling		Shepperton	Shepperton	late Devensian	cold	late 2
Aylesford Upper			East Tilbury Marshes Upper	Devensian	cold	5d-2
	?Kingsnorth deposits	East Tilbury Marshes	Trafalgar Square deposits	Ipswichian	warm	5e
Aylesford Lower			East Tilbury Marshes Lower	intra-Saalian	cold	late 6
Binney Upper			Mucking Upper	intra-Saalian	cold	6
	?Allhallows deposits	Mucking	Aveley Silts and sands	intra-Saalian	warm	7
Binney Lower			Mucking Lower	intra-Saalian	cold	late 8
			Botany	intra-Saalian	cold	8
Stoke (Grain Gravel*)	?Allhallows deposits	Corbets Tey (Grain Gravel)	Purfleet deposits	intra-Saalian	warm	9
			Little Thurrock	intra-Saalian	cold	late 10
			Orsett Heath Upper	intra-Saalian	cold	10
Shakespeare		Orsett Heath	Swanscombe interglacial deposits	Hoxnian	warm	11
			Orsett Hearth Lower	late Anglian	cold	late 12
Newhall?		Black Park		Anglian	cold	12
Dagenham Farm/Chalkwell/Caidge		Winter Hill	St.Osyth	Anglian	cold	12
Clinch Street/Canewdon/St. Lawrence			Wivenhoe	pre-Anglian	c/w/c	14-12?
High Halstow/Belfairs/Mayland			Ardleigh	Cromerian complex	c/w/c	?

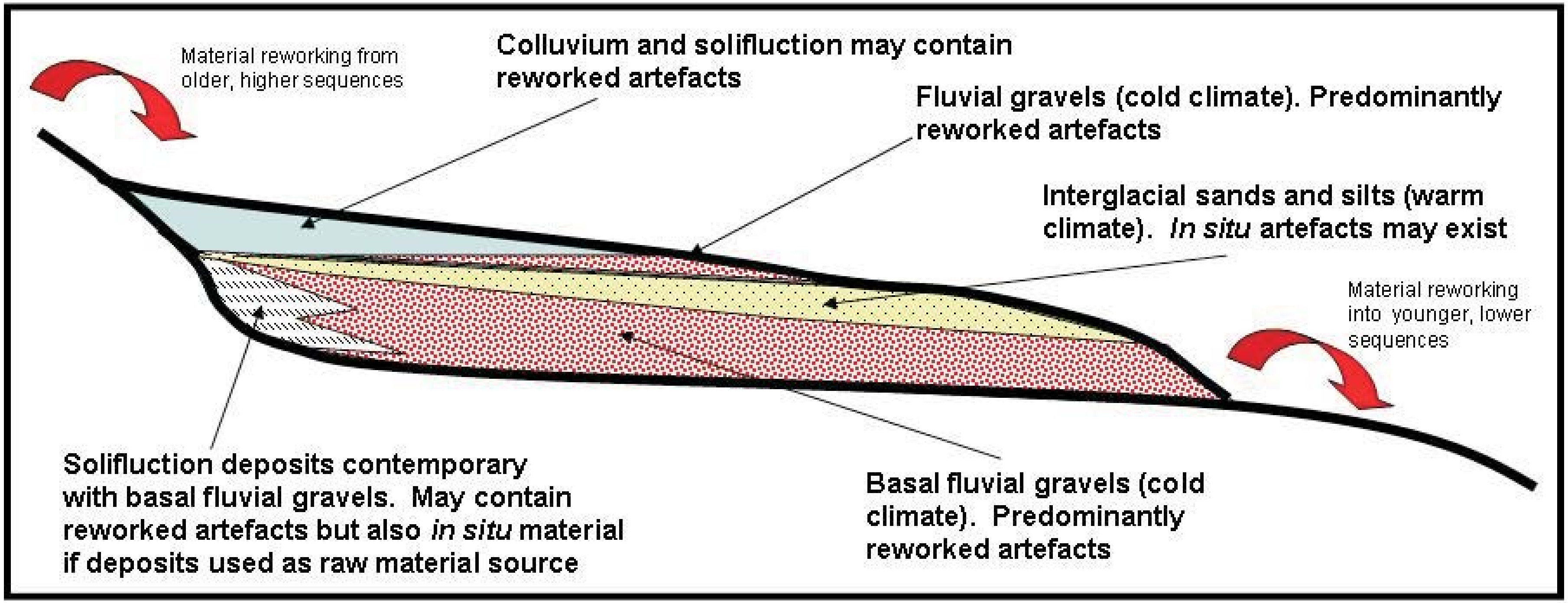
* The Grain Gravel (present on the Isle of Grain) is a Thames not Medway deposit and is equivalent to the Corbets Tey Terrace of the Lower Thames

Table 2. The Quaternary sequence in the lower reaches of the Medway showing lithostratigraphic sequence and suggested correlations with Thames formations and with chronostratigraphic, climatic and marine isotope (MI) stages (modified from Bridgland, 2003).

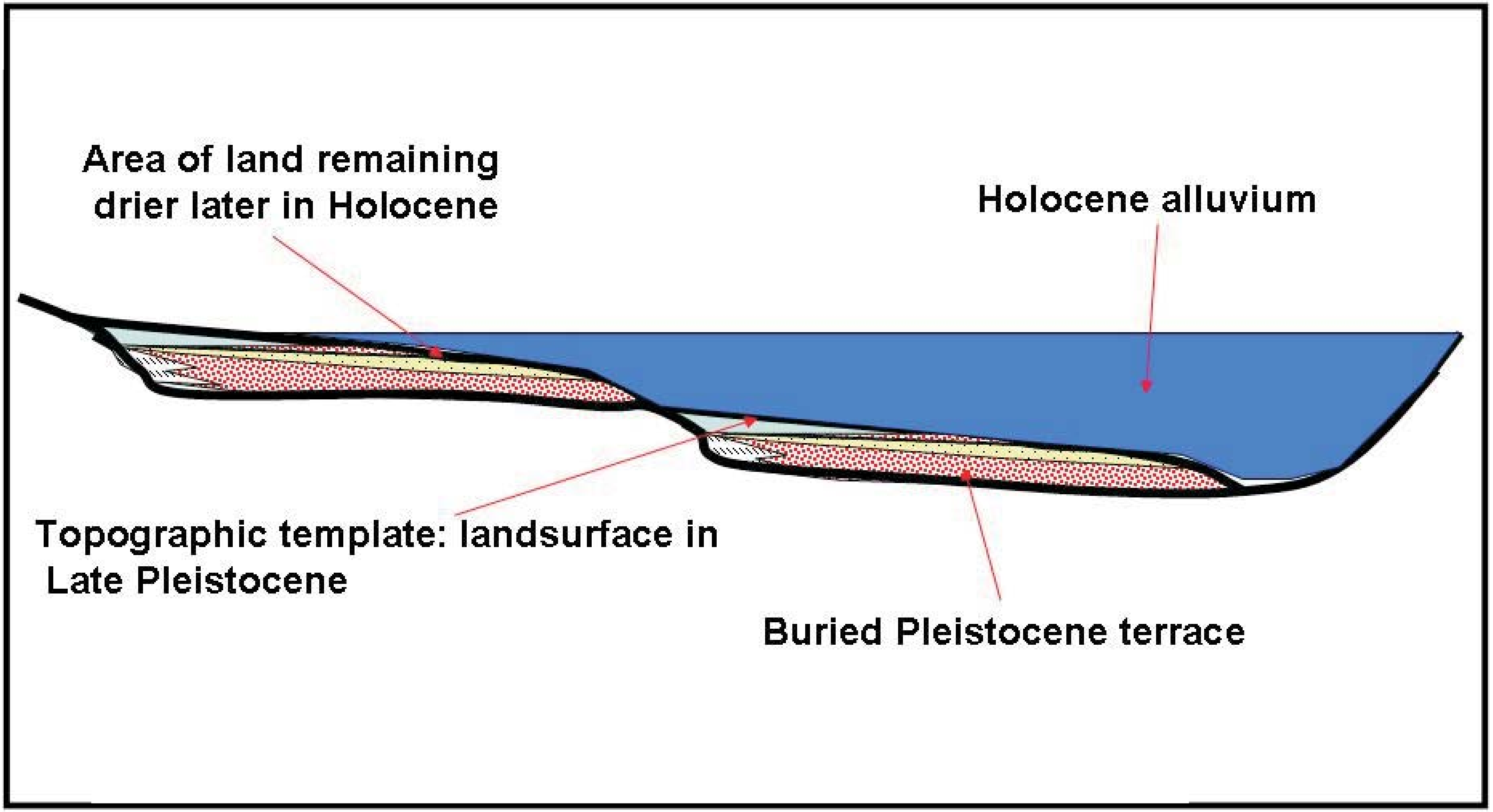
Kent County Council SMR summary form

Site Name: **Grain Power Station**	
Site Address: Grain Power Station Isle of Grain Kent	
Summary: Geoarchaeological desk-based assessment in advance of the construction of a new power station on the Isle of Grain, Kent.	
District/Unitary: Medway	**Parish:** Grain
Period(s): Upper Palaeolithic, Mesolithic	
NGR (centre of site : 8 figures): 588444 174940	
Type of archaeological work (delete) Geoarchaeological investigation	
Date of Recording: August 2006	
Unit undertaking recording: Archaeology South East	
Geology: London Clay	
Title and author of accompanying report: Geoarchaeological Desk-Based Assessment in Advance of the Construction of a New Power Station on the Isle of Grain, Kent Bates, M.	
Summary of fieldwork results (begin with earliest period first, add NGRs where appropriate) *The evidence suggests that a complex history of sequence generation exists within the vicinity of the study site, with three possible distinct sequences of fluvial sand and gravel aggradation. Upper Palaeolithic archaeology may well exist in association with these gravels and a channel sequence identified is likely to preserve palaeoenvironmental remains.* *Only Mesolithic or late Upper Palaeolithic artefacts may occur on the topographic template between the gravels and overlying clay-silt sediments. By the Neolithic period the entire site area would have been transformed into an estuarine situation.* *However, the nature of the sediments recorded in the stratigraphic stack suggests shifts in the nature of that landscape from estuarine mudflats (clay-silts) to sand banks (sands). The presence of organic rich horizons in some boreholes also suggest periodic emergence of the landscape from the estuary and the possibility that semi dry habitats may have temporarily existed at times. These may have been targets for human activity.* **(cont on attached sheet)**	
Location of archive/finds: Archaeology South-East Offices, Ditchling, Sussex	
Contact at Unit: Neil Griffin	**Date:** 11/09/06

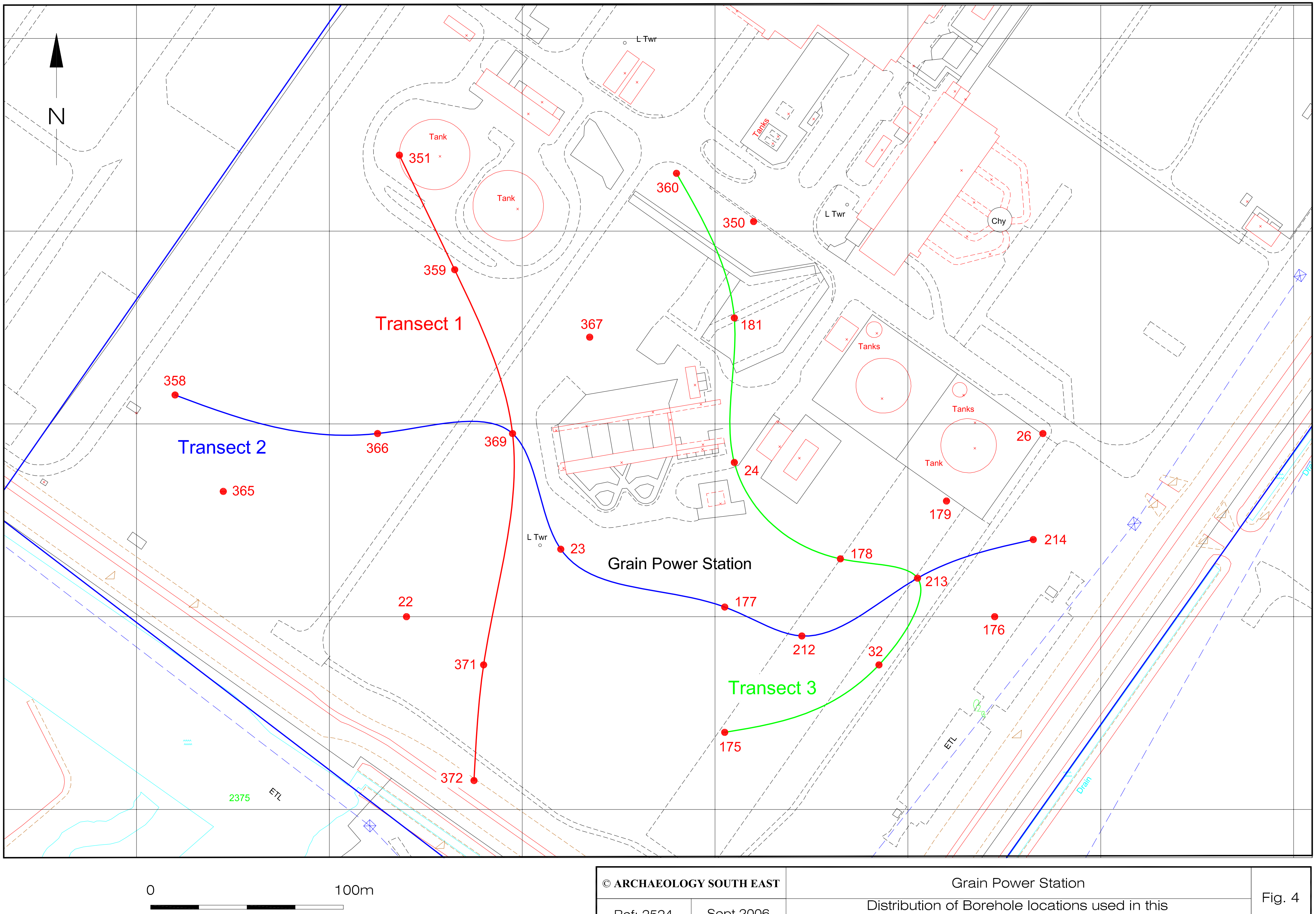
© Archaeology South-East			Grain Power Station	Fig. 1
Ref: 2524	Aug 2006	Drawn by: JLR	Site Location Plan	



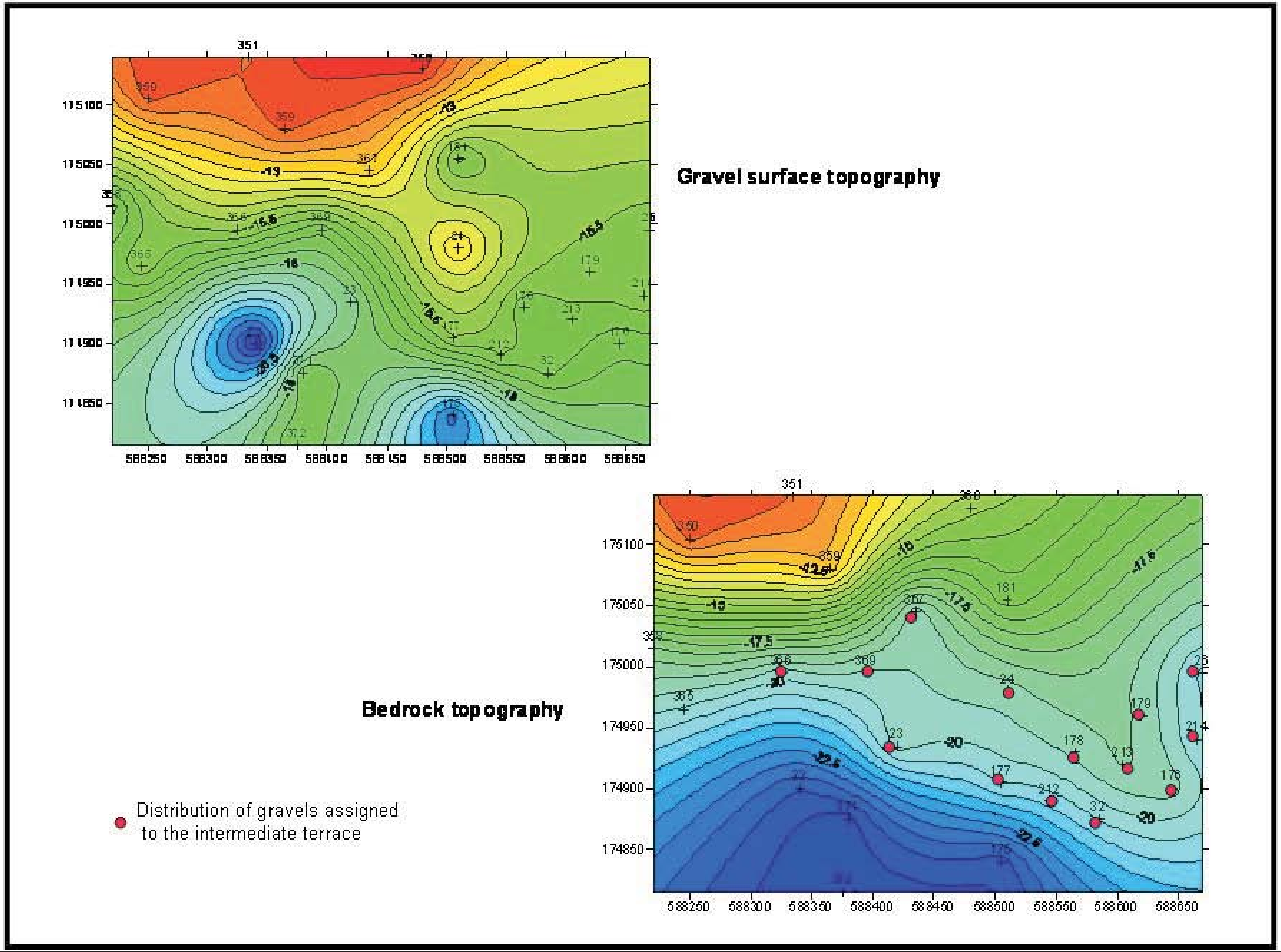
© Archaeology South-East			Grain Power Station	Fig. 2
Ref: 2524	Sept 2006	Drawn by: Jps	Elements of a Pleistocene terrace from South-East England	



© Archaeology South-East			Grain Power Station	Fig. 3
Ref: 2524	Sept 2006	Drawn by: Jps	Schematic section through sequences in major river valley in SE England	



© ARCHAEOLOGY SOUTH EAST		Grain Power Station	Fig. 4
Ref: 2524	Sept 2006	Distribution of Borehole locations used in this investigation showing location of transect lines	



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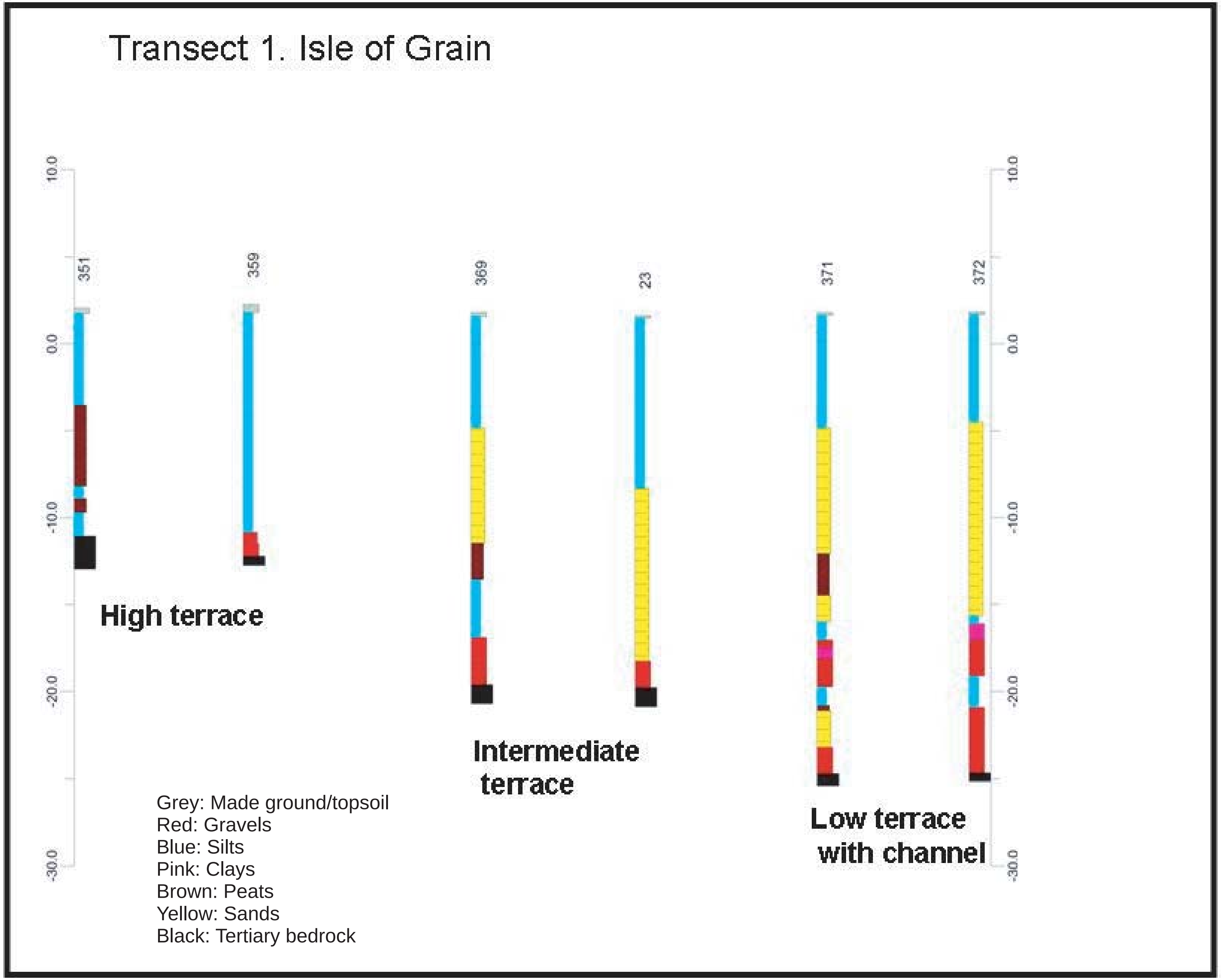
Ref: 2524	Sept 2006	Drawn by: Jps	Topographic projections for gravel surface topography and base of gravels	



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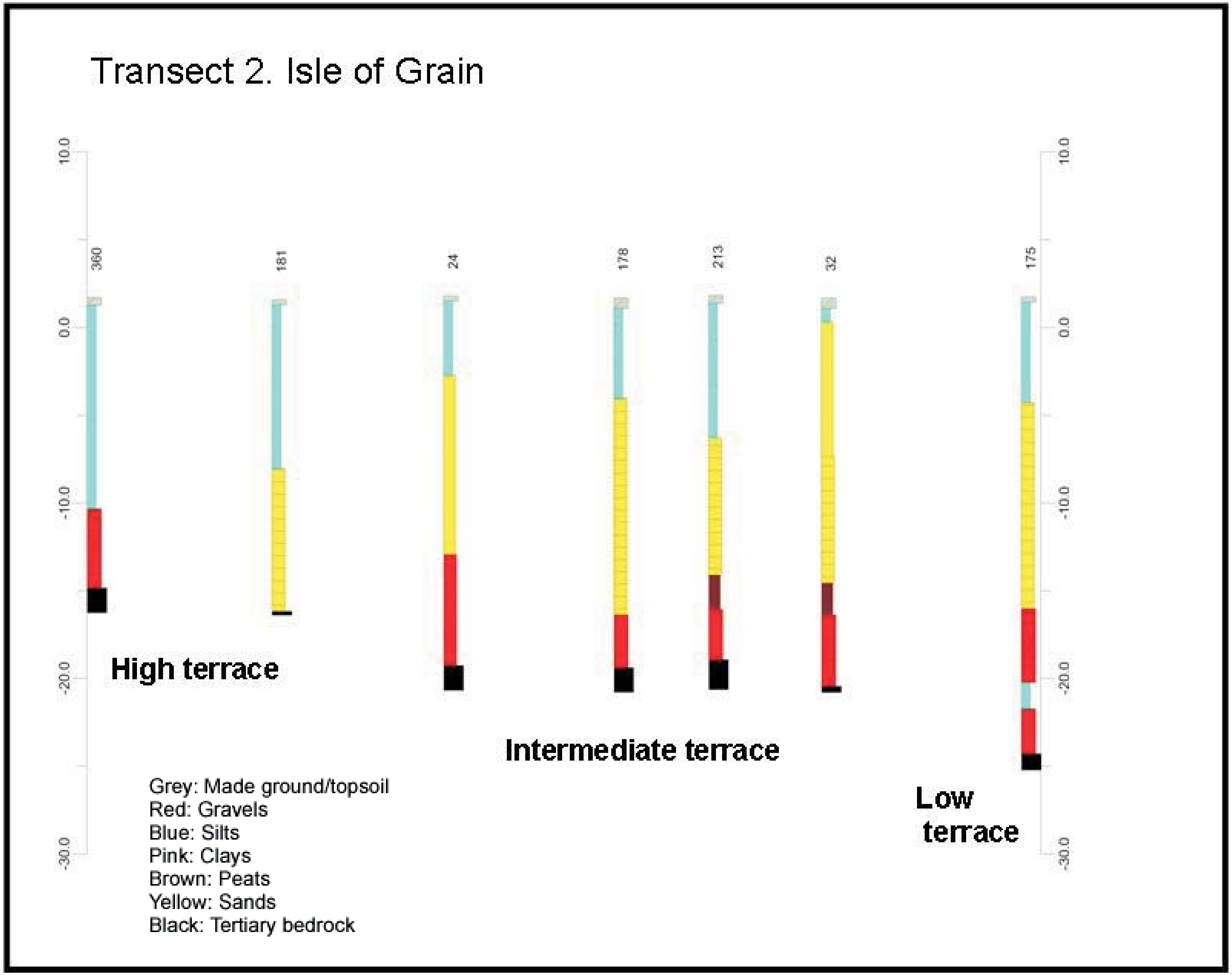
Ref: 2524	Sept 2006	Drawn by: Jps	Transect 1 (approximately N/S through site centre)	



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Ref: 2524	Sept 2006	Drawn by: Jps	Transect 2 (approximately N/S through eastern part of site)	

Transect 3. Isle of Grain

Grey: Made ground/topsoil
Red: Gravels
Blue: Silts
Pink: Clays
Brown: Peats
Yellow: Sands
Black: Tertiary bedrock

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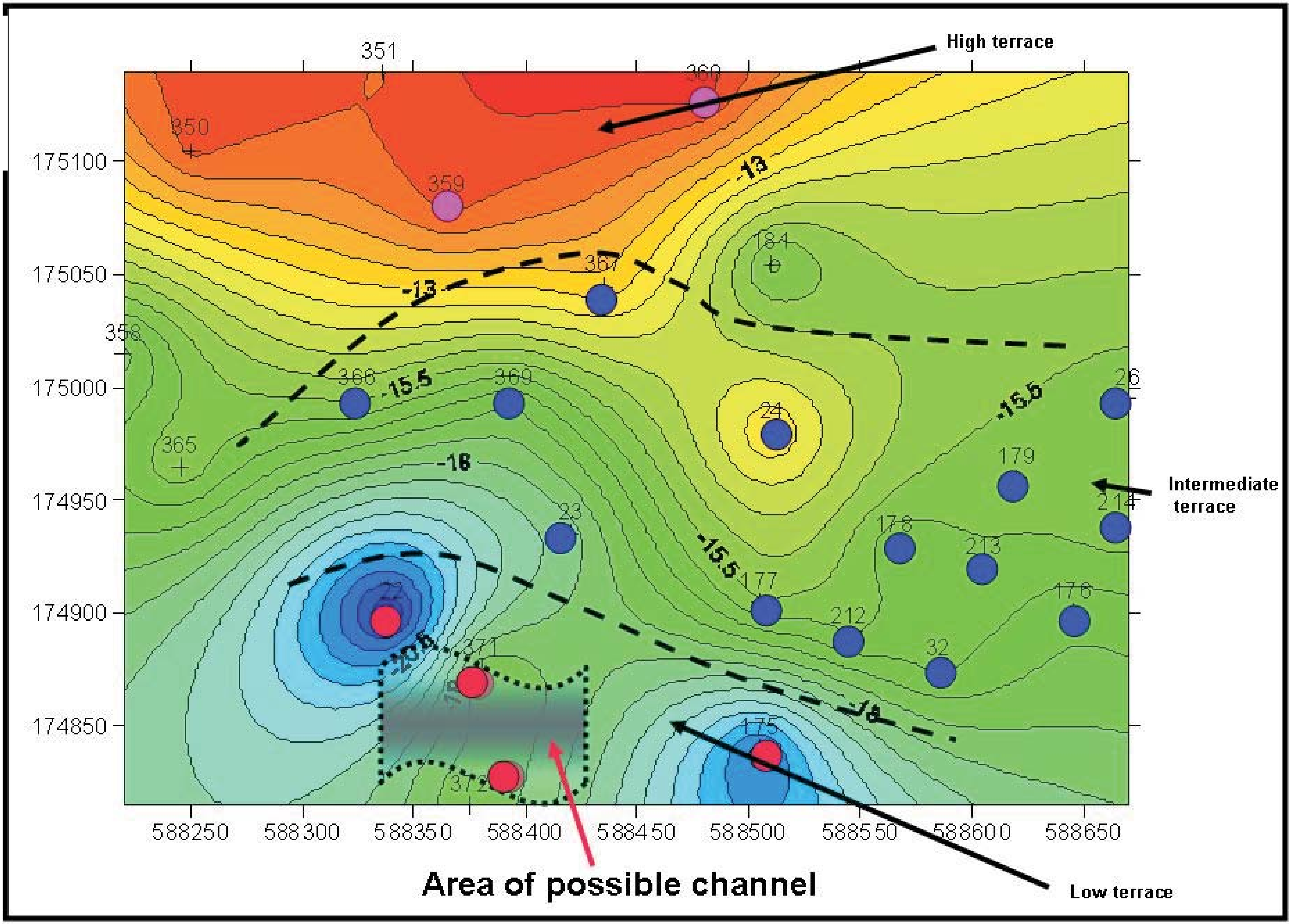
Ref: 2524	Sept 2006	Drawn by: Jps	Transect 3 (approximately W/E through centre of site)	



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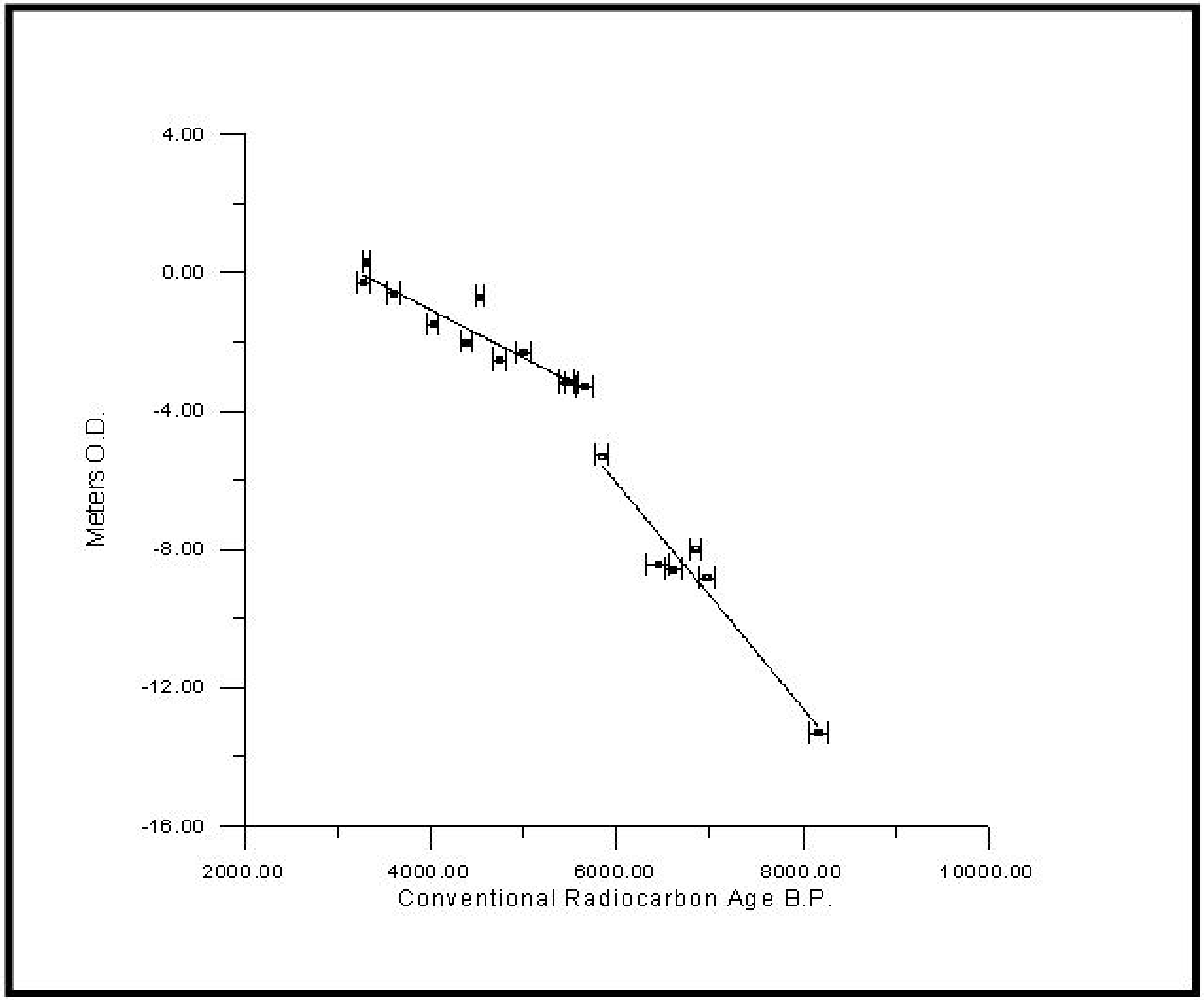
Ref: 2524	Sept 2006	Drawn by: Jps	Gravel surface topography showing distribution of identified gravel units	



© Archaeology South-East			Grain Power Station	Fig. 10
Ref: 2524	Sept 2006	Drawn by: Jps	Age/altitude curve for C14 age estimates from contexts documenting on-set Of Holocene sedimentation on topographic template in Lower Thames area	

Head Office
Units 1 & 2
2 Chapel Place
Portslade
East Sussex BN41 1DR
Tel: +44(0)1273 426830 Fax:+44(0)1273 420866
email: fau@ucl.ac.uk
Web: www.archaeologyse.co.uk

London Office
Centre for Applied Archaeology
Institute of Archaeology
University College London
31-34 Gordon Square, London, WC1 0PY
Tel: +44(0)20 7679 4778 Fax:+44(0)20 7383 2572
Web: www.ucl.ac.uk/caa

The contracts division of the Centre for Applied Archaeology, University College London