Chapter 12

The Ebbsfleet Valley

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The Ebbsfleet Valley (Zones E1–E3)

The line of HS1, after exiting the Thames tunnel on the Swanscombe Marshes, continues southwards through the Ebbsfleet Valley (Fig 78). Initially the line passes through the Pleistocene deposits on the western side of the lower part of the valley and then skirts the western edge of the alluvial floodplain in the vicinity of Northfleet Roman villa. It then continues southwards through the Upper Ebbsfleet Valley to Springhead. The results of the extensive archaeological excavations carried out in the Ebbsfleet Valley are published in detail elsewhere (Andrews *et al* 2011a; Wenban-Smith *et al* forthcoming). The following is a summary of the results and is largely focused on the investigation of the extensive Holocene alluvial sequences preserved in the lower reaches of the valley. It should be noted, however, less extensive freshwater alluvial and peat sequences along with valley side colluvium exist in the upper reaches in the vicinity of Springhead which are associated with archaeological remains.

Construction Impacts

Considerable development impacted on the sequences through the construction not only of the rail corridor but also the major international station at Ebbsfleet and the cross valley line linking HS1 with the North Kent Line (Fig 78). Construction of the rail and associated station complex involved considerable excavation of the Pleistocene sediments while the construction of the North Kent Line Link involved excavation of the alluvial sediments of the floodplain floor. Linked into the development impact within the valley was the construction of a new road corridor on the eastern side of the valley; South Thameside Development Route 4 (STDR-4), funded by Kent County Council (KCC). This road also impacted on the valley floor sediments and the sequences are included in the following synopsis of results.

Key Archaeological Issues

Today it is recognised that this area is of national importance for the Pleistocene sands, gravels and chalk-rich sediments present on the valley sides (Wenban-Smith 1995; Oxford Archaeological Unit 1997) (Fig 79). In places these are associated with rich archaeological remains, for example, the Levallois site at Baker's Hole and the elephant and associated archaeology at Southfleet Road (Wenban-Smith *et al* 2006). Less well known are the rich prehistoric archaeological remains associated with the alluvium in the valley bottom (Burchell 1938; Burchell and Piggott 1939; Sieveking 1960; Barham and Bates 1995; Oxford Archaeological Unit 1997; URL 1997). Later evidence for human activity comes from the Late Iron Age and Roman periods with a villa at Northfleet and temple complex and extensive town at Springhead (Detsicas 1983; Millet 2007; Andrews *et al* 2011a).

Previous work demonstrated that complex alluvial stratigraphies exist in the valley base consisting of clay-silt and organic silts/peats. A peat complex forms the main sediment body resting between two clay-silt units. The peat consists of a basal woody peat and an upper reed peat. The archaeological potential of these deposits has previously been described and both Mesolithic and Neolithic remains have been found (Burchell 1938; Burchell and Piggott 1939; Sieveking 1960; Barham and Bates 1995; Oxford Archaeological Unit 1995, 1997; URL 1997). Towards the valley sides these units probably interdigitate with colluvial sediments derived from the valley margins. The unconsolidated Holocene sediments overlie basal sand and gravel units of probable Late Pleistocene age. Complex sequences of Pleistocene sediments lie beneath the valley sides. However, some uncertainty regarding the precise location of the boundary between the valley sides and alluvium exists.

Today the challenge that faces archaeologists and geologists working in the valley is a function of the recent quarrying history of the area. Extensive quarrying activity up until the middle of the 20th century has resulted in the wholesale removal of large parts of the valley (Fig 79). Small patches, linear strips and unknown extents of elements of the formerly more extensive Pleistocene and Holocene sediments certainly exist in the landscape, however relating these patches to each other and placing them within the framework of the local and regional development of the valley remains a significant challenge.

Strategy, Aims and Objectives

The aims and objectives of the investigation were to identify the location of buried archaeological remains within the floodplain and near floodplain area. Specifically, attempts were to be made to focus investigation on those sequences thought to be of high archaeological potential and those where correlations may be attempted with the previously noted archaeological sequences. Additionally, focus was to be made on the extensive palaeoenvironmental remains recognised to be present within the valley.

A number of phases of investigation were conducted that included works on both HS1 and STDR-4 (Table 74; Figs 80–85) These formed part of the phased response to sequences, construction and the findings of previous investigations. As the archaeological programmes for both HS1 and STDR-4 ran concurrently, the opportunity was taken at an early stage to utilise and integrate data from both projects to inform each phase of work.

Methodologies

Geoarchaeological investigation of the Holocene sequences in the valley bottom and sides was led by Martin Bates and included a range of remote and direct investigations during the early evaluation stages. Some geophysical investigation (Richard Bates) were undertaken using Direct Current electrical soundings along a single transect (Figs 81–82) while borehole and test pit/trench excavations were undertaken to directly view sequences and contained archaeology (Figs 83–85).

Post-excavation work included the analysis of a number of sample profiles in order to characterise the environments of deposition associated with the sediments and the artefactual evidence. The selection of sequences and samples took into account all material recovered from both HS1 and STDR-4 in order to target resources efficiently and avoid duplication between the two projects. It was also agreed between HS1 and KCC at the beginning of the post-excavation analysis that the results related to the prehistoric periods

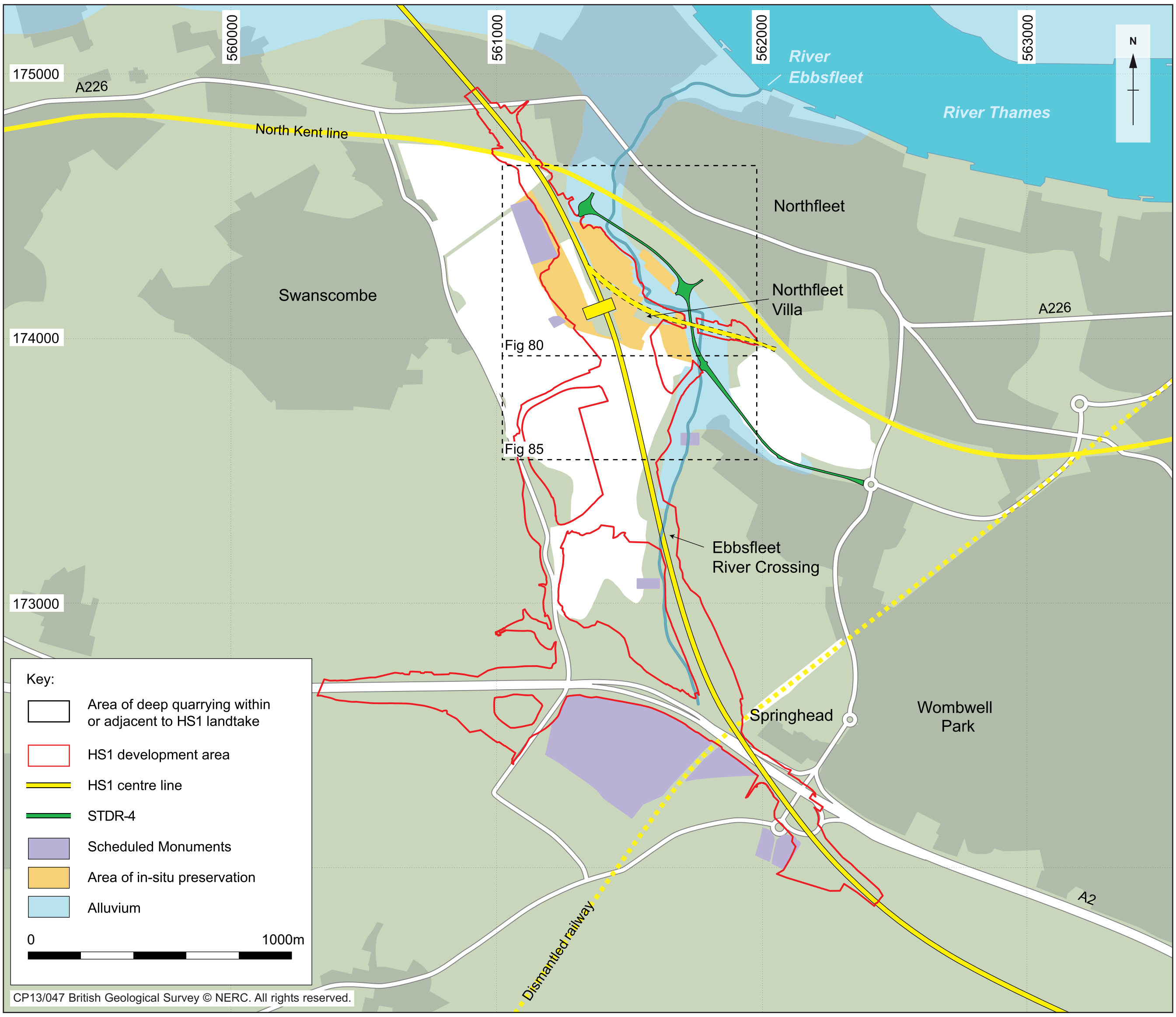

Figure 78 Site location plan of the HS1 and STDR-4 land take within the Ebbsfleet Valley

Table 74 Summary of fieldwork events, Lower Ebbsfleet Valley

Event name	Event code	Type	Zone	Number Interventions	Archaeological contractor
Ebbsfleet Valley, Northfleet	ARC EFT97	Evaluation	E1–E2	7BH (CP), 7TP, 68TT	Oxford Archaeology
Northfleet Rise	EBBS97	Evaluation	E1	11BH(CP), 3TP Geophysical survey	Oxford Archaeology
Ebbsfleet Sportsground	ARC ESG00	Evaluation	E1–E2	45TT	Oxford Archaeology
Ebbsfleet Valley detailed Mitigation	ARC EBB01	Excavation	E1–E2	Multiple area excavation plus 7TT, 1BH(MOS)	Oxford Archaeology
North Kent Line (Reedbeds)	ARC NKL02	Mostap survey	E2	13BH(MOS)	Oxford Archaeology
Ebbsfleet Valley detailed Mitigation	ARC 342W02	Watching Brief	E1–E3		Oxford Archaeology
Ebbsfleet Valley detailed Mitigation	ARC 342E02	Watching Brief	E1–E3		Wessex Archaeology
South Thameside Development Route 4	STDR400	Evaluation	E1–E2	20BH(CP), 15TP	Oxford Archaeology
South Thameside Development Route 4	STDR401	Excavation		4COFF (Areas1–4)	Oxford Archaeology
South Thameside Development Route 4	STDR401	Watching brief	E1–E2		Oxford Archaeology

BH = borehole (CP) = Cable percussion (MOS) = Mostap TP = testpit TT = trench COFF = cofferdam excavation

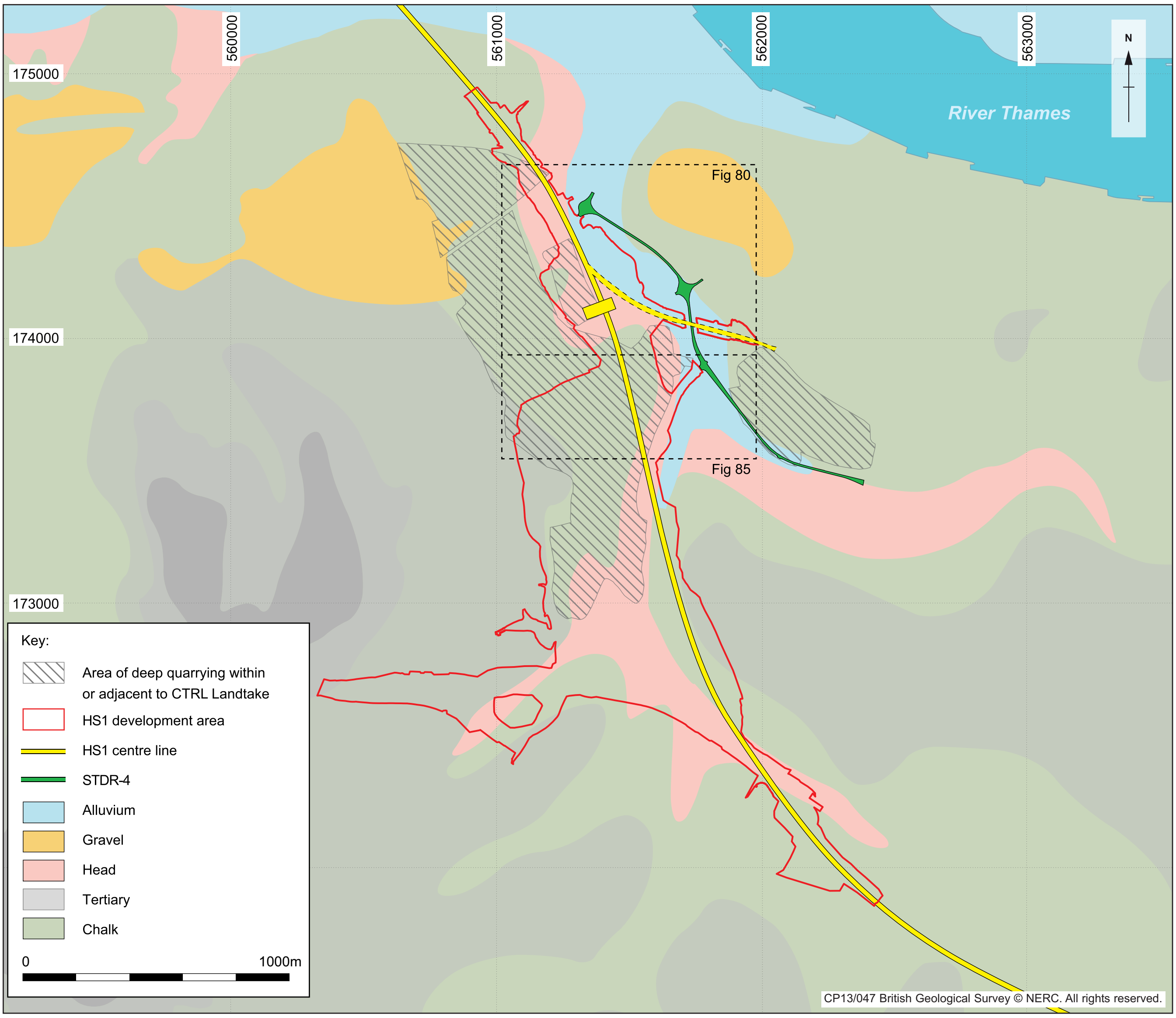

Figure 79 Ebbsfleet Valley superficial geology map

from both projects (geoarchaeology, environment and archaeology) would be most effectively disseminated if integrated into a single publication (Wenban-Smith *et al* forthcoming).

Much of the detailed analysis in the lower reaches of the valley has targeted the deep and most complete sample sequences recovered from borehole, trench and cofferdam excavations during the STDR-4 works, the latter producing considerable evidence of stratified Neolithic activity. Due to the fact the HS1 excavations were located along the shallower floodplain edge which did not produce such well-preserved sequences; the post-excavation analysis of one of the STDR-4 evaluation boreholes (BH7) was funded by HS1. The analysis of sequences from STDR-4 Trench 9 and cofferdam Area 4 were funded by KCC.

Overall interpretation of the sedimentary sequences was carried out by Martin Bates and Elizabeth Stafford. The palaeoenvironmental work was carried out by Denise Druce, Elizabeth Huckerby, Sylvia Peglar and Lucy Verrill (pollen), John Whittaker (ostracods and foraminifera), Nigel Cameron (diatoms), Wendy Smith and Chris Stevens (charred and waterlogged plant remains), Mark Robinson and David Smith (insects) and Catherine Barnett (charcoal and waterlogged wood species). The radiocarbon dating programme was coordinated by Elizabeth Stafford and Catherine Barnett. The following sections provide a summary of the sediment sequences and associated palaeo-environmental evidence, reported in detail elsewhere (Andrews *et al* 2011a–b; Barnett *et al* 2011; Wenban-Smith *et al* forthcoming).

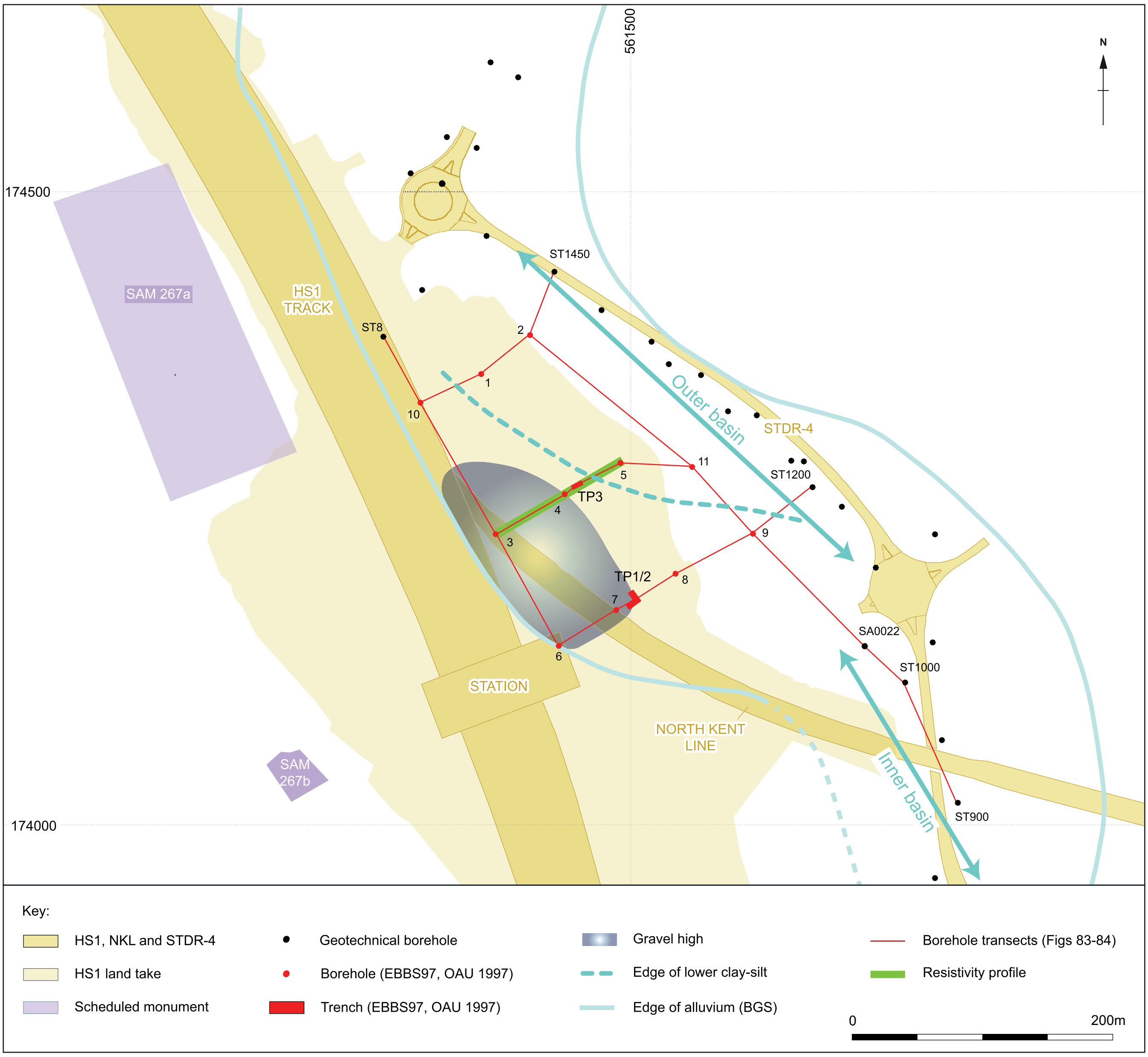

Figure 80 Ebbsfleet Valley showing location of borehole transects and geophysical profile from the Northfleet Rise evaluation (EBBS97)

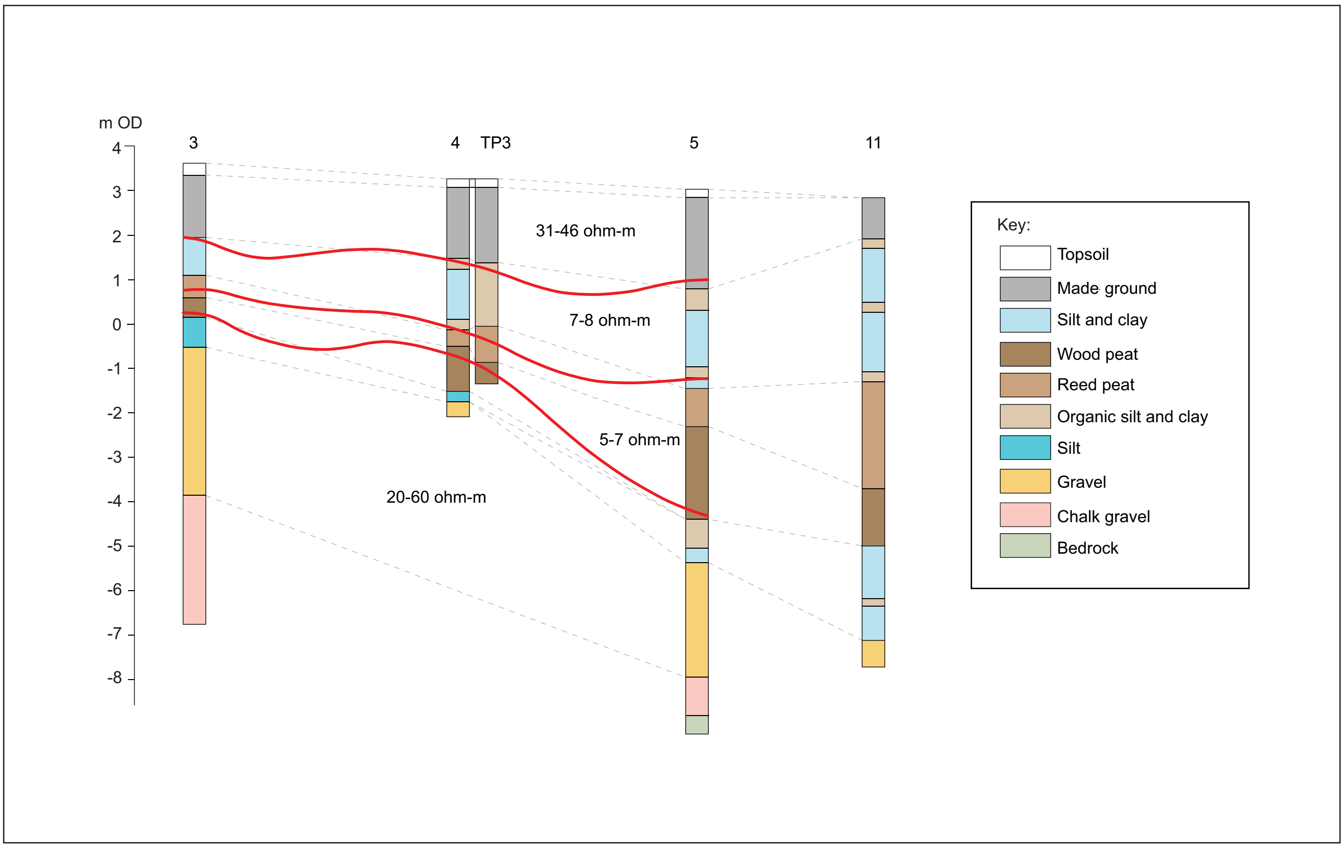

Figure 81 Borehole transect with geophysical profile from the Northfleet Rise evaluation (EBBS97) (Bates and Bates 2000)

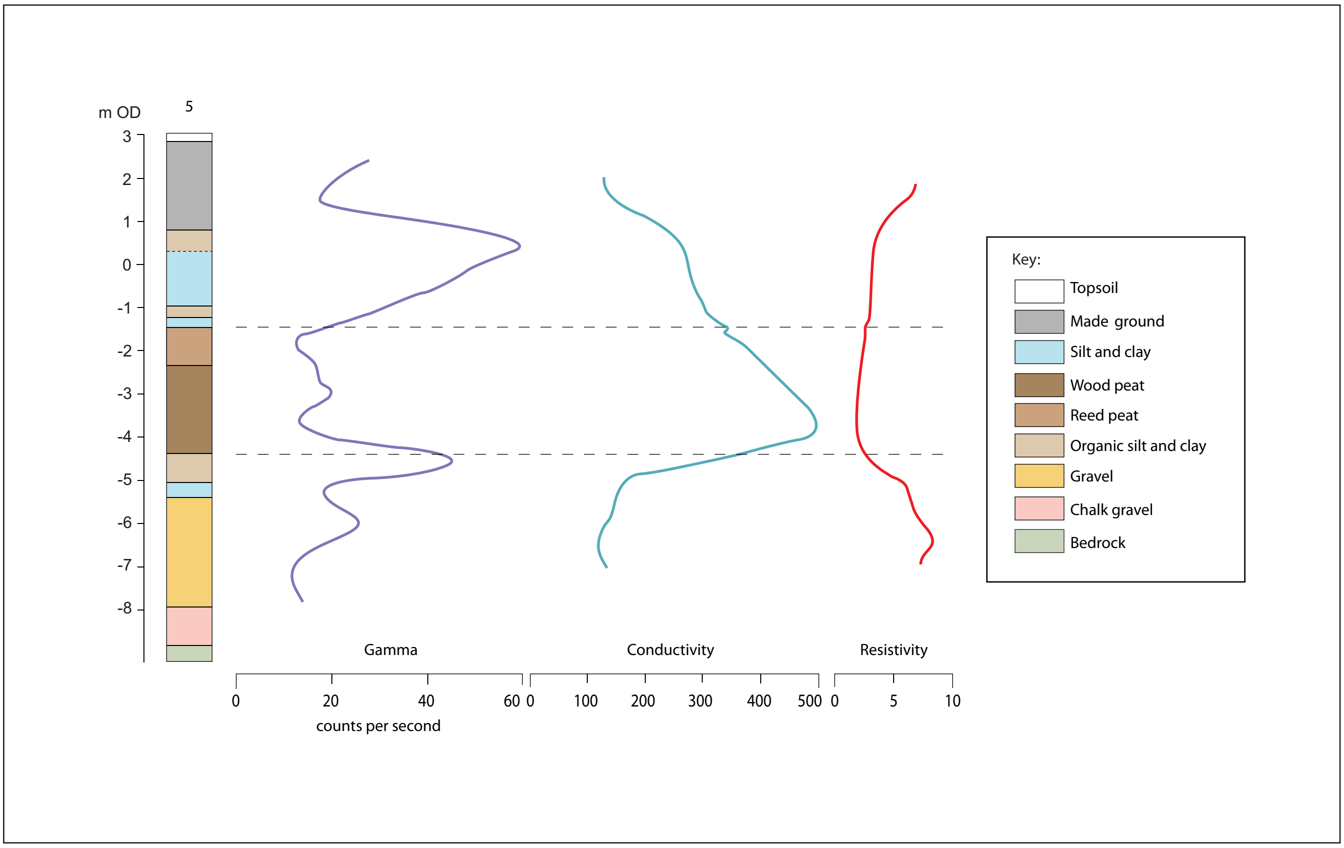

Figure 82 Borehole 5 lithology and gamma, conductivity and resistivity logs from the Northfleet Rise evaluation (EBBS97) (Bates and Bates 2000)

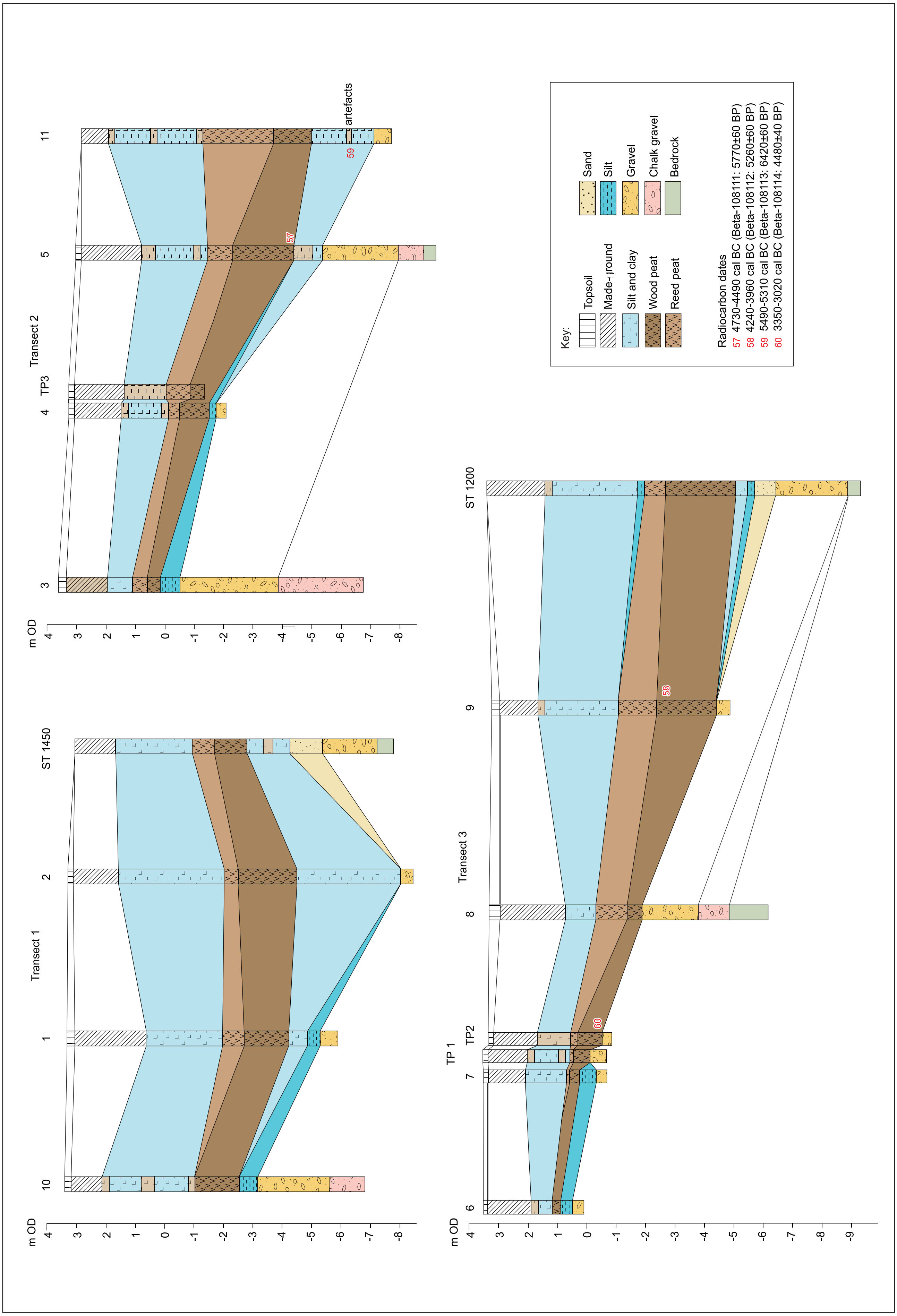

Figure 83 Transects 1–3, from the Northfleet Rise evaluation (EBBS97)

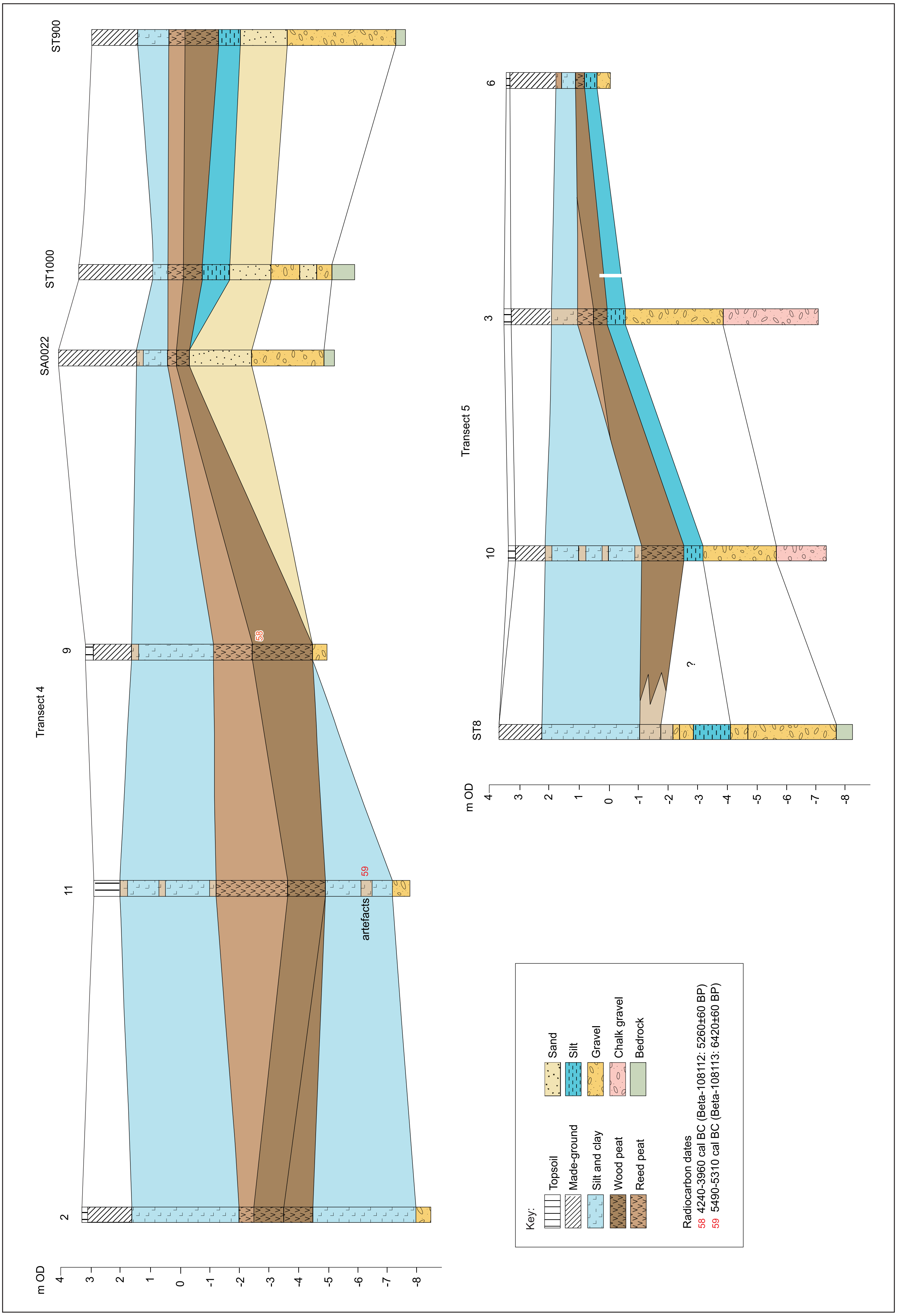

Figure 84 Transects 4–5, from the Northfleet Rise evaluation (EBBS97)

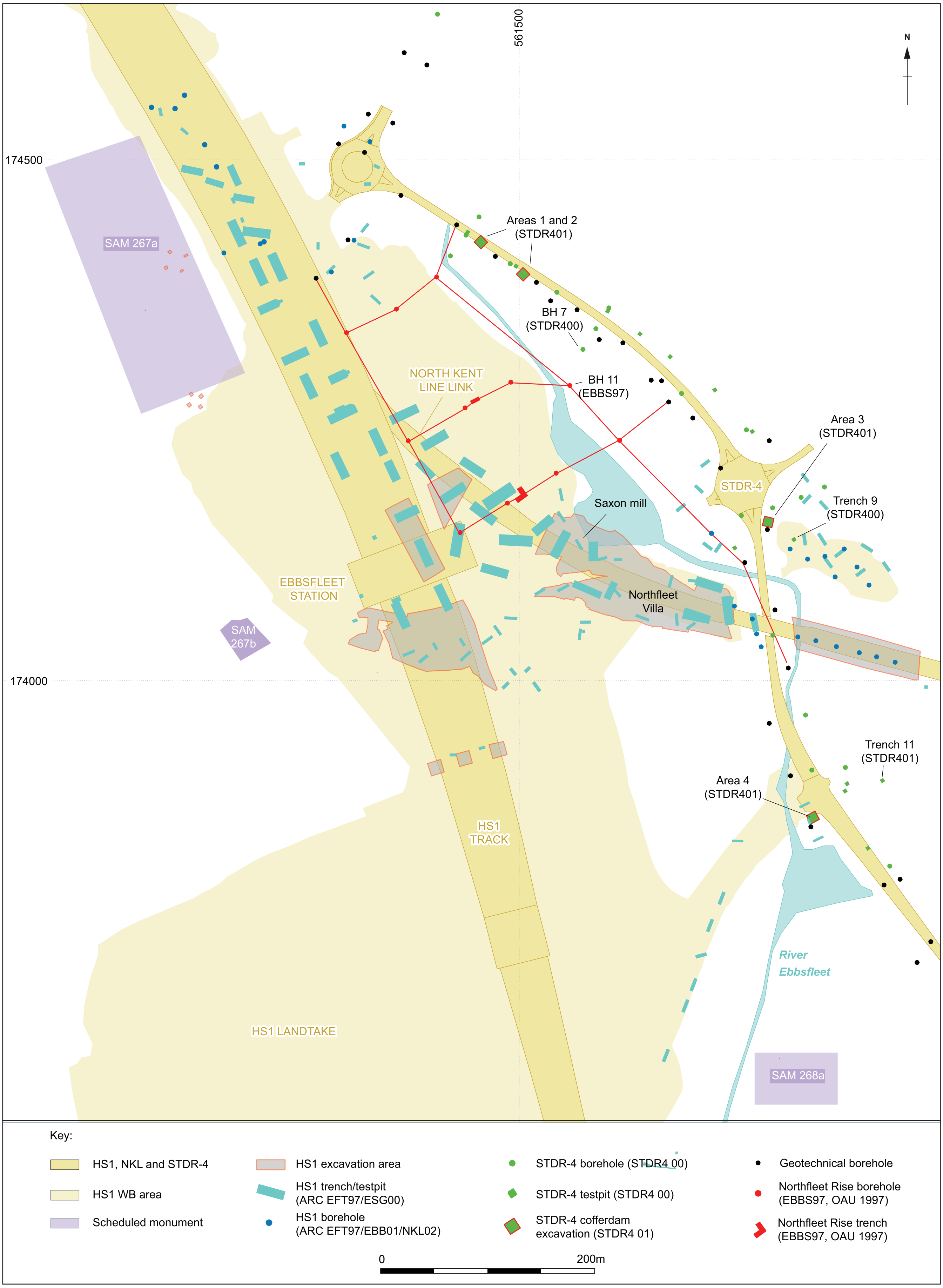

Figure 85 Lower Ebbsfleet Valley (excluding Brook Vale) showing distribution of all interventions

Results of the Investigations

In addition to historical boreholes, 27 boreholes, 22 test pits and 113 trenches (including those for the STDR-4) were excavated within the valley floor area during the various evaluation stages (Pl 27). Aside from the large open area excavations for HS1 focused on the Roman site associated with Northfleet villa (Pl 28), a further 17 boreholes and 11 deep trenches were excavated during the mitigation stages. The latter included four cofferdams (Areas 1–4) carried out to mitigate the effects of the STDR-4 (Pl 29). Overall, this amounts to 190 separate interventions (excluding the open area excavations) into the sediments of floodplain and adjacent valley slopes to add to historical borehole records and data from earlier investigations (Fig 85).

Plate 27 Evaluation trenching in the Ebbsfleet Valley

Table 75 Main lithological units identified in valley floor area

Unit	Inferred environment of deposition
Made ground	Recent dumping/landfill
Upper peat	Reedswamp
Upper clay-silt	Inter-tidal/estuarine mudflats
Reed peat	Reedswamp
Wood peat	Alder carr wetland
Lower clay-silt	Inter-tidal/estuarine mudflats
Organic silts	Freshwater infilled creeks
Sand	Fluvial channel
Sandy flint gravel	Braided fluvial channel
Chalky gravel	Cold climate slope (solifluction) deposits
Chalk	Bedrock

The 'off-site' sequences

The results of the numerous phases of investigation (Table 74) have revealed a consistent but complex picture of sediments buried beneath the main Ebbsfleet Valley floor (Table 75). The Holocene alluvial sediments in the Lower Ebbsfleet Valley are underlain by sands, chalky solifluction and fluvial gravel deposits of Pleistocene age, over chalk bedrock in many places. The surface of these deposits formed the Early Holocene topography that dictated patterns of later sediment accumulation. Reconstruction of this surface revealed a deep Outer Basin downstream of Northfleet villa, forming a low lying marshy environment and later a tidally-influenced estuarine inlet (Fig 86). The sequences filling this basin consist of more than 10m of fine-grained sediments. A shallower Inner Basin is located upstream of the villa site. The site of Northfleet villa itself is located on a promontory or 'spur' extending from the western slopes of the valley. This would have remained an area of higher drier ground throughout much of the Holocene. Prior to the investigations associated with HS1 and STDR-4 the only published data on the sedimentary history of the valley infill derived from the limited 1930s excavation undertaken by Burchell (Burchell and Piggott 1939), which included analysis of the pollen from a 'peaty alluvium' containing Neolithic artefacts. Two master palaeoenvironmental sequences have been analysed in detail (Wenban-Smith *et al* forthcoming). STDR-4 Borehole 7 was located in the Outer Basin approximately 160m north of Northfleet villa (Figs 85 and 87) and STDR-4 Trench 9 in the Inner Basin 60m to the north-west (Figs 85 and 88). Palaeoenvironmental analysis was also been carried out from the sequence in STDR-4 Area 4 cofferdam, 190m to the south-west (Fig 85).

Deposits of Early Holocene age are represented in places by a discontinuous unit of organic sandy silt identified in a number of boreholes and deep trench excavations across the valley bottom. These deposits represent fresh water infilled creeks, radiocarbon dated in Borehole 7 (STDR-4) to 8540–8240 cal BC (NZA-28766, 9122±55 BP). Pollen assemblages (Huckerby *et al* forthcoming) were dominated by tree and shrub pollen and suggest rather open scrubby deciduous woodland with *Betula* (birch), *Corylus* (hazel) and an understorey of grasses and ferns growing on the banks of the river. More closed deciduous woodland probably grew further away from the site. There is very little evidence of any human impact on the landscape at this time. A few microscopic charcoal particles noted during the pollen analysis may have come from some distance, having been blown or carried into the site by wind or water. Although this could be interpreted as evidence of human activity in the catchment, for example the use of fire to create woodland clearings for grazing (Mellars 1976; Simmons and Innes 1997; Simmons 1996), it could equally be the result of natural events such as forest fires (see Whitehouse and Smith 2004).

Evidence for an early influx of estuarine waters (the 'Lower Clay Silts') during the Late Mesolithic period was found in a number of sequences examined from the Outer Basin. Deposition was dated in Borehole 7 (STDR-4) to between 5480–5070 cal BC (WK-8801, 6340±80 BP) and 4370–4240 cal BC (NZA-28974, 5464±35 BP). Pollen and diatom (Huckerby *et al* forthcoming; Cameron forthcoming) evidence suggests the local development of saltmarsh and reedswamp environments in the tidally affected Outer Basin. Values

Plate 28 Northfleet villa under excavation (ARC EBB01), Roman quayside in the foreground

Plate 29 Area 4 cofferdam excavation in the Ebbsfleet Valley (STDR4 01)

of microscopic charcoal particles were quite high, including pieces of charred grass, and are evidence for local, possibly man-made, fires in the catchment. In a regional context this early marine transgression into the Lower Ebbsfleet Valley can be broadly correlated with the first phase of estuary expansion on the Thames floodplain (Long *et al* 2000).

Towards the end of the 5th millennium BC minerogenic sedimentation was replaced by peat formation in the Outer Basin, commencing in Borehole 7 (STDR-4) at 4370–4240 cal BC (NZA-28974, 5464±35 BP). Initially, the Inner Basin remained relatively dry land and it is here that significant evidence of human activity, in the form of *in situ* Early Neolithic flint scatters, was identified during the investigations associated with the STDR-4 (Anderson-Whymark forthcoming). These occupation horizons were, however, rapidly inundated as the wetland front expanded into more marginal areas In Trench 9 (STDR-4) this occurred at 3780–3640 cal BC (NZA-29080, 4926±35 BP) and in Area 4 (STDR-4) at 3800–3650 cal BC (NZA-29247, 4945±35 BP). Pollen, macroscopic plant remains, diatoms and Coleoptera (Wenban-Smith *et al* forthcoming) from the peat indicate that, locally, fresh water alder carr environments predominated in the valley bottom during the Neolithic period, along with marsh/fen and an understorey of ferns and sedges. Fresh water mollusc assemblages included *Bithynia tentaculata*, suggesting that episodes of flooding occurred. Trees and shrubs continued to dominate the pollen assemblages with *Quercus* (oak), *Tilia* (lime), *Ulmus* (elm), *Fraxinus* (ash) and *Corylus* values suggesting that the regional vegetation was deciduous woodland during the period of peat formation. There was, however, some indication of small clearances, possibly for domestic animals on areas of drier ground. A temporary decline in values of *Tilia* pollen noted in the lower part of the peat sequence from Trench 9 (STDR-4), and commensurate with the first appearance of cereal-type pollen, may be related to human activity within the catchment. In a number of sequences, particularly within the more marginal Inner Basin, deposits of micritic tufa, containing rich assemblages of ostracods (Whittaker forthcoming), were noted within the upper part of the peat suggesting the presence locally of freshwater springs. This period of tufa formation, occurring at some point between 3340–2940 cal BC (NZA-28869, 4448±30 BP (date from top of the main peat), and 2470–2140 cal BC (NZA-28971, 3836±50 BP (date from top of the peat with tufa)) in Borehole 7 (STDR-4), Trench 9 (STDR-4) and Area 4 (STDR-4) appears to have been a relatively synchronous event across the valley bottom, occurring between the Early Neolithic and Early Bronze Age periods. Within the wider context, the prehistoric peat in the Lower Ebbsfleet Valley generally occurs at similar elevations, stratigraphic position and date to Devoy's Tilbury III peat on the Thames floodplain (Devoy 1979). The dates are also consistent with Long's proposed phase of mid-Holocene estuary contraction (Long *et al* 2000).

The cessation of tufa formation is probably related to the onset of a further phase of marine incursion into the Lower Valley, which eventually caused the cessation of peat formation and the accumulation a further unit of clay silts (the 'Upper Clay Silts'). Towards the top of the

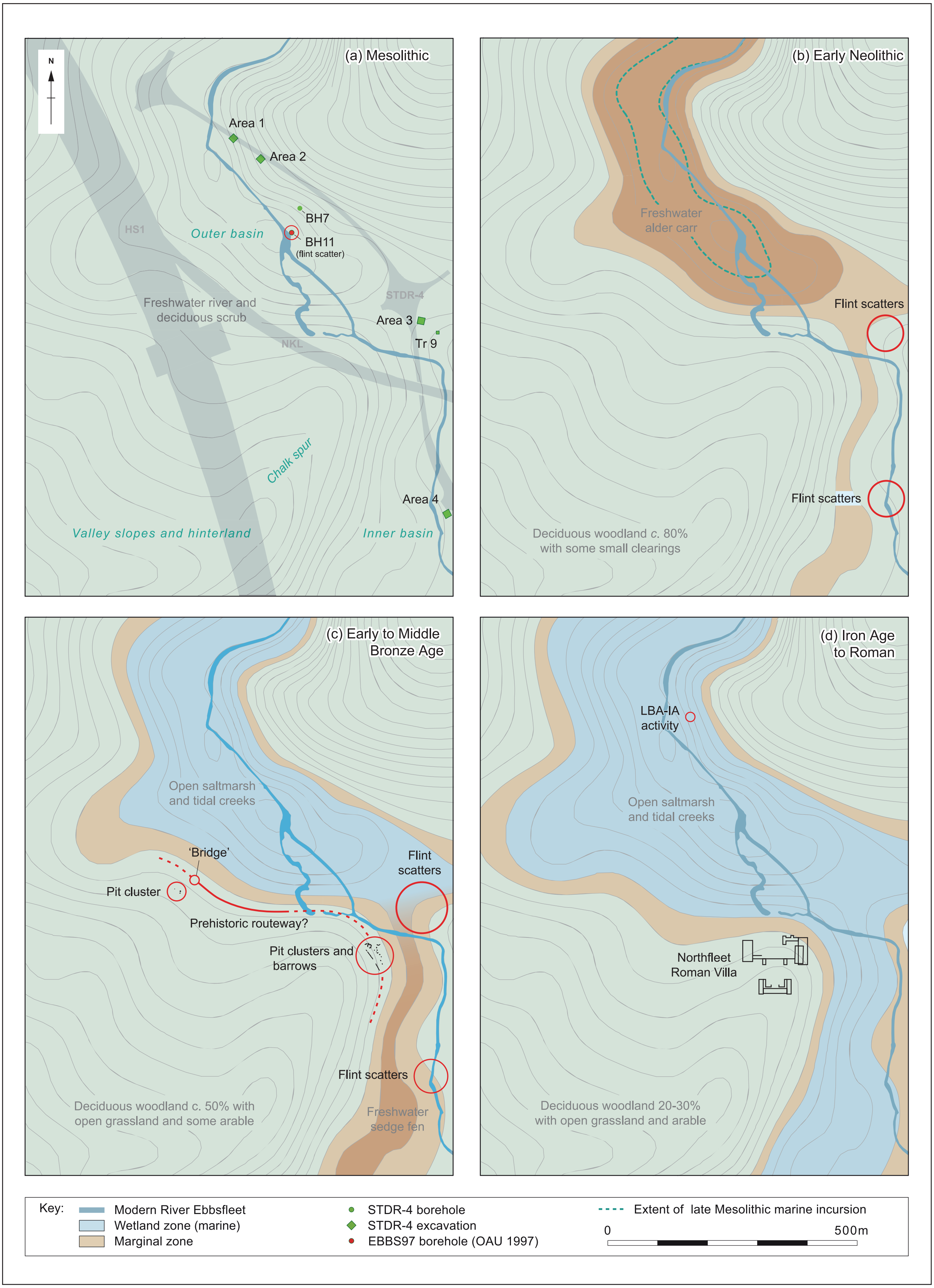

Figure 86 Summary of topography, environment and archaeology in the Lower Ebbsfleet Valley during the Holocene

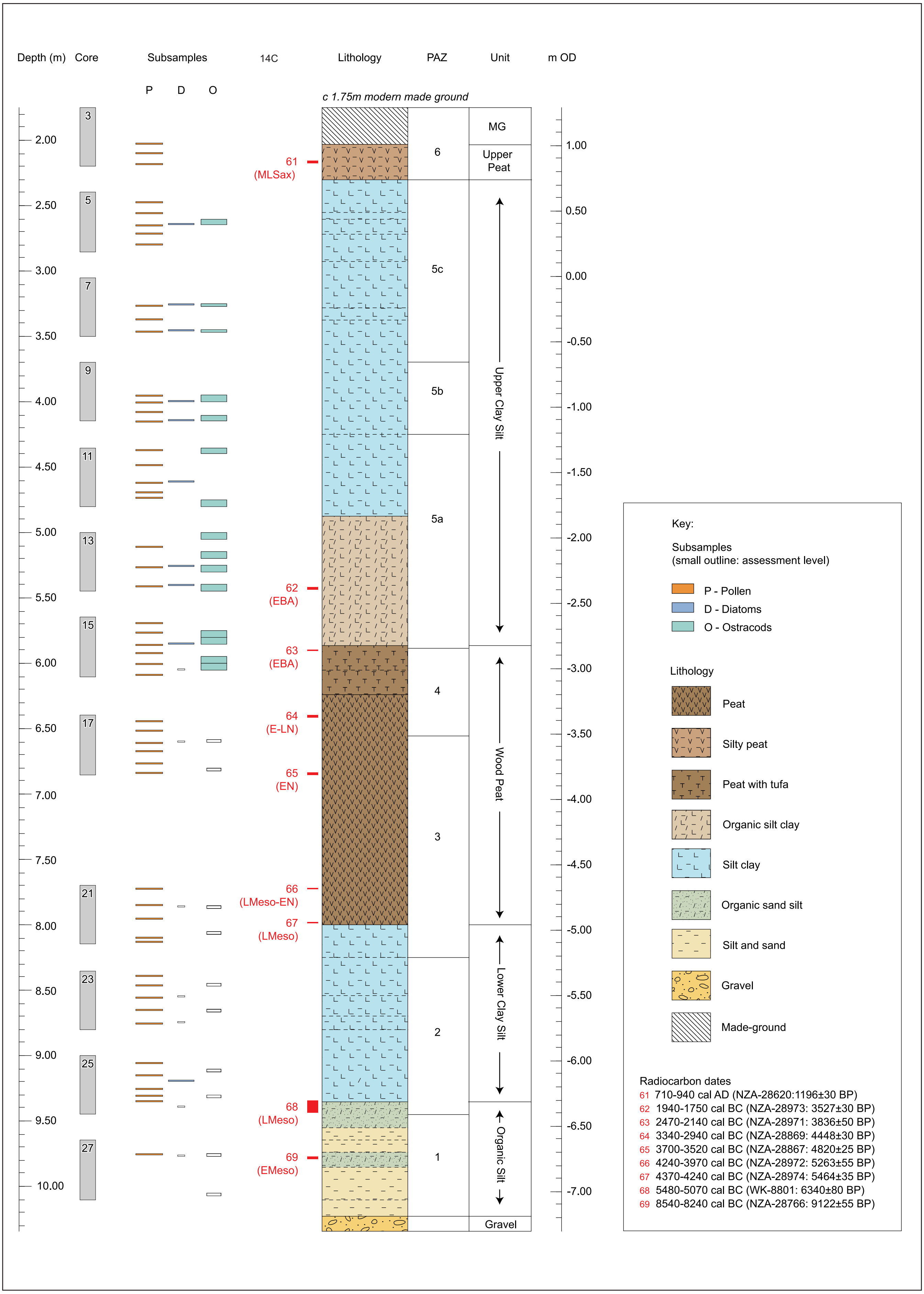

Figure 87 Lithological log and sample locations from Borehole 7 (STDR4 00)

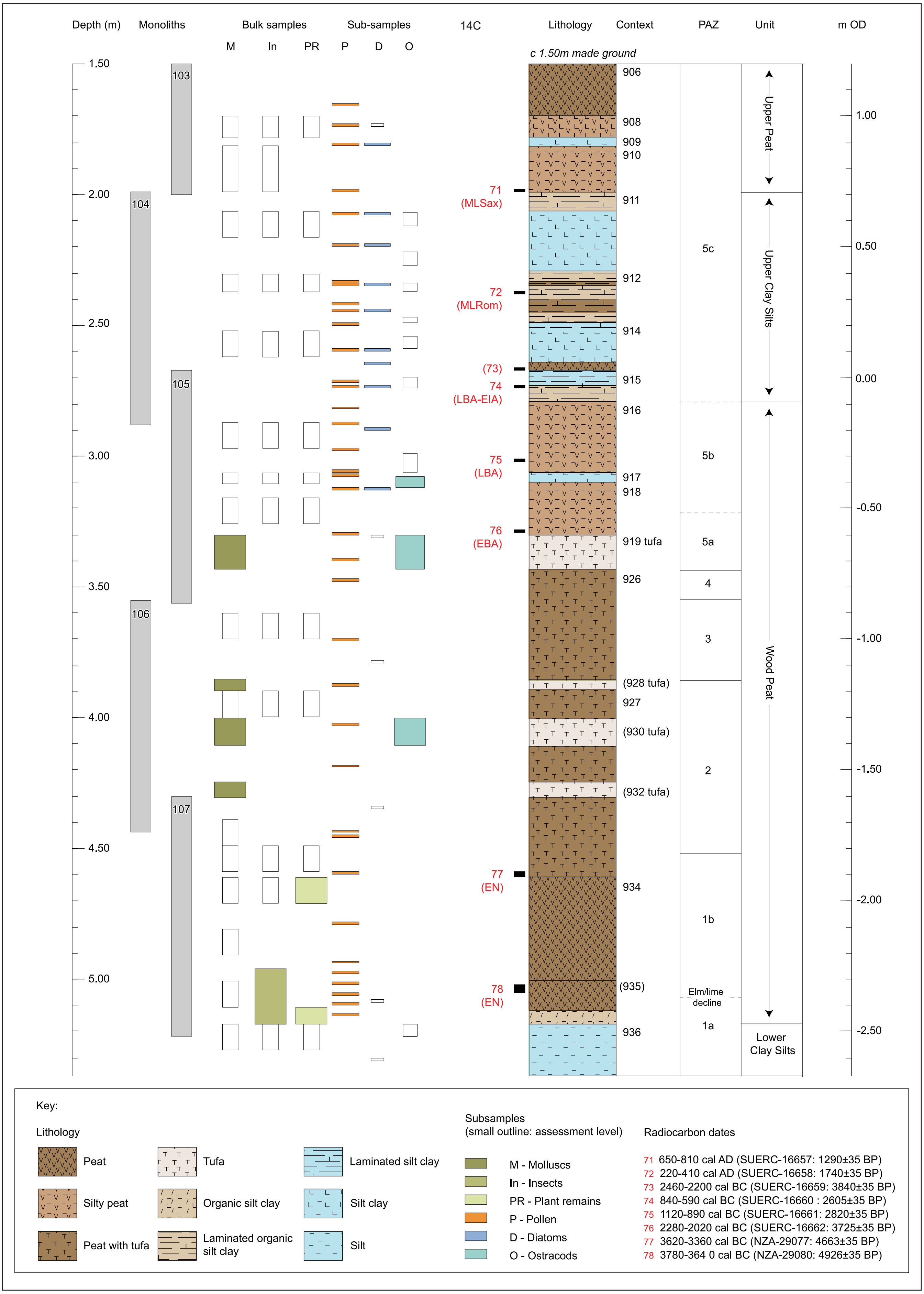

Figure 88 Lithological log and sample locations from Trench 9 (STDR4 00)

peat profile, there is evidence locally for an increase in marsh/sedge fen environments with abundant ferns, indicating increased wetness in the valley bottom. The change to minerogenic sedimentation is dated in Borehole 7 (STDR-4) in the Outer Basin to the Early Bronze Age between 2470–2140 cal BC (NZA-28971, 3836±50 BP) and 1940–1750 cal BC (NZA-28973, 3527±30 BP), although the earlier date may represent an eroded peat surface. In the Inner Basin in Trench 9 the change is dated to the Late Bronze Age or Early Iron Age at 840–590 cal BC (SUERC-16660, 2605±35 BP), discounting the anomalous early date immediately above which is possibly a result of contamination by old carbon (SUERC-16659). However, in this trench the upper part of the peat became increasingly silty from 2280–2020 cal BC (SUERC-16662, 3725±35 BP). The microfossil analysis indicates the presence of a tidal river with mudflats and fringing saltmarsh, fen and reedswamp environments associated with the upper minerogenic units. This phase of marine transgression into the Ebbsfleet Valley in the later prehistoric and historic periods is mirrored at many sites previously investigated up and down the Lower Thames Estuary. It can be broadly correlated with the second phase of estuary expansion on the Thames floodplain (Long *et al* 2000). The regional pollen assemblages suggest that the environment beyond the valley bottom was much more open during the later prehistoric period. Woodland cover decreased significantly at the beginning of the Bronze Age and may be related to human activity in the catchment. The landscape is likely to have comprised open grassland with arable cultivation and some stands of oak and hazel woodland.

Accumulation of the 'Upper Clay Silts', both in the Inner and Outer Basins in the Lower Ebbsfleet Valley, continued throughout the later prehistoric and into the historic period. An organic lens in Trench 9 (STDR-4), at +0.33m OD, produced a mid–late Roman date of cal AD 220–410 (SUERC-16658, 1740±35 BP). Locally the pollen, diatoms, ostracods and foraminifera suggest that environments of middle and upper saltmarsh had developed by this period. This is supported by the recovery of Chenopodiaceae (goosefoots), *Plantago maritima* (sea plantain) and occasional grains of *Armeria*/*Limonium* (thrift/sea lavender). Away from the valley bottom the landscape, as in the later prehistoric period, probably comprised open grassland pasture with arable cultivation and some stands of *Quercus* and *Corylus* woodland. However, woodland cover continued to decrease from the Early Bronze Age. By the late Roman period arboreal pollen values were 20–30%, as recorded in the sequence from Trench 9 (STDR-4).

Towards the top of the 'Upper Clay Silt' unit there is evidence in both the Borehole 7 (STDR-4) and Trench 9 (STDR-4) sequences that saltmarsh was gradually replaced by fresh water reedswamp, with some areas of open water. The 'Upper Clay Silts' are generally overlain in the valley bottom by a laterally extensive fresh water peat unit (the 'Upper Peat'), suggesting a further episode of negative sea-level tendency. Radiocarbon determinations suggest peat accumulation during the middle or late Saxon period. This unit was dated in Borehole 7 (STDR-4), at +0.88 m OD, to cal AD 710–940 (NZA-28620, 1196±30 BP), and in Trench 9 (STDR-4) at +0.72m OD, cal AD 650–810 (SUERC-16657, 1290±35 BP). There is no evidence for further marine incursion in these sequences following the Saxon period. However, it is possible the upper parts of the sequence at these locations have been truncated by modern disturbance. The 'Upper Peat' in both Borehole 7 (STDR-4) and Trench 9 (STDR-4) was sealed by varying thicknesses of modern made ground. Pollen evidence from the 'Upper Peat' suggests locally fresh water marsh and sedge fen environments. The pollen data suggest that some woodland was extant in the area (AP <10%), but that the landscape was largely cleared; pollen evidence suggests pasture and particularly arable fields increases in the Saxon period.

The 'on-site' historical sequences

Useful information on the local environment in vicinity of Northfleet villa (ARC EBB01) during the Roman period has also been gained from the analysis of waterlogged well deposits located on the higher ground of the gravel 'spur' during the HS1 investigations (Stevens 2011a, 84–7). The plant assemblages included species associated with wasteland and human occupation; such as *Urtica dioica* (nettle) and *Conium maculatum* (hemlock). There was also some indication of areas of rough, perhaps wet, grassland with, for example, *Ranunculus* (buttercup), *Rumex conglomeratus* (clustered dock) and *Stellaria palustris* (marsh stitchwort). Taxa such as *Ranunculus sardous* (hairy-buttercup), *Chenopodium vulvaria* (stinking goosefoot), *Atriplex littoralis* (grass-leaved orache) and *Atriplex prostrate*/*portulacoides* (spear-leaved orache/sea purslane), while common on cultivated ground and grassland, are more frequently found in coastal areas. More significant were frequent finds of *Juncus gerardii* (saltmarsh rush). Coleoptera included *Geotrupes*, *Onthophagus* and *Aphodius* dung beetle, suggesting the presence of grazing herbivores and pasture. Several ground beetles identified, such as *Dyschirus salinus*, *Bembidion normannum* and *B. minimum*, and the water beetle, *Octhebius dilatus*, are all associated with muddy areas or saline pools in saltmarshes or along the coast (D Smith 2011, 88–90).

A wide range of taxa is represented in the charcoal assemblages at Northfleet (Barnett 2011, 113–8) and exploitation of a rich variety of open woodland and scrub wood for domestic/everyday fuel use is indicated by the mid-Roman period. There was, however, some indication of a shift in the exploitation of woodland resources during the late Roman period, with perhaps a greater local reliance on trees typical of scrub or hedges, such as hawthorn and/or non-wood fuels such as malting waste (spelt chaff and sprouts).

Evidence of cereal cultivation was well represented. Cereal-type pollen in the basal fills of the wells was quite high (up to 26% TLP, Scaife 2011a, 68–76) and Coleoptera also included taxa associated with stored cereal grain (D Smith 2011, 88–90). In the charred plant assemblages across the villa site the majority of the weed/wild taxa typically comprised weeds of arable crops or cultivated/disturbed ground. The four most consistently recovered taxa were dock, scentless mayweed, rye-grass and wild or cultivated oat. The dominance of spelt remains suggests that the weed flora recovered is directly associated with cultivation conditions for this cereal crop (W Smith 2011, 105–113).

Data from the post-Roman period is largely derived from minerogenic alluvial deposits associated with a Saxon tidal mill which was located in the low-lying area immediately north of villa site during the HS1 investigations (ARC EBB01). Information on changes in salinity levels within the deposits derive from analysis of ostracods, foraminifera (Whittaker 2011, 80–85) and diatoms (Cameron 2011, 75–80) from sequences infilling the mill wheelhouse and millpond. The assemblages were relatively diverse and despite the homogeneous appearance of the lithostratigraphy in places, show some variation through the profiles. Initially the evidence suggests the presence of a tidal creek and mudflats with the occurrence of brackish ostracod species such as *Leptocythere porcellanea*, also common in the Borehole 7, and the abundance of marine plankton. Over time the mudflats, exposed at low tide, appear to have become vegetated by encroaching saltmarsh and experienced increased silting. The agglutinating foraminifera in particular, which build their shells (tests) from grains of sediment, are an important ecological marker species for low, mid- and high saltmarsh. All three recorded in the sequences (*Jadammina macrescens*, *Haplophragmoides* sp. and *Tiphotrocha comprimata*) are herbivores and detrivores living both on the surface (epifaunal) and in the substrate of the water body (infaunal) and are widespread on mid- to high saltmarsh. The diatom samples were initially dominated by brackish water epipelic species that live in or attached to sediments in the water (*Nitzschia navicularis, Diploneis didyma*) and planktonic marine-brackish species (*Cyclotella striata*). This evidence suggests the site of the mill was clearly tidal for at least medium and high water spring tides. Higher up the sedimentary profiles the diatom assemblages indicate a period where freshwater input increased. This is seen by an increase in the number of fresh water diatom species and a decline in brackish and marine species, associated with slightly darker, more humic, laminations within the clay silts. In the mill wheelhouse deposits of organic and peaty detritus accumulating within and adjacent to the penstocks were initially dominated by brackish water aerophile diatoms (air-loving). The overlying, more minerogenic deposits, however, contained high numbers of freshwater diatoms and, in particular, opportunistic early colonisers such as *Fragilaria* spp. with wide salinity tolerance (but with optimal growth in freshwaters). These non-planktonic, shallow water, freshwater diatoms included *Fragilaria brevistriata* and *Fragilaria pinnata*, often associated with less stable conditions and rapidly changing environments.

Broadly the deposits indicate increased freshwater influence occurred at similar elevations to the 'Upper Peat' in Borehole 7 (STDR-4) and Trench 9 (STDR-4) and may be related to a general period of marine regression dated to the mid–late Saxon period (see above). The evidence for a regression in the Ebbsfleet Valley contrasts somewhat with the evidence presented for changing river levels on the Thames floodplain at this time. In the Outer Thames Estuary, Greensmith and Tucker (1973) present evidence of sea transgression between AD 800 and 1000. In Central and East London the River Thames appears to rise in the post-Roman and medieval periods (Sidell *et al* 2000, 17), although a brief period of regression has been suggested between the mid-10th and late 12th centuries at Thames Court in Central London (*ibid*, 17). The regression in the Ebbsfleet Valley may well be related to very local factors and as such may not be entirely comparable to the sequences from the Thames floodplain. As previously stated, the Ebbsfleet Valley has in the past acted rather like a sump. In the absence of a major fluvial system, accretionary processes have tended to dominate. It is possible that accumulation of the 'Upper Clay Silts' reached a point where the valley was simply choked with sediment, inhibiting the flow of tidal waters into the upper reaches. The pollen profiles provide evidence for a reduction in woodland cover and an increase in arable activity during this period that may have resulted in a significant increase in the amount of colluviation and sediment run-off into the channel system. Human interference related to the building of sea-walls and land reclamation cannot be entirely ruled out as a mechanism for environmental change during the mid–late Saxon period, although on social and economic grounds it is thought unlikely and there is no direct archaeological evidence for this. Furthermore, evidence from the onsite sequences at Northfleet show a further phase in marine incursion after the period of peat/organic silt formation. The upper part of the alluvial sequence in the millpond and wheelhouse was not dated but it is likely deposition occurred sometime during the medieval period and may be related to the period of increased storminess and flooding that affected the whole of the eastern seaboard *c* AD 1250–1450 (Galloway and Potts 2007). This event was not apparent in many of the sequences examined during both the evaluation and excavation stages in the valley bottom and deposition may have been very localised and restricted to former creek systems in the Outer Basin.

Historical records suggest marshland in the Thames Estuary and North Kent was being embanked and drained immediately after the Norman Conquest and it is possible that sea banks downstream of Gravesend, at Sittingbourne and on the Cliffe Marshes, date to this period (Spurrell 1885b; Whitney 1989, 33; Hallam 1981, 76). Historical records suggest, however, that by the late 13th century the River Ebbsfleet had silted up sufficiently to allow a bridge or causeway to be built close to its confluence with the Thames at Stonebridge (see above). This enabled a direct route for passengers disembarking from the Long Ferry at Gravesend to rejoin Watling Street at Brent, Dartford (Hiscook 1968, 255). Mention in historical records of flood protection measures in place in the Ebbsfleet Valley dates to the post-medieval period when the low-lying marshes close to the confluence of the Rivers Ebbsfleet and Thames frequently flooded at high tides. The embanked London Road which dissects the valley east–west close to Robins' Creek, and probably followed the line of the earlier causeway, provided protection for a large part of the valley bottom marshland. Sluice gates on the bridge at the junction of London Road and Stonebridge Road controlled the flow of both tidal water from the Thames and fresh water from the River Ebbsfleet (Parishes: Northfleet, 302–18).

The on-site pollen data (Scaife 2011b, 66–69) providing information on the vegetation for the Saxon and medieval periods are again largely based on a sequence through the fills of the mill wheelhouse (ARC EBB01). This is supported by data from waterlogged plant remains and insects from a range of alluvial deposits associated with the mill. Overall the environmental evidence suggests that a relatively open landscape prevailed in the vicinity during the mid–late Saxon and medieval periods. The range of tree taxa was diverse, however, total tree pollen numbers were generally small with the lowest values at <10%. *Quercus* was the most important tree. *Alnus* was also significant but is a high local pollen producer and the values obtained do not reflect any substantial local growth. There were also occasional occurrences of *Betula*, *Pinus* and *Ulmus* that probably derived from the region as a whole. *Tilia*, *Fraxinus*, *Fagus* (beech) and *Salix* (willow) were not generally well represented and may be of more local origin. *Corylus* was the dominant shrub probably growing locally. Poaceae were the dominant pollen taxa in all samples examined from the wheelhouse. This pollen may derive from various habitats from arable, pastoral and local fen. *Plantago lanceolata* (ribwort plantain) and a range of other taxa; *Ranunculus*, *Medicago* sp. (medicks), *Vicia* sp. (vetches), *Rumex* sp. and Asteraceae-types (aster), are strongly indicative of important areas of local grassland. As seen in the Roman period, the waterlogged plant remains provide evidence for rough grassland, which was possibly grazed, with some patches of barer wasteland (Stevens *et al* 2011b, 85–89). The samples provided less evidence for disturbed soils than seen in the Roman period, and it might be assumed that the level of activity associated with settlement, for example middens and trampling by animals, was lower in the Saxon and later periods. Grazing is most clearly suggested by the presence of a limited number of *Onthophagus* and *Aphodius* 'dung beetles' which are associated with animal dung, often lying in open pasture (D Smith 2011b, 89–91). Marshland, with brackish water and saltmarsh, is well presented in the environmental assemblages. Reedswamp taxa included Cyperaceae (sedges), *T. latifolia* (reedmace) and *Sparganium* (bur-reed). Evidence of standing water comes from seeds of *Potamogeton* sp. (pondweed), *Callitriche palustris* (water starwort) and *Lemna* sp. (duckweed).

Summary of Archaeological Evidence

As stated above, prior to the investigations associated with HS1 and STDR-4, the Ebbsfleet Valley was known to contain important prehistoric archaeology dating to the Mesolithic and Neolithic periods. The results of the HS1 and STDR-4 investigations have added significantly to the archaeological record for these periods. However, they have also provided evidence dating to the Bronze Age and Iron Age, suggesting activity in the valley over much of the prehistoric period. The following sections provide a summary of the archaeological evidence, presented in detail elsewhere (eg, Andrews *et al* 2011a; Wenban-Smith *et al* forthcoming).

Early Post-glacial and Mesolithic

Evidence recovered during the HS1 investigations attests to groups visiting the Ebbsfleet Valley from the very earliest part of the Holocene and is an important addition to that recovered from earlier investigations in the valley. Unfortunately the absence of *in situ* land surfaces or faunal assemblages associated with the more significant assemblages has precluded detailed interpretation. An assemblage of 176 Early post-glacial worked flints (Anderson-Whymark forthcoming) recovered from the Springhead excavations (ARC SPH00; Fig 89) largely represents residual material within Early and Middle Bronze Age contexts, although mostly from a single colluvial sequence.

Catalogue of illustrated flint
(Fig 89)

1. Long blade bipolar core with refitting blade (ARC SPH00, 5876)
2. Long blade, 152mm long, with two areas of bruising (ARC SPH00, 5875)
3. Bruised flake with a con-joining fragment, broken by burning (ARC SPH00, 6553)
4. Bruised flake (ARC SPH00, 5899)
5. Blade with basal retouch which removes bulb (ARC SPH00, 6553)
6. Obliquely retouched flake, burnt and broken (ARC SPH00, 6553)

The flint was in a relatively fresh condition and a number of refitting pieces indicate it had not moved far from the original place of deposition. Diagnostic elements included bruised flakes and blades, and a long blade core. The deposits also contained a quantity of debitage, apparently contemporary with the diagnostic elements. The flint fulfils the criteria established by

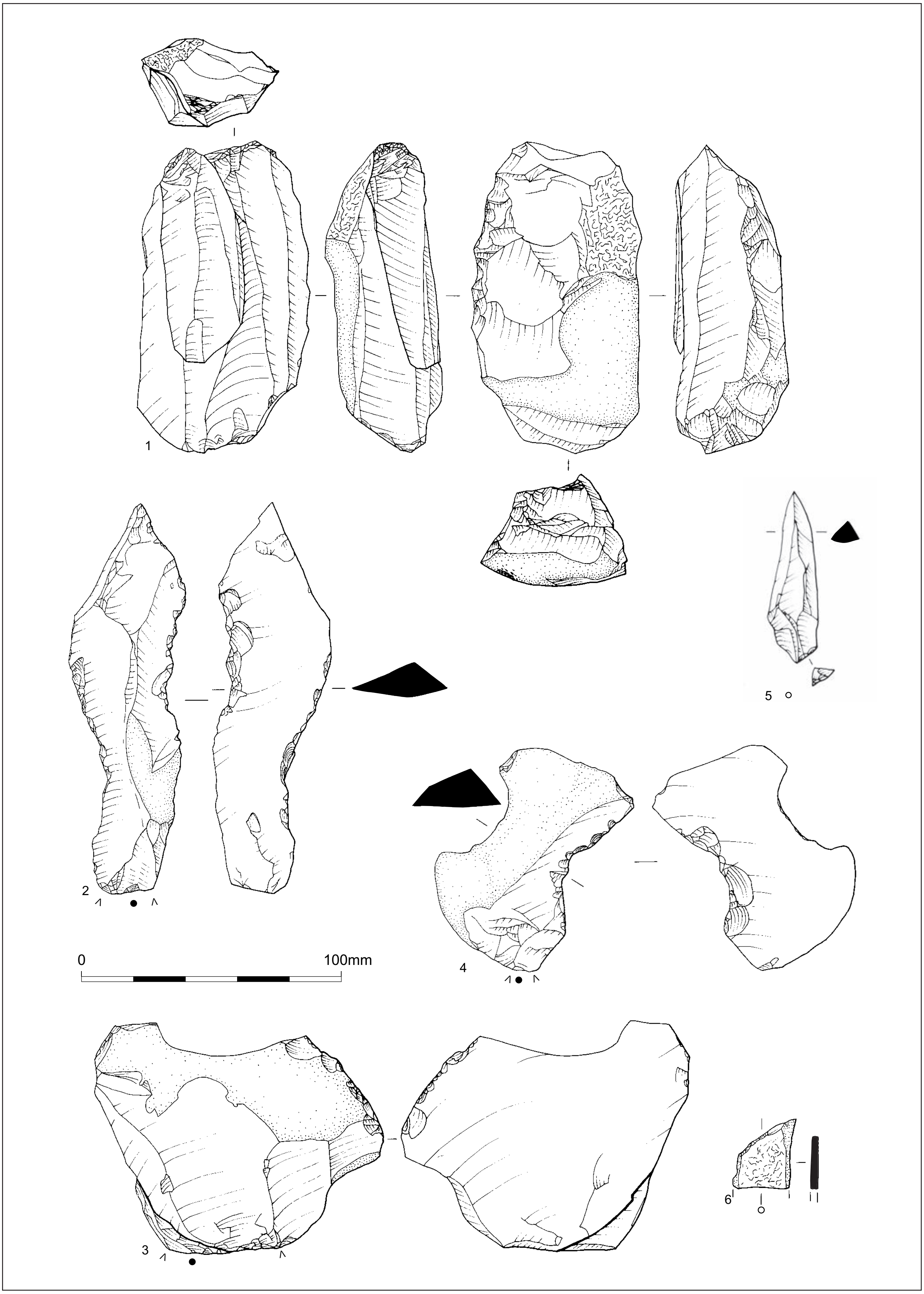

Figure 89 Early post-glacial worked flint from Springhead

Barton (1998) for a long blade assemblage. A number of long blade find spots have been identified along the Thames corridor including Burchell's excavations in the Ebbsfleet Valley (Burchell 1938) where a 'Mesolithic floor' sealed within alluvium produced blades considered by Barton to represent a long blade industry. Associated dating of technologically similar assemblages, for example at Three Ways Wharf, Uxbridge (Lewis 1991; Lewis and Rackham 2011) and Avington VI (Barton *et al* 1998), suggest long blade industries date from the very end of the Late Glacial period but also the beginning of the Post-glacial (*c* 10,000 BC). The function of long blade sites is subject to some debate, but it has been argued that they represent short term sites associated with the processing and butchery of large herbivores, such as red deer and horse (Barton 1995, 64).

Very little direct evidence for human occupation was recovered immediately following this activity and, again, consisted almost entirely of occasional worked flint as residual finds in later archaeological features and layers. The majority of diagnostic flint artefacts, and several blades and flakes, can be broadly attributed to the Mesolithic period on the basis of technological attributes and reflects a general background scatter of activity during this period. A coherent assemblage of 755 flints was, however, recovered from the lower portion of the colluvial sequence containing the redeposited Early post-glacial flintwork at Springhead (Anderson-Whymark forthcoming). These contexts contained debitage resulting from blade production, including several refitting flakes, but the only diagnostic artefacts were a burin and a distal micro-burin. The assemblage reflects the exploitation of local deposits for flint nodules and their primary preparation as blade cores. It is likely these cores were removed for further working, and presumably tool production and use elsewhere. Dating of this assemblage from the colluvial deposits is problematic due to the absence of diagnostic artefacts. The use of the micro-burin technique suggests a Mesolithic date; a date also appropriate for the burin. The presence of a large crested blade, measuring 96mm long, suggests the production of relatively substantial blades characteristic of the earlier Mesolithic.

A small assemblage (26 pieces) of Late Mesolithic worked flint; consisting of reasonably fresh flakes, chips and burnt fragments, was retrieved from an organic silt sampled in a Borehole 11 on the floodplain of the Lower Valley at a depth of 9.1–9.0m (BH11 EBBS97, Oxford Archaeological Unit 1997). Radiocarbon dating of the organic sediment produced a date of 5480–5310 cal BC (Beta-108113, 6420±50 BP). In addition two complete Late Mesolithic microliths (Fig 90A, 1–2) and a third broken example were recovered from the interface of the minerogenic alluvial silt and the main overlying peat body in a 10 x 10m cofferdam excavation for STDR-4 (Area 4, STDR401). A radiocarbon date of 4350–4070 cal BC (NZA-29246, 5405±35 BP, Oxford Archaeological Unit 1997) was obtained on a charred hazelnut shell from the context in which one of the microliths was recovered, and may date the Mesolithic activity. However, the microliths and hazelnut shell occurred with flint of Early Neolithic character on the same extant land surface (see below).

Catalogue of illustrated flint

(Fig 90A)

1. Late Mesolithic microlith comparable to Jacobi's type 5 (1978) (4044, STDR401)
2. Late Mesolithic rod-like backed bladelet comparable to Jacobi's type 5 (1978) (4054, sf 2018, STDR401)
3. Early Neolithic leaf-shaped arrowhead (300042, SF 340000, ARC EBB01)
4. Early or Middle Neolithic chisel arrowhead (11071, SF 15283, ARC SHN02)
5. Early or Middle Neolithic chisel arrowhead (11207, ARC SHN02)
6. Late Neolithic/Early Bronze Age barbed and tanged arrowhead, Sutton type B (11739, SF 15275, ARC SHN02)
7. Late Neolithic/Early Bronze Age roughout of barbed and tanged arrowhead (16238, ARC EBB01)
8. Late Neolithic/Early Bronze Age piercer (5875, ARC SPH00)
9. Late Neolithic/Early Bronze Age knife (16794, ARC SHN02)
10. Late Neolithic/Early Bronze Age knife (16967, ARC SHN02)
11. Late Neolithic/Early Bronze Age Levallois-style discoidal core (5643, ARC SPH00)
12. Bronze Age? crude pick or chisel-like implement (3797008, ARC ESG00)
13. Middle Bronze Age end scraper (5774, ARC SPH00)
14. Middle Bronze Age denticulated end and side scraper (5774, ARC SPH00)
15. Middle Bronze Age waisted tool (5775, ARC SPH00)
16. Middle Bronze Age waisted tool (2910, ARC SPH00)

Neolithic and Early Bronze Age

During the Neolithic and Bronze Age periods, from about 4000 BC, the valley appears to have held special focus for local communities. There was little evidence for areas of extensive settlement during this period, farming, or indeed the monument building such as that which occurred in the Medway Valley. The type of activity in the Ebbsfleet Valley is of quite different character. Water and watery places play a central role during the later prehistoric period, and the springs themselves, at the head of the valley, appear to have been held with some reverence well before the establishment of the Roman temple complex and town of *Vagniacae*.

The investigations in the earlier part of the 20th century identified a series of Neolithic sites (scatters of pottery and worked flint) stratified within the floodplain deposits where a distinctive style of pottery was first identified; decorated with incised patterns, fingernail and, vertical cord impressions (Burchell and Piggott 1939). The sites are now designated Scheduled Ancient Monuments (SAMs Kent 268A and 268B) and the valley provide the type-site for Ebbsfleet Ware pottery.

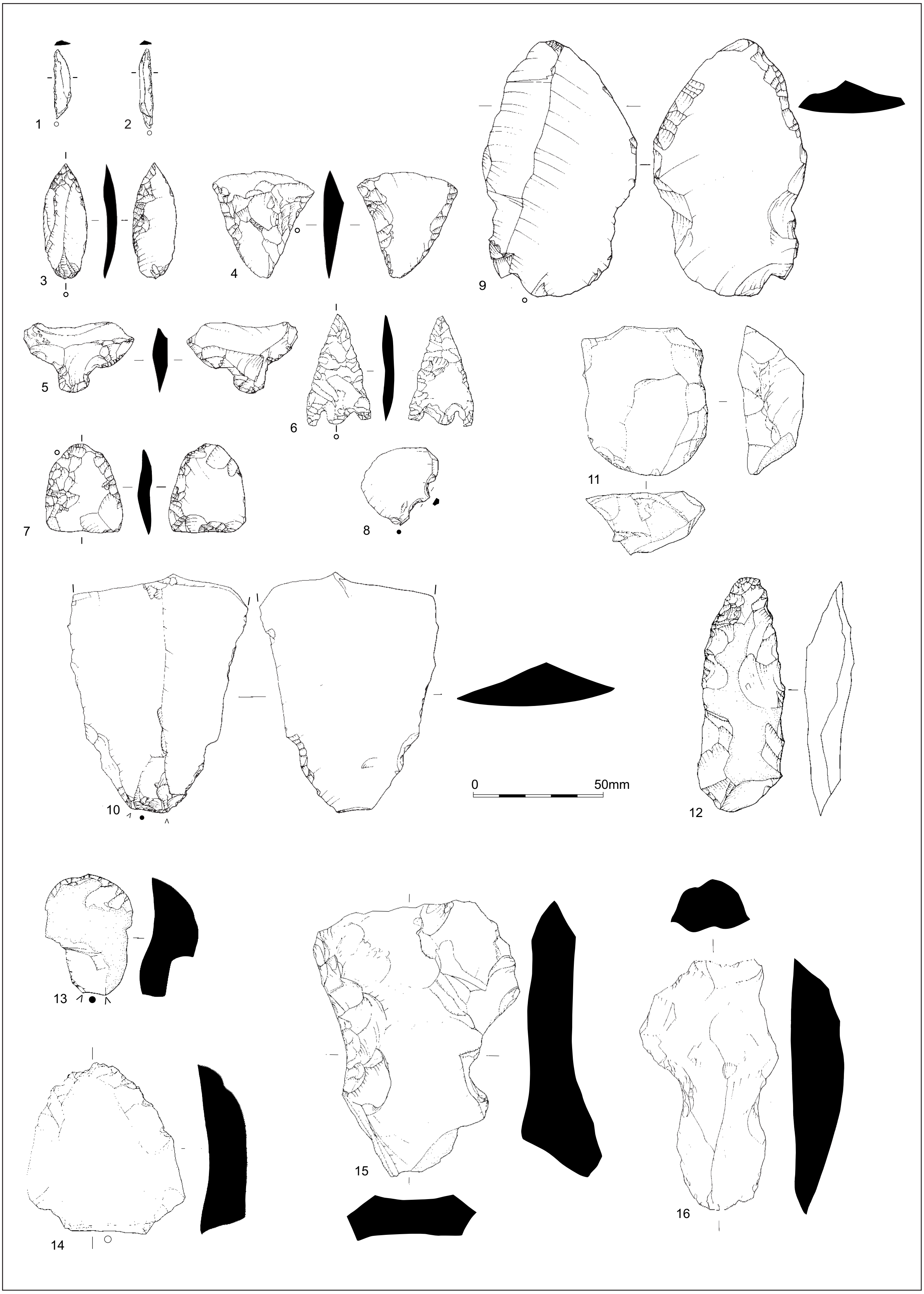

Figure 90A Neolithic and Bronze Age worked flint recovered from the Ebbsfleet Valley for HS1 and STDR4

Plate 30 Reconstruction of the Ebbsfleet Ware bowl from Trench 9 in the Ebbsfleet Valley (STDR4 00)

Along the line of HS1 and STDR-4 further evidence of activity was recovered which included scatters of burnt and worked flint (Fig 90A), butchered animal remains and pottery fragments.

The finds included part of an Ebbsfleet Ware bowl recovered from the lower part of the main peat unit in the valley bottom during the STDR-4 evaluation (Trench 11, STDR400, Pl 30). The bowl consisted of over 50 fragments, although less than a quarter of the original vessel survived, with simple decoration of closely spaced finger-tip impressed neck pits and a continuous finger-tip impressed row on the rim (Barclay forthcoming). Traces of black residue on the rim and neck could be from cooking and the lower part of the vessel also has signs of heat damage, probably from use as a cooking pot. Two further Ebbsfleet Ware vessels were also recovered from the same context, represented by single body sherds, one of which also preserved a thin deposit of charred residue on the interior surface. Two radiocarbon measurements were obtained from samples of charred residue that adhered to the interior surfaces of two of the vessels. A sample from the bowl was dated to 3640–3370 cal BC (NZA-29079, 4723±35 BP) and one of the plain body sherds to 3370–3100 cal BC (NZA-29155, 4547±35 BP). The date on the bowl is as expected and approximates well to the suggested range of 3500/3550–3350/3300 cal BC for this style of pottery (Barclay 2007, 343 and table 15.1; Barclay 2002, 90; Cotton 2004, 133; Gibson and Kinnes 1997). The second vessel date is later than expected for this style of pottery, perhaps suggesting that the vessels were not contemporaneous.

Two additional radiocarbon dates from hazelnut shell and roundwood fragments from the peat around the Ebbsfleet Ware bowl provided similar dates (WK-8799 and WK-8800). Found within the same context as the pottery were two fish bones identified as *Gadus* sp. (cod), although it is impossible to determine whether the fish had been cooked (R Nicholson, pers comm). The recovery of the bones from fresh water peat deposits is intriguing and clearly indicates that the fish was brought to the site from a distance. Cod is often associated with deep-sea fishing, although it can also be caught closer to land. Although usually caught using hook and line, on Danish Mesolithic sites it has been suggested the fish may have been caught in stationary traps (Enghoff 1995).

In situ scatters of Early Neolithic worked flint along with a small assemblage of animal bones showing signs of butchery were found at a number of locations, particularly along the margins of the Inner Basin concentrated towards the base of the main peat unit (Anderson-Whymark forthcoming; Strid forthcoming). The largest assemblages were recovered from 10 x 10m cofferdam excavations associated with the STDR-4 (Areas 3 and 4, STDR401). Detailed analysis of the worked flint assemblage from Area 4 (1606 items, Fig 90B) suggests episodes of knapping utilised the locally abundant flint and the range of activities included working of unseasoned woods, fibrous plants or dry hide. The fact that many of the flints recovered had been burnt and were found in association with unworked burnt flint suggests that the activities involved the use of fire, although no clear hearth features of areas of burning were identified. The small faunal assemblage included the usual range of domesticated species: pig, sheep/goat and cattle, with cattle the most frequently identified. Due to its larger size, cattle are likely to have been the main meat provider of the three species. While not all skeletal elements were represented in the assemblage, bones from meat-rich body parts as well as meat-poor body parts were present, suggesting these species were

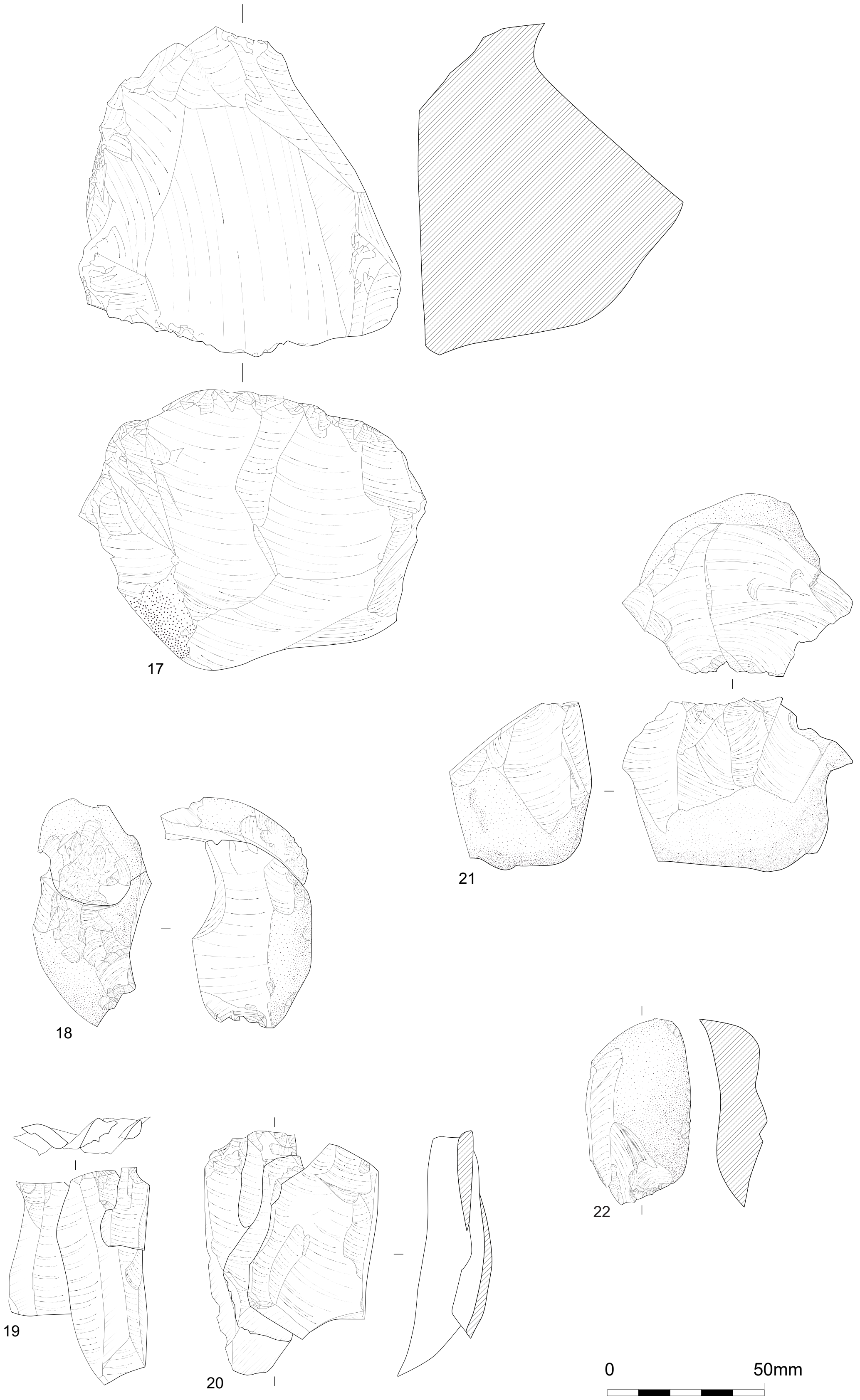

Figure 90B Early Neolithic flint from Area 4 (STDR4 01)

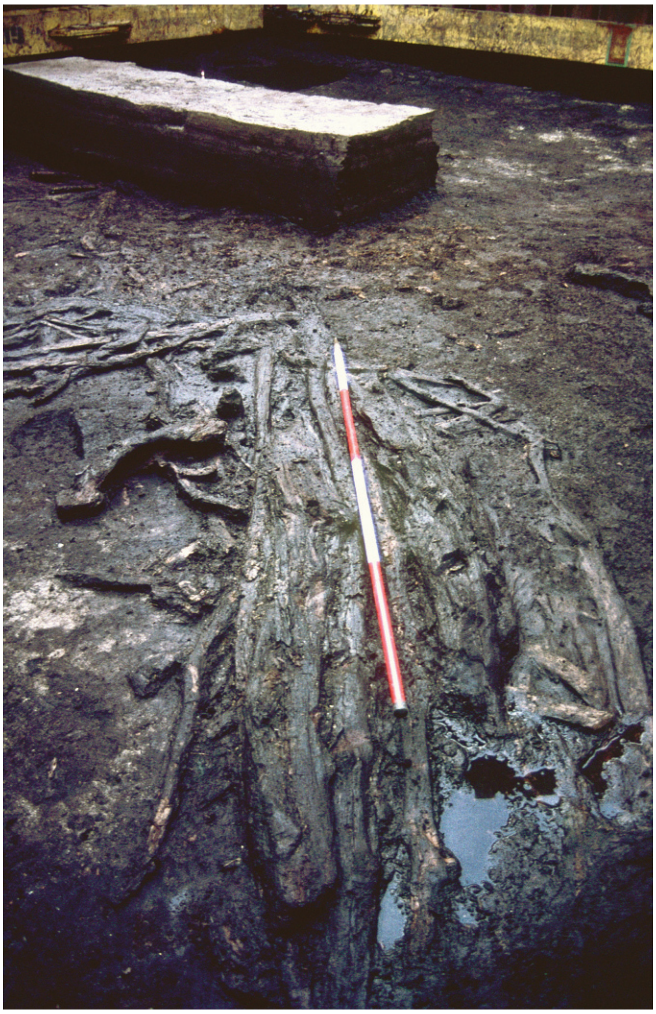

Plate 31 Late Neolithic log and pole trackway from Area 4 in the Ebbsfleet Valley (STDR4 00)

butchered in the vicinity. Butchery marks found on bones from cattle and sheep/goat derive from filleting and/or disarticulation. The faunal assemblage included a number of wild species such as auroch, red and roe deer whose meat would have complemented the diet.

Catalogue of illustrated flint

(Fig 90B)

17. Multi-platform flake core (4044, SF 1994, STDR401)
18. Refit between a hammerstone reworked as a flake core and flake (4042/4044, STDR401)
19. Refit between three utilised flakes (4045/4043, SF 1347/1519/1528, STDR401)
20. Refit between four flakes (4043/4044, SF1537/1872/1747/1538, STDR401)
21. Single platform flake core (4044, SF 1755, STDR401)
22. End and side scraper (4043, SF 1984, STDR401)

The evidence recovered from the Ebbsfleet Valley during the HS1 and STDR-4 works provides little direct evidence for the cultivation of cereals during this period. No charred cereal assemblages were recovered and the pollen evidence indicates only limited opening of the woodland on the Lower Valley slopes or further upstream at Springhead until the beginning of the Bronze Age. As previously noted, the pollen evidence indicated that during the Early Neolithic the area would have been predominantly wooded, although more open clearings probably existed within this woodland and it is likely that these areas were used for grazing domesticates. The insect assemblages from the basal (Early Neolithic) part of the peat sequence in both Area 4 and Trench 9 (STDR-4) contained a small component dependent upon grassland habitats, probably located on the well-drained soil of the valley side rather than in the valley bottom. Also present in abundance were scarabaeoid dung beetles which feed on the droppings of larger herbivorous mammals and it is likely that the grazing extended from the grassland into partly wooded areas (Robinson forthcoming).

Concentrations of large oak timbers at the base of the peat in an STDR-4 evaluation trench (Trench 9, STDR400) dated to 3780–3640 cal BC (NZA-29080, 4926±35 BP), may represent the remains of some form of Early Neolithic trackway, although no evidence of working was identified in the small area exposed and the evidence remains equivocal (Wenban-Smith *et al* forthcoming). It is, however, noteworthy a concentration of large timbers was also interpreted as a possible trackway at the base of the peat at Burchell's original site to the south-west of Area 4 (SAM 268A, Sieveking 1960); radiocarbon dated to 3750–2900 cal BC (BM-113, 4660±150 BP). More convincing, perhaps, was a section of a Late Neolithic log and pole trackway recorded in the STDR-4 Area 4 cofferdam excavation (Pl 31). The structure was identified within the upper part of the main peat unit sealing the Early Neolithic activity and comprised a NW–SE linear arrangement with clearly defined edges, 1.1–1.2m wide, with the log and pole elements laid along the long axis of the structure. The material used was quite varied and included cleft and charred log sections and identified species included oak, alder and hazel (Wenban-Smith *et al* forthcoming). The edges of several lifted items, examined by Damian Goodburn, bore traces of weathered axe trimming but no clear cut ends were lifted. A piece of alder roundwood from the structure was radiocarbon dated to 2870–2570 cal BC (SUERC-19950, 4120±30 BP).

A number of timber trackway structures have been identified within the Lower Thames floodplain area in recent years; although the majority appear to date to the later Bronze Age period (for recent reviews see Stafford *et al* 2012; Waller and Grant 2012, fig 7). An example recently excavated from the base of a peat deposit at Belmarsh on the Plumstead Marshes contained two possible timber structures, with the earliest dated to *c* 3960–3710 cal BC (WK-25955, 5039±30 BP; and WK-25954, 5023±44 BP; Hart 2010), constructed of tangentially split timber planks alder and hazel laid side by side. A later Neolithic structure at Fort Street, Silvertown, provided a single date of 3030–2700 cal BC (GU-4409, 4280±50 BP), also utilised timber planks with vertical anchoring posts (Crockett *et al* 2002). However, a second date of 2280–1940 cal BC (GU-

4408, 3700±50 BP) on an alder retaining post associated with this trackway may cast some doubt over its true age. Parallels for the log and pole trackway from Area 4 include two structures along the A13 East London at Woolwich Manor Way (Stafford *et al* 2012) and at the Beckton Golf Driving Range (Carew *et al* 2009), although both of these structures were dated to the Early–Middle Bronze Age.

Distributed along the banks of the Ebbsfleet, from Springhead to the valley bottom, a series of features were identified during the HS1 investigations, variously comprising small spreads of burnt flint and pits also containing large quantities of burnt flint (Wenban-Smith *et al* forthcoming). Radiocarbon dating of associated charcoal fragments mostly produced Early Bronze Age dates. Where the HS1 line crosses the current Ebbsfleet Stream, in the middle reaches of the valley, groups of burnt flint filled pits sealed beneath colluvium were found associated with a structure (ARC ERC01). The structure comprised a shallow kidney-shaped pit flanked by two curvilinear slots, each of which contained three substantial post-holes (Pl 32). A shallow gully led from the front of the pit towards the former edge of the river channel. The fill of the pit comprised a dark grey silty clay with frequent burnt flint and charcoal and a sample of *Prunus* sp. roundwood charcoal was radiocarbon dated to the Early Bronze Age, 1760–1530 cal BC (NZA-28445, 3379±35 BP).

Plate 32 'Sauna' feature from the Ebbsfleet River Crossing near Springhead (ARC ERC01)

Concentrations of burnt flint are a feature of prehistoric settlement sites and provide evidence for the use of heated stones for various activities such as cooking (Lambrick 2009, 179–80). However, some sites produce much larger quantities of burnt flint and include the much debated class of monuments commonly referred to as 'burnt mounds'. Burnt mounds are more generally dated to the Middle to Late Bronze Age and remains of this date were found associated with the Bronze Age barrows during the HS1 works at Springhead (see below). They are often found adjacent to water courses and in the classic form appear as a crescent-like or circular mound of burnt stone often associated with a central trough, probably used to boil water with heated stones (Raymond 1987; O'Neill 2009). Activities that have been suggested for these features include cooking, perhaps large pieces of meat for communal gatherings (O' Kelly 1954; Barber 1990), the processing of fleeces (Jeffery 1991), salt production (Barfield 1991) or the creation of large amounts of steam for the use in sweat lodges (Barfield and Hodder 1987). The only other published 'burnt mound' sites in Kent include the Late Neolithic feature at Crabble Paper, near Dover (Parfitt 2006) and a Late Bronze Age example excavated during the A282/M25 road improvements at Dartford (Simmonds *et al* 2010). Further afield a few examples have been found in the Greater London area, for example at Phoenix Wharf on the Isle of Dogs (Bowsher 1991; Sidell *et al* 2002; 27–29) and Campden Hill Road, Kensington (Moore *et al* 2003). In common with many other sites, the Early Bronze Age remains identified during the HS1 works did not produce any quantity of faunal remains or midden-type deposits one would perhaps expect of domestic settlement activity. The Early Bronze Age feature group at the Ebbsfleet River Crossing was particularly enigmatic; the identification of a series of possible post-holes within the gullies flanking the central pit or hollow suggests some form of enclosing structure which may point to the sauna hypothesis of Barfield and Hodder (1987). If this interpretation is correct, the absence of any evidence for *in situ* burning within the main pit or hollow might suggest stones were heated from outside the structure, perhaps on the hearths identified a little further to the south. The central gully could have fed water from the nearby River Ebbsfleet to pour on the hot stones that had been brought into the structure to create steam.

Middle Bronze Age

During the Middle Bronze Age a number of barrows were constructed in the valley. At Springhead (ARC SPH00) two intersecting ring-ditches were found at the head of the valley, immediately adjacent to the former springs (Wenban-Smith *et al* forthcoming). The earliest of these lay almost entirely within the excavated area, while the majority of the later ring-ditch (including any central burial) extended beyond the limit of excavation to the south-west. The earlier ring-ditch had a diameter of *c* 18m, although only just less than half of the ditch survived, the north-western part having been eroded away by an advancing spring line. The remains of a central, urned cremation burial survived, though this had been substantially truncated by a later Roman road which had been cut through the area down to the water's edge. Insufficient of the later ring-ditch survived to calculate its diameter, but the ditch was of similar width and depth to the earlier example. Further down the valley, beneath the later Roman villa, on an area of slightly higher ground overlooking what would have been the wetland zone, two ring-ditches surrounded by an enclosure were excavated (ARC EBB01). As at Springhead, they may also represent barrows, one of these ditches, albeit smaller at 5m diameter, contained a central cremation burial dated to 1450–1300 cal BC (NZA-28208, 3113±30 BP). Although the other ring-ditch was only partially preserved, two other cremation deposits of similar date were identified nearby.

In the floodplain zone of the Lower Valley the HS1 investigations revealed contemporary activity represented by a number of wooden structures (Wenban-Smith *et al* forthcoming). This includes a wattle panel of intertwined hazel branches and several concentrations of (coppiced) roundwood laid on the surface of the peat deposits. On the whole these structures are of lightweight construction, perhaps the remains of temporary walkways or trackways linking areas of drier ground. They are located along the line of former wetland edge and may provide evidence of prehistoric routeway through the Lower Valley (Fig 86c). A number of similar Bronze Age structures have been identified in recent years along the edges of the Thames floodplain, particularly in the East London wetlands between the Rivers Lea and Ingrebourne (Carew *et al* 2009; Meddens 1996; Meddens and Beasley 1996; Stafford *et al* 2012) where it has been suggested they may be associated with the movement of stock for seasonal grazing.

One structure recorded during the HS1 watching brief, however, was more substantial and comprised a double row of large timber piles driven into alluvial clay. A total of five oak pile tips and one peaty void of a pile tip were recorded. The diameter of the piles ranged between *c* 100mm and 150mm, with the largest surviving to a length of 520mm. Although the exposure in plan was small, there was a clear deliberate pattern; the piles were set in pairs *c* 3m from each other, and each pile was *c* 1m apart within the pair. The size and layout of the structure suggests it could have supported a walkway, perhaps even a bridge, traversing an ancient water course. Unfortunately the piles were made from rather fast-grown oak and no more than 40 tree-rings could be found; insufficient for tree-ring dating. A sample of the outer rings of one of the piles was radiocarbon dated to the Middle Bronze Age, 1410–1220 cal BC (NZA-28703, 3055±30 BP). The pile alignment can be compared with a number of other similar structures excavated in the Thames Valley. The closest parallel based on form is the Early Bronze Age pile group found along the A13 at Freemasons Road, Newham (Stafford *et al* 2012). Obvious comparisons can also be drawn with the Middle and Late Bronze Age pile groups excavated at Vauxhall (Haughey 1999) and further upstream at Eton (Lambrick 2009; Allen *et al* forthcoming).

Late Bronze Age and Iron Age

Evidence for human activity dating the Late Bronze Age–Iron Age is sparser although potsherds attest to occasional visits. In the Outer Basin excavations for the STDR-4 (Area 1) recorded a series of small wooden structures, possibly revetting the edge of a channel (Wenban-Smith *et al* forthcoming). The structures comprised fragmented wooden stakes, on occasion roughly joined by thin horizontal 'bundles' of rods or 'withies'. The form of the structures is not clear however and it is likely, in part, that they represent repairs, additions or replacements of one or more former structures, as the channel silts accumulated against them. An alder stake from one of the structures produced a radiocarbon date of 835–765 cal BC (SUERC-19949, 2615±30 BP). Fragments of briquetage, a coarse ceramic material used to make evaporation vessels, were found buried in the estuarine silts sealing the wooden structures and may suggest salt production was carried out nearby. The briquetage was found in association with a quantity of Iron Age pottery and animal bone; cattle, sheep, pig and horse. A radiocarbon date on a cattle femur produced an Early–Middle Iron Age date of 730–390 cal BC (SUERC-19947, 2385±30 BP). A cetacean vertebrate bone, from a dolphin or porpoise, along with remains of gannet further emphasises the maritime influence on the Ebbsfleet Valley during this period.

Roman and Saxon Northfleet

Northfleet villa, 1.5km downstream of Springhead Roman town, was originally excavated by W H Steadman in 1909–11. He uncovered evidence for agricultural buildings, a limekiln, and traces of the east wing of the main house, including hundreds of *tesserae* that pointed to the existence of a tessellated floor or mosaic (Steadman 1913). A bath-house was revealed by subsequent fieldwork by the Thameside Archaeological Group between 1979 and 1983 (Ansell 1981; 1982; 1983; Smith 1979; Smith 1980), but the 2001 excavation by Oxford Archaeology for HS1 was the most extensive, exposing a large part of the main complex and the villa's hinterland (Biddulph 2011, 135–88).

Although the main house could not be re-examined, a number of finds recovered from the excavation suggested that the villa estate accommodated the town's elite. A piece of white marble *opus sectile* paving, possibly Carrara marble, was of the sort found at luxury buildings, for example at Fishbourne Palace and a building in Southwark thought to have been used by the provincial administration (Crowley 2005, 91). A seal-box in the shape of a *beneficarius* lance suggested the movement of documents between the villa owners and the legionary staff of the provincial governor (Schuster 2011, 298). And a life-size theatrical face-mask imported from the Rhineland and associated with religious festivals or processions may have been a badge of office. The rarity of such pieces in Britain suggests that the mask was more a symbol of status than merely a practical prop, and provides a tantalising clue that the town's elite lived at the villa and took a leading role in civic and religious life (Biddulph 2011, 229).

However, Northfleet villa was also a working farm. The earliest-known building was a timber rectangular building, erected after AD 70. Something of its use is suggested by the clay- or wood-lined tanks that surrounded it. Some of these were connected to pipes and drains, while another contained large quantities of germinated spelt wheat. The evidence points to the production of malt, which may have been stored or processed in the building ready for on-site brewing, or export. The earliest timber building was replaced by a building with stone footings after AD 120. This was itself replaced with a larger aisled barn after AD 160, which was joined by a second aisled building after AD 200. Like the earliest structure, these later buildings or barns were used for malting or storage. A technological advance arrived in AD 350 with the construction of a malting oven (*cf* Reynolds and Langley 1979). The structure was used to generate moisture to encourage the grain to sprout. Heated subsequently, the oven dried the grain to arrest germination, and the greater control of temperature permitted variation of flavour.

The extraordinary range of evidence recovered from Northfleet – not recorded on such a scale anywhere in Roman Britain – identifies the villa as a major malting and brewing centre. Quantities were vast; the largest brewing tank held up to *c* 10,800 litres. How far the malt or ale was exported is unknown, but it may well have been loaded onto rivercraft from a quayside immediately north of the villa complex (Pl 28) and sent down the Ebbsfleet into the Thames. The waters were shallow at this point, restricting access to flat-bottomed barges or lighters. Once out in the Thames, the cargoes were probably transferred to larger vessels or merchantmen for onward distribution. The quay was built during the late 2nd century at the mouth of a backwater. In its first phase, the quay comprised a wooden revetment and platform, which extended into the water. In the 4th century, the wooden staging was replaced by a more robust structure of timber piles and rubble dumps, which raised the height of the quayside, possibly in response to rising water levels.

A bath-house was built after AD 160. The structure took a simple form initially, being provided with a warm room (*tepidarium*) and hot room (*caldarium*). More rooms were added over the years, so that a more complete range of rooms was present, including changing room (*apodyterium*), cold room (*frigidarium*), sweat room (*sudatorium*) and cold bath. In its final incarnation in the first half of the 3rd century, two sets of cold baths and hot rooms were provided, suggesting perhaps that men and women were segregated.

The villa was abandoned by AD 380. Occupation of sorts continued in the area; quarries were dug for the underlying chalk, while the crumbling villa walls were robbed of their masonry, and it is possible that people living in the area continued to receive new pottery and other goods. However, in time this too ceased, and there was no occupation until the late 5th or early 6th centuries AD (Biddulph 2011, 215).

Plate 33 Remains of the Saxon tidal mill at Northfleet (ARC EBB01)

The first evidence of Saxon activity at Northfleet occurs perhaps by the middle of the 5th century (Hardy and Andrews 2011, 249–305). A number of sunken featured buildings (SFBs) were excavated in the vicinity of the villa buildings. Each building probably had a suspended wooden floor set over a square pit, which served as storage space and ventilation. One of the buildings was more elaborate: the sides of the pit were lined with planks to prevent the sides collapsing. In one of the SFB pits was a collection of seven lead loomweights. The walls of these buildings were probably light wooden screens plastered with clay and the roofs were probably thatched. The settlement was scattered along the higher and drier ground to the south of the Ebbsfleet channel. There were no divisions of the land, no property boundaries. Although there was no evidence for re-use of the Roman buildings, for a time spelt wheat continued to be cultivated in the surrounding fields. After perhaps a century signs of occupation vanished at Northfleet. This area of the valley was probably slowly getting wetter and probably became a less attractive area to live.

A unique discovery during the 2001 excavations was the remains of a Saxon tidal mill immediately adjacent to the old Roman waterfront (Pl 33; Hardy *et al* 2011, 307–49). Dendrochronological dating of one of the planks from the mill provided a construction date in the spring of AD 692. Detailed analysis of the sediments, palaeoenvironmental remains and structural evidence confirmed the mill had clearly operated in tidal conditions; capturing water in a pond at high tide and then releasing it through the mill at low tide. The mill appeared to operate two millwheels, possibly for up to three hours, producing around 30kg of flour. The water ran from the pond through two square funnels, or pentroughs, made of hollowed-out tree trunks, and the jets probably drove two horizontal paddle wheels. Each wheel was connected by a shaft to a pair of millstones on the milling floor above. Once the water had passed the wheel, it ran along the mill tailrace and joined the main stream channel. There was also evidence that a system of levers may have been used to raise the waterwheel and shaft in order to separate the upper and lower stones while they were turning. At high tide, when the waterwheel would be under water and the mill would not be operating, a boat would perhaps load the flour from a jetty alongside the tailrace, and head off downstream before the tide ebbed again. The wood used to construct the mill was entirely axe-hewn, almost all oak and mostly from quite young trees. The design was quite sophisticated and would have been built by a skilled and experienced builder, possibly one brought over especially from the continent. The structure is likely to have stood on its own in a landscape of open tidal creeks, mudflats and saltmarsh.

The Northfleet structure is virtually alone in England as an example of a middle and late Anglo-Saxon tidal mill with a horizontal wheel; the evidence is otherwise slim and conflicting. Better parallels come from Ireland. The earliest securely dated example is the first phase tide mill at Nendrum, on the shore of Strangford Lough, County Down, which has been dated by dendrochronology to AD 619–21 (McErlean and Crothers 2007). The site at Nendrum, together with Northfleet, provides a growing body of evidence for the use of salt water as well as fresh water for powering early medieval mills.