Part III

Field Investigation of the HS1 Corridor

Chapter 7

The Lea Valley

by Catherine Barnett, Michael J Grant and Martin Bates
with contributions by Nigel Cameron, Phil Harding, David Smith,
Chris J Stevens, John Whittaker and Sarah F Wyles

The area of the Lea Valley impacted on by HS1 includes both the Stratford Box and the Temple Mills Depot (Fig 5). The archaeological remains and site-related sedimentary sequences for the former have been reported separately (Valler and Crockett forthcoming; Barnett *et al* forthcoming). This area (Window 3) was not assessed in the original 1999 desk-top study (Chap 6), although individual geoarchaeological desk-top studies were carried out for both sites prior to field investigations (Table 12). The sites lie between 5m and 6m OD, a topography created in part by the character of Holocene deposits in the Lea Valley and enhanced by the creation of the modern railway shunting yards. To the east the ground rises to form the east side of the valley. Bedrock geology is mapped as the London Clay Formation, largely eroded in the valley bottom itself, overlying a sequence of Palaeocene deposits that are collectively referred to as the Lambeth Group (Woolwich and Reading Beds), which lie on Cretaceous Upper Chalk (British Geological Survey 1993). The Woolwich and Reading Beds include sandy elements (Upper Thanet Beds) and pebble beds (Upnor Formation).

The principal Quaternary deposits recorded in the area comprise the Lea Valley Gravel (Gibbard 1994; equivalent to the Shepperton Gravels of the Lower Thames), deposited during the infilling of the valley during the Middle to Late Devensian period (*c* 26,000–9,700 cal BC), and are known to contain Upper Palaeolithic flint artefacts (Bridgland 1993). These gravels are also known to contain occurrences of the 'Lea Valley Arctic Plant Beds' (Warren 1912; 1915), organic deposits containing a 'full glacial' plant assemblage (Reid 1949; Allison *et al* 1952), insect assemblage typical of arctic tundra (Coope and Tallon 1983), cold indicator and dwarfed specimens of molluscs (Warren 1912, 239) and 'steppe tundra' fauna (Lister and Sher 2001), which have been radiocarbon dated to between 34,700 and 20,650 cal BC (see Powell 2012 for details). These have generally been recorded as lying towards the base of the Lea Valley Gravels at several locations in the Lower Lea Valley and adjacent tributary valleys, with local occurrences recorded at the former Temple Mills Pit by Warren (1912) and beneath the Olympic Park in a borehole by Corcoran and Swift (2004). Grant and Norcott (2012) have suggested, based upon deposit modelling of the area, that the local deposits in the Stratford area might be associated with a tributary river (course of the present Phillibrook Stream) draining into the River Lea through the centre of the Temple Mills Depot footprint, although no evidence for these deposits was uncovered in the borehole survey across the site.

Softer unconsolidated sand, silt, clay and peat, which overlie the Lea Valley Gravel, represent Holocene fluvial activity within the floodplain of the River Lea. A number of palaeochannels that cut the earlier gravel are filled with these softer sediments. The likelihood of former land surfaces of Late Upper Palaeolithic, Mesolithic and Neolithic date preserved below and within these deposits is well-documented (eg, see Corcoran *et al* 2011).

Investigations of the Stratford Box site (Fig 32) are examined elsewhere (Valler and Crockett forthcoming; Barnett *et al* forthcoming) and are not the focus of study here. However, it should be noted that investigation of the borehole logs from the route corridor and the purposive drilling of a number of additional boreholes identified the presence of at least two bodies of gravel beneath the floodplain here (Fig 35, see below). No trace of the Lea Valley Arctic Beds was found and the main focus of attention was close to the active course of the Lea where some evidence of later prehistoric activity on the floodplain was recovered. Here we report on the findings at Temple Mills sheds located to the north.

Table 12 Summary of fieldwork events, Stratford Box and Temple Mills

Event name	Event code	Type	Interventions	Archaeological contractor
Stratford Box	ARC SBX00	Evaluation	3839-3844TT, 7BH (CP)	Wessex Archaeology
Stratford Box	ARC SBX00	Excavation		Wessex Archaeology
Stratford Box	ARC SBX00	Watching brief		Wessex Archaeology
Temple Mills Depot Boreholes	ARC TPD04	Evaluation	12BH	Wessex Archaeology
Temple Mills Depot Evaluation	ARC TPD04	Evaluation	4038TT–4044TT	Wessex Archaeology
Stratford Connection	ARC SCX04	Watching Brief		Wessex Archaeology

TT = trench BH = borehole (CP) = Cable percussion

Temple Mills

Construction Impacts

Development at Temple Mills Depot included the construction of a 400 x 100m service shed for Eurostar trains, a separate facility to allow replacement of bogies (wheeled chassis; generically referred to as the Bogie Drop), a storage warehouse and ancillary works including an office block (Fig 33). In addition, a new section of track following the east bank of the River Lea (the Stratford Box Connection) to connect the high-speed railway through Stratford Box (the below-ground housing for Stratford International station) with Temple Mills Depot was also constructed.

Key Archaeological Issues

Desk-top study of the area noted records of 17 imprecisely provenanced Neolithic axes in an area focused at the north-west end of the main Eurostar shed, while additional records indicated a possible, but poorly provenanced, Roman causeway towards the south-east end of the shed (Fig 33). From at least the 16th century the marsh was being drained by a network of open ditches and/or natural channels collectively known as the Stratford Back Rivers which are shown on 18th century maps as forming the boundaries of a patchwork of small pasture fields. Towards the end of the 19th century this (by then largely defunct) drainage system had been replaced by sewers and culverts, and most of the former ditches and channels had been lost from the visible landscape.

Roman settlement associated with roads and a cemetery was also noted, as well as Saxon river-side activity. The sites of several medieval buildings fall within the study area, including Ruckholt Manor, Chobham Manor, the Temple Mills watermill complex and St Mary the Virgin Church.

Post-medieval sites include places of worship and several other notable buildings including Leyton House, Leyton Grange, Ive Farm, Etloe House, the *White House* public house, medical facilities and structures relating to crossings over the River Lea. Several post-medieval industrial premises worthy of note were also recorded, including hop-drying sheds, calico printers and a silk mill. Twentieth century structures in the study area include the church of St Luke, two Second World War anti-aircraft sites, and most recently the Olympic Park.

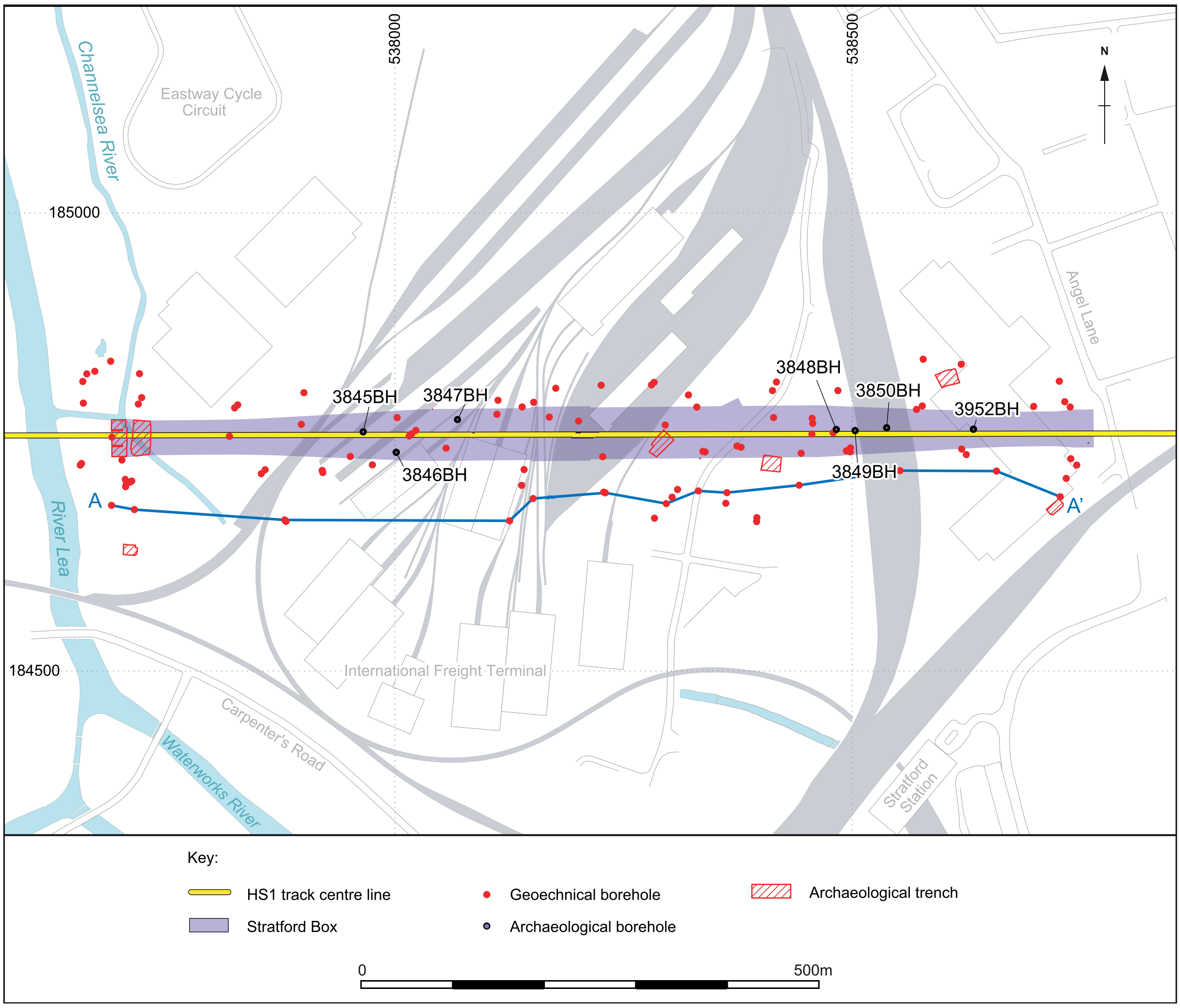

Figure 32 Plan of archaeological and geotechnical interventions, Stratford Box

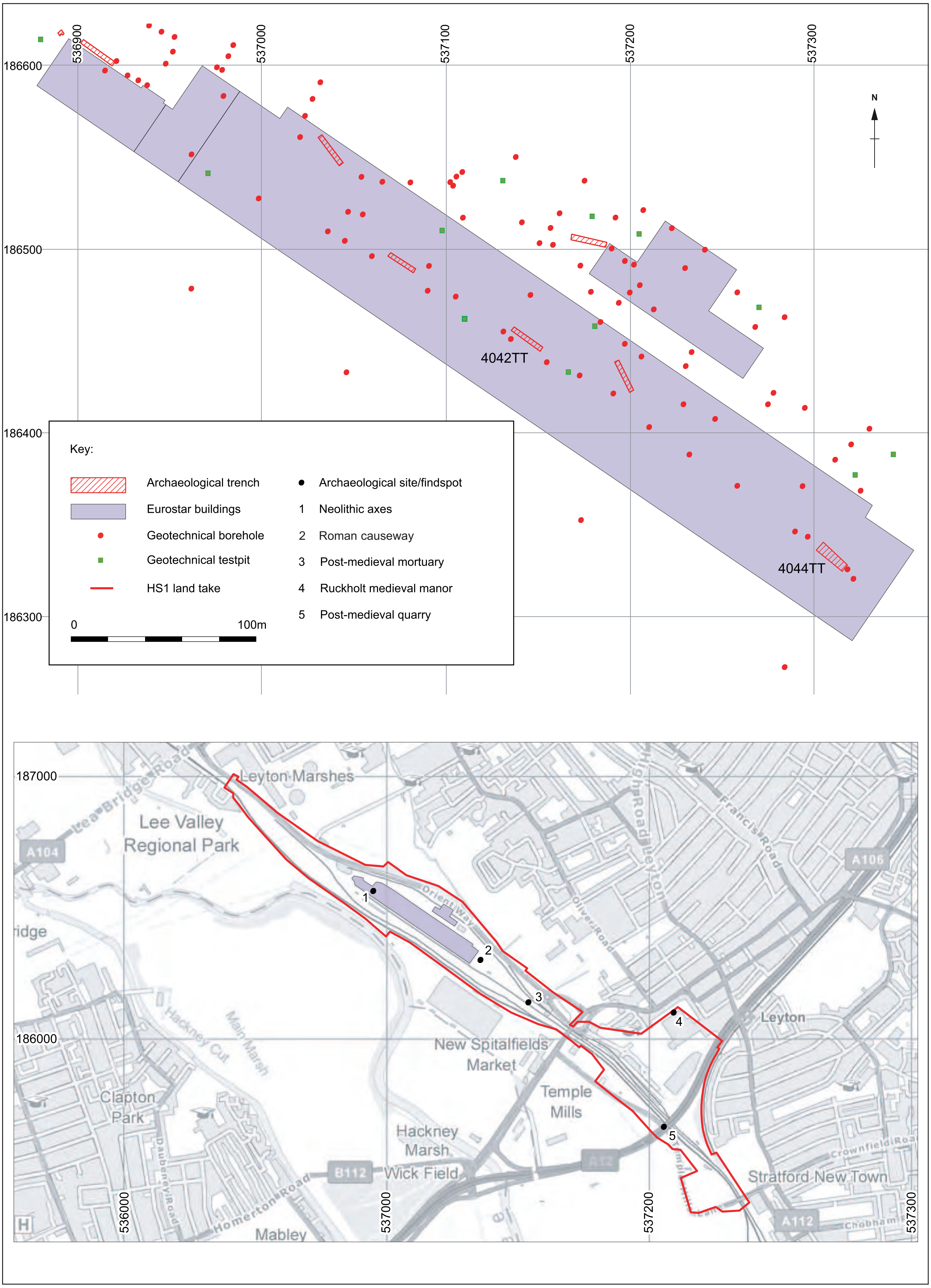

Figure 33 Site location and plan of archaeological and geotechnical interventions, Temple Mills

Strategy, Aims and Objectives

A mixed approach was used to the investigation of the Stratford Box/Temple Mills area that included borehole investigation as well as conventional trenching and excavations. The initial desk-top assessment of the route corridor only focused on the main Stratford Box site (at the time of production of the assessment it was unclear that development would be taking place at Temple Mills). Consequently, drilling initially focused on the box area, leading to a programme of targeted excavations within the box area. Excavation at Temple Mills followed later in the project.

Methodologies

An initial desk-top assessment was followed by a purposive borehole survey and a series of machine-excavated evaluation trenches on land proposed for redevelopment at Temple Mills Depot. Thereafter, an archaeological watching brief was maintained on all groundwork that might have impacted upon archaeological remains, including the Stratford Box Connection. Subsequent palaeoenvironmental analysis on the key sediment sequences at Temple Mills was carried out by Catherine Barnett (dating, wood, sediments), Michael Grant (pollen), Chris Stevens (waterlogged plant remains), David Smith (insects), John Whittaker (ostracods and foraminifera) and Sarah Wyles (molluscs). Diatom assessment was carried out by Nigel Cameron, though these were found to be generally absent in the two trench sequences investigated. Interpretation of the sedimentary sequences was carried out by Catherine Barnett and Martin Bates.

Results of the Investigations

Desk-top assessment

One hundred and eleven geotechnical logs of varying quality from previous surveys were examined to inform and model the sub-surface stratigraphy. Of these, 71 provided data that was of sufficient quality to be incorporated into a database. In addition, a further 12 purposive boreholes were drilled at locations across the proposed development area, their location designed to fill gaps within the geotechnical record and/or to provide clarification of ambiguous logs. These failed to uncover deep organic sediments that could be associated with the Lea Valley Arctic Beds.

The Lea Valley Gravel was found in all boreholes with a surface elevation of *c* 3m OD (Fig 34). The gravel was crossed, through the central part of the main shed footprint and to the west of the Bogie Drop, by a 1.5m deep palaeochannel, aligned approximately north–south that matched closely the course of a north to south flowing tributary stream of the River Lea shown on Rocque's Survey of London (1744–6). The gravel surface rose, with minor undulations, towards the north-west end of the main shed footprint, while to the south-east, the eastern bank of the channel formed a ridge beyond which the gravel surfaces fell to the south-east into a second palaeochannel, possibly a former meander. The gravels were overlain by peat (up to 0.7m thick) and sediments rich in molluscs were identified at the base of the Holocene sequence within the palaeochannel and in the possible river meander. These deposits, and Lea Valley Gravel flanking the palaeochannels, were capped by Holocene alluvium/clay (Fig 36). Between 1.0m and 2.5m of madeground (average 1.8m) capped the sequences, much of which was railway ballast with a surface height of 6.0–6.5m OD.

Preliminary analysis of geotechnical logs within the vicinity of the site demonstrated that the site lay within a location containing river-side gravel ridges that was potentially favourable for prehistoric occupation from at least the Mesolithic period through to the Bronze Age or Early Iron Age.

Trench excavations

The location of the seven trenches (4038TT–4044TT), each aligned approximately NW–SE, along the long axis of the site are shown in Figures 33 and 34 and key profiles in Figure 36; an environment summary is given in Table 18.

Trench 4042TT

This trench (Fig 36) was one of two (also 4044TT, below) that were positioned specifically to evaluate the archaeological and environmental potential of the peat deposits recorded in the borehole logs, and obtain samples from them. The trench was located towards the eastern side of the palaeochannel and high-energy fluvial activity is indicated at the base of palaeochannel sequence by the presence of sands and gravels, probably reworked from the underlying Devensian gravel matrix.

Shelly silt (Late Glacial)

The overlying deposits were significantly finer grained suggesting deposition within the channel under a fluvial regime of decreasing energy. This sediment consisted of a fine shelly silt unit (context 420004) that produced a moderately sized assemblage of beetles (*Tables 13* and *14*; Fig 37). The assemblage is dominated by a range of water beetles and other taxa associated with watersides. The majority of the water beetles recovered are indicative of slow-flowing or stagnant pools of water. Examples of water beetles that favour this environment are *Hygrotus decoratus*, *Ochthebius minutus*, and the *Hydroporus*, *Agabus* and *Enochrus* species (Nilsson and Holmen 1995; Hansen 1986). Another typical indicator for this kind of environment is the 'reed beetle' *Donacia vulgaris*. This species is associated with a range of emergent waterside plants such as *Juncus* spp. (rushes), *Carex* spp. (sedges), *Sparganium* spp. (bur-reeds) and *Typha* spp. (bulrushes) (as are many of the *Notaris* species of weevil). Similarly the 'leaf beetle' *Prasocuris phellandri* is associated with waterside umbellifers (Apiaceae). A small number of species suggest that a faster flowing river or stream, with a gravelly or sandy bed, must have been also present in the river system. This is suggested by the

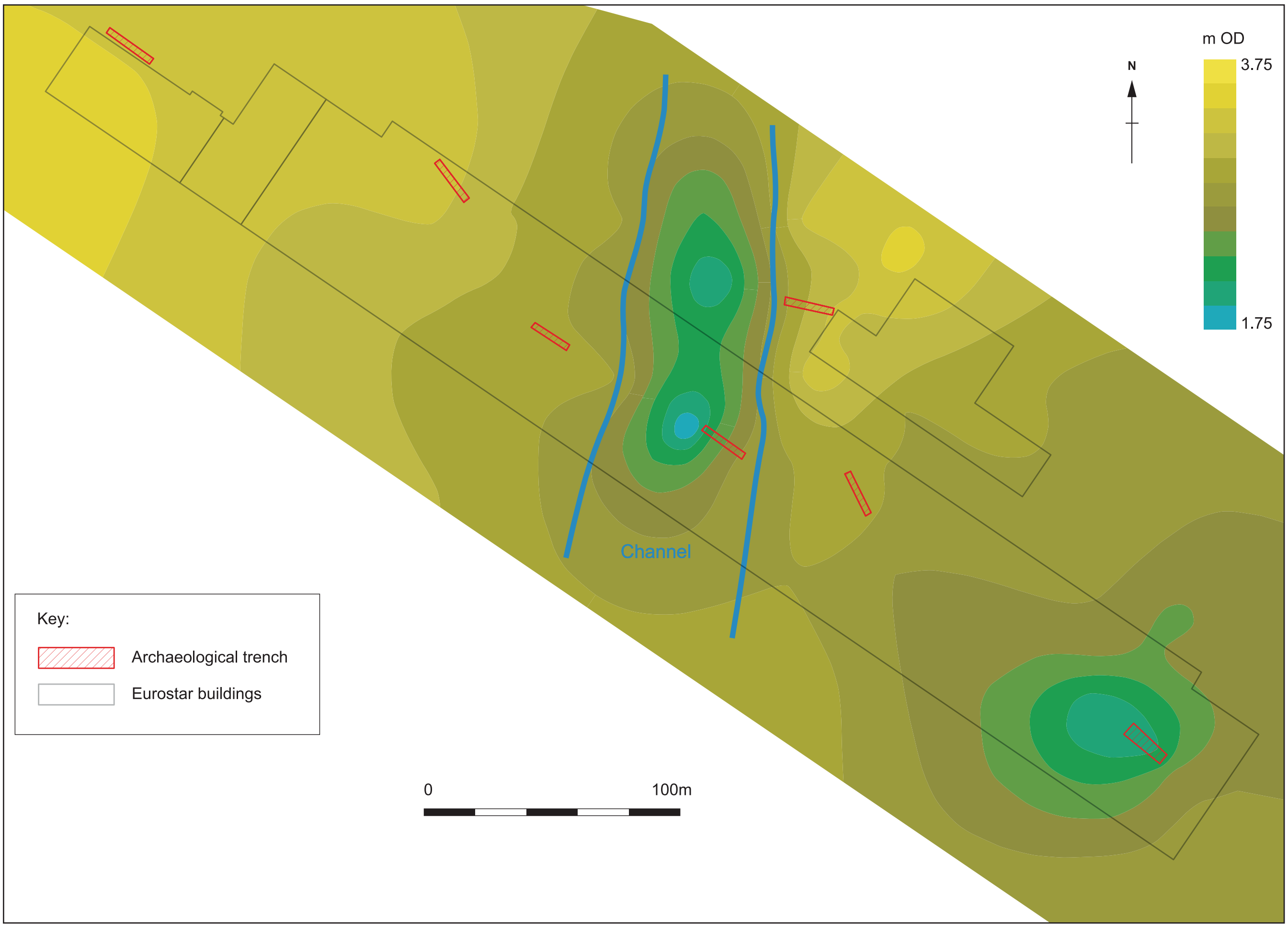

Figure 34 Modelled surface of Lea Valley Gravel, Temple Mills, showing the inferred position of a palaeochannel across the gravel surface

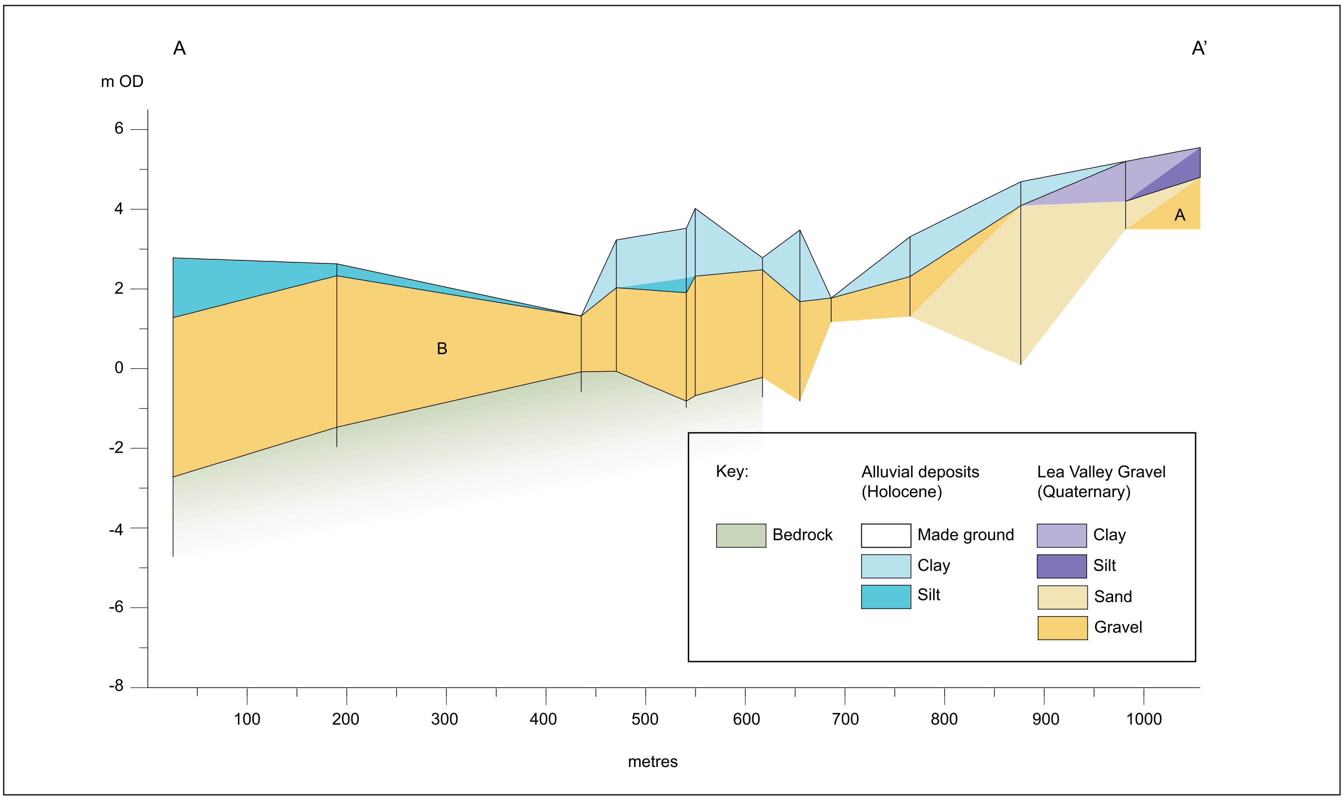

Figure 35 Borehole cross-section through Stratford Box

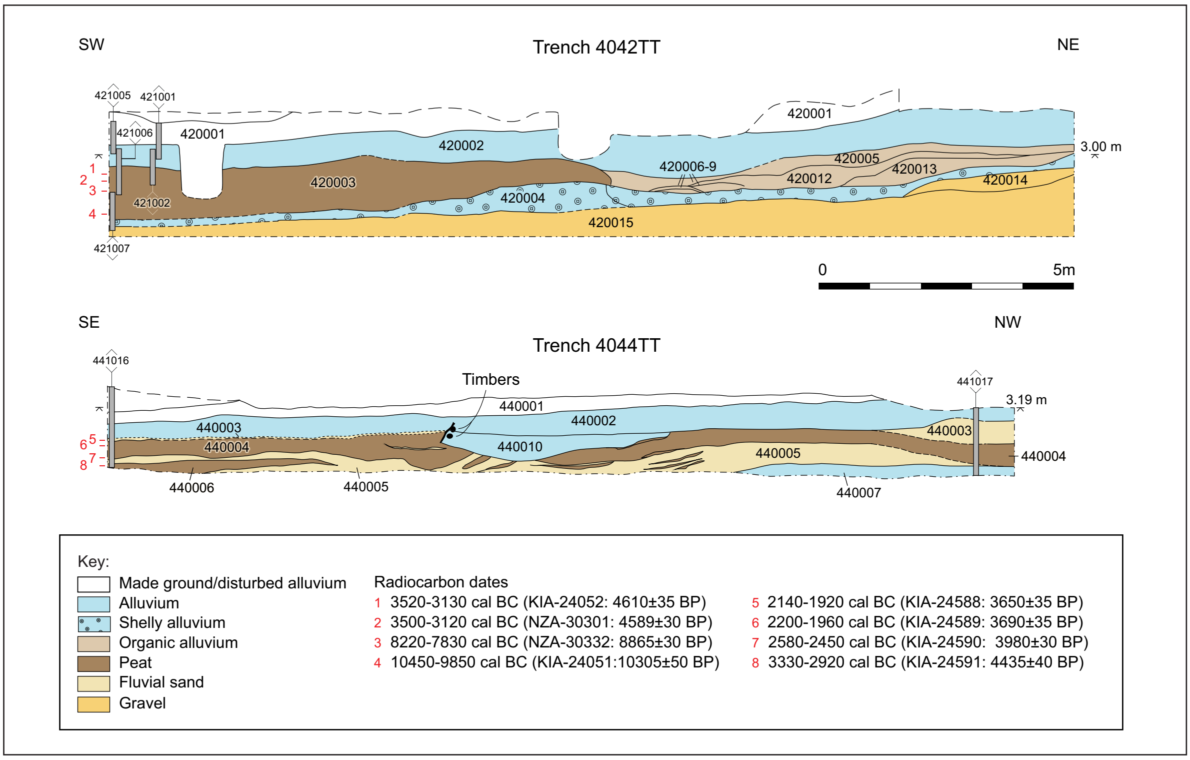

Figure 36 Cross-section through trenches 4042TT and 4044TT at Temple Mills

Table 18 Temple Mills palaeoenvironmental summary

4042TT	**4044TT**	**^{14}C years BP**	**Lithological summary**	**Palaeoenvironmental summary**	**Inferred human activity**
420001	440001		Weathered clay-alluvium and made ground	Semi-stable landsurface with soil formation	17th and 18th century artefacts
	440002		Clay-silt and organic alluvium	Slow moving or stagnant water. Reduction of tree cover in local environment	Charred wetland plant remains indicate local burning activity on floodplain
	440003		Tufa sand and pellet gravel	Old land surface formed on fluvial gravels	Burnt flint on weathered surface possibly indicative of human activity in Early Bronze Age
	440004	3650±35 (KIA-24588) 3690±35 (KIA-24589) 3980±30 (KIA-24590)	Woody peat and peaty alluvium	Alder carr dominates local wetland	
	440005		Sand	Moderately fast flowing water close to channel edge	
	440006	4435±40 (KIA-24591)	Sandy-woody peat		
420002		*4610±35 (KIA-24052) *4589±30 (NZA-30301)	Clay-silt alluvium	Initial expansions of lime, ash and alder woodland	
420003		8865±30 (NZA-30332)	Peat	Expansion of mixed oak woodland	
		10305±40 (KIA-24051)		Fen developed locally with expansion of tree cover (pine)	Peak in micro-charcoal which may be the result of deliberate on-site burning
420004			Tufa sand and pellet gravel	The terrestrial environment was dominated by herbs with marshland in places. Locally channel conditions were characterised by slow-flowing or stagnant pools of water perhaps under cool conditions	
420015	440007		Sands and gravels	High energy braided channel environment under cold climate conditions	

* Dates suspected as being erroneous (too young) TT = trench

'diving beetle' *Stictotarsus duodecimpustulatus*, the hydreanid *Hydraena riparia* and the 'riffle beetle' *Esolus parallelepipedus*, all of which are typical of this type of water condition (Nilsson and Holmen 1995; Hansen 1986). The occurrence of species that indicate the presence of areas of both fast and slow flowing water in the same insect fauna is not uncommon in the palaeoentomological record. This is particularly true where main river channels interact with a range of oxbow cut-offs, slow back channels and fen swamps in large multi-channelled river systems (ie, Osborne 1988; Greenwood and Smith 2005; Smith 1999; Smith and Howard 2004). Unfortunately, there were very few indicators for the nature of the landscape that surrounded the watersides at this time. The only species that is specifically indicative of surrounding vegetation is *Lochmaea suturalis*. This is the 'heather beetle' and, as the name suggests, it feeds on heather (*Calluna* spp./*Erica* spp.) in moorland and heathland. There are no indicators for the presence of woodland or scrubland in the area. However, none of the distinctive species associated with glacial climates in general, and the Late Glacial in particular, were recovered in these faunas (ie, Atkinson *et al* 1987; Coope 1977; Coope and Brophy 1972). This probably suggests that the material dates either from the Windermere interstadial or from some point in the Early Holocene.

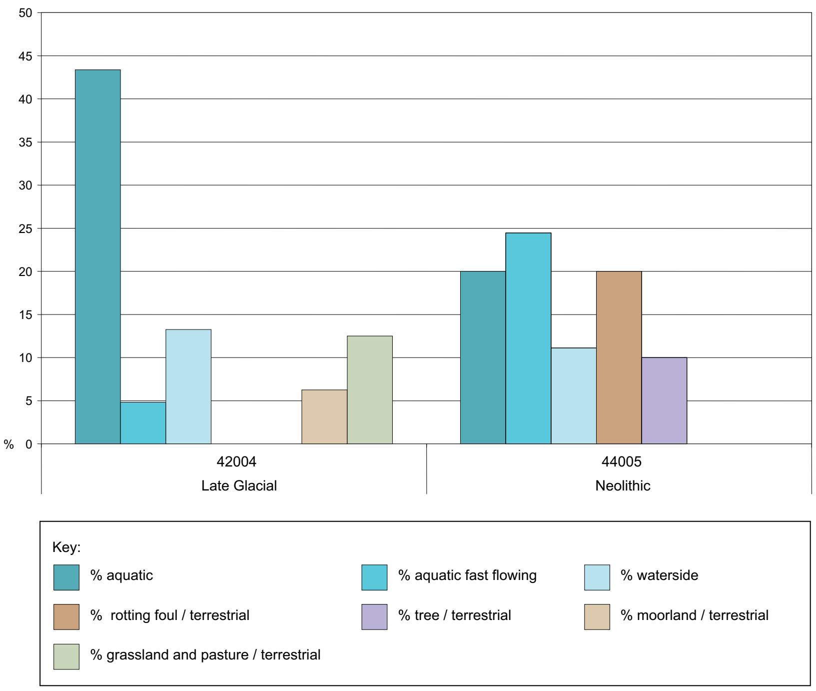

Figure 37 The proportions of the ecological groups for the Coleoptera from Temple Mills from Late Glacial and Neolithic contexts

Pollen from the shelly silt and the lower parts of overlying peat (PAZ TR4042–2, Fig 38) show an environment dominated by herbs, including Poaceae (grasses), Cyperaceae (sedges) and *Filipendula* (dropwort/meadowsweet). *Pinus sylvestris* (pine) and *Betula* (birch) are also present in low amounts, with some pollen grains of the latter probably derived from *Betula nana* (dwarf birch). *Juniperus communis* (Juniper), *Populus* (probably derived from *Populus tremula*, aspen) and *Salix* (willow) are also present and are typical of a Late Glacial assemblage. A number of typical Late Glacial pollen types are identified including *Helianthemum* (rock-rose) and *Polemonium caeruleum* (Jacob's ladder), along with an increase in *Filipendula* which is recorded within many contemporary dated sequences from along the Lea Valley (eg, Stratford Box, Barnett *et al* forthcoming; Enfield Lock, Chambers *et al* 1996; Innova Park, Ritchie *et al* 2008; Olympic Park, Powell 2012). The rise in *Filipendula* is often interpreted as indicating a response to rising temperatures after the end of the last glaciation (*cf* Barnett *et al* forthcoming), though it could be attributed to two different species of *Filipendula* likely to be present at this time – *Filipendula vulgaris* (dropwort), associated with steppe vegetation (Bell 1969; Godwin 1975, 183), or *Filipendula ulmaria* (meadowsweet), found in marshy habitats (suggested by the high values of Poaceae and Cyperaceae) and often associated with *P. caeruleum* (Godwin 1975).

The local wetland environment is also represented by *Typha latifolia* (bulrushes), *Sparganium emersum*-type (bur-reeds), *Potamogeton natans*-type (pondweed), *Myriophyllum verticillatum* (whorled water-milfoil) and *Myriophyllum spicatum* (spiked water-milfoil), suggesting slow-moving water conditions. It is likely that *Ranunculus acris*-type (buttercup) is also associated with this environment. A number of large Poaceae grains are present within these basal samples, and are within the size range that is commonly associated with cereals. Similar contemporary deposits from the Holderness area, Yorkshire (Tweddle *et al* 2005), yielded pollen grains of a similar size, identified as belonging to Poaceae groups outlined by Küster (1988) of *Bromus hordeaceus*-type (soft brome), *Glyceria*-type (sweet-grass) and very occasionally *Cerealia*-type (cereals). The exact species/types identified here is uncertain (due to the pollen methodology applied at the time of analysis), though those distinguished in contemporary sequences from the adjacent Olympic Park were found to be predominantly *Glyceria*-type (Powell 2012).

Alnus glutinosa (common alder), *Quercus* (oak) and *Corylus avellana*-type (hazel) pollen are also present in low amounts, yet it is unclear whether they are derived from reworked material, long-distance transport or the existence of small localised stands. For *A. glutinosa* a local presence is supported by the presence of a single *Alnus* seed within these deposits which is thought to be contemporary and not derived from reworked material. It is not clear which species of *Alnus* the seed is derived from (or indeed the pollen), though it is most likely that this may be derived from *A. incana* (grey alder) rather than *A. glutinosa*, as the former is more likely to be associated with the contemporaneous climatic conditions. *Quercus* is not thought to be derived from local stands but more likely derived from reworked material (see below) or long distance transport. Godwin (1975, 279) notes that in a number of Late Glacial (Late Weichselian) pollen diagrams there is a low presence of *Quercus* that increases through the Early Holocene. He attributes this to long-distance transport, with

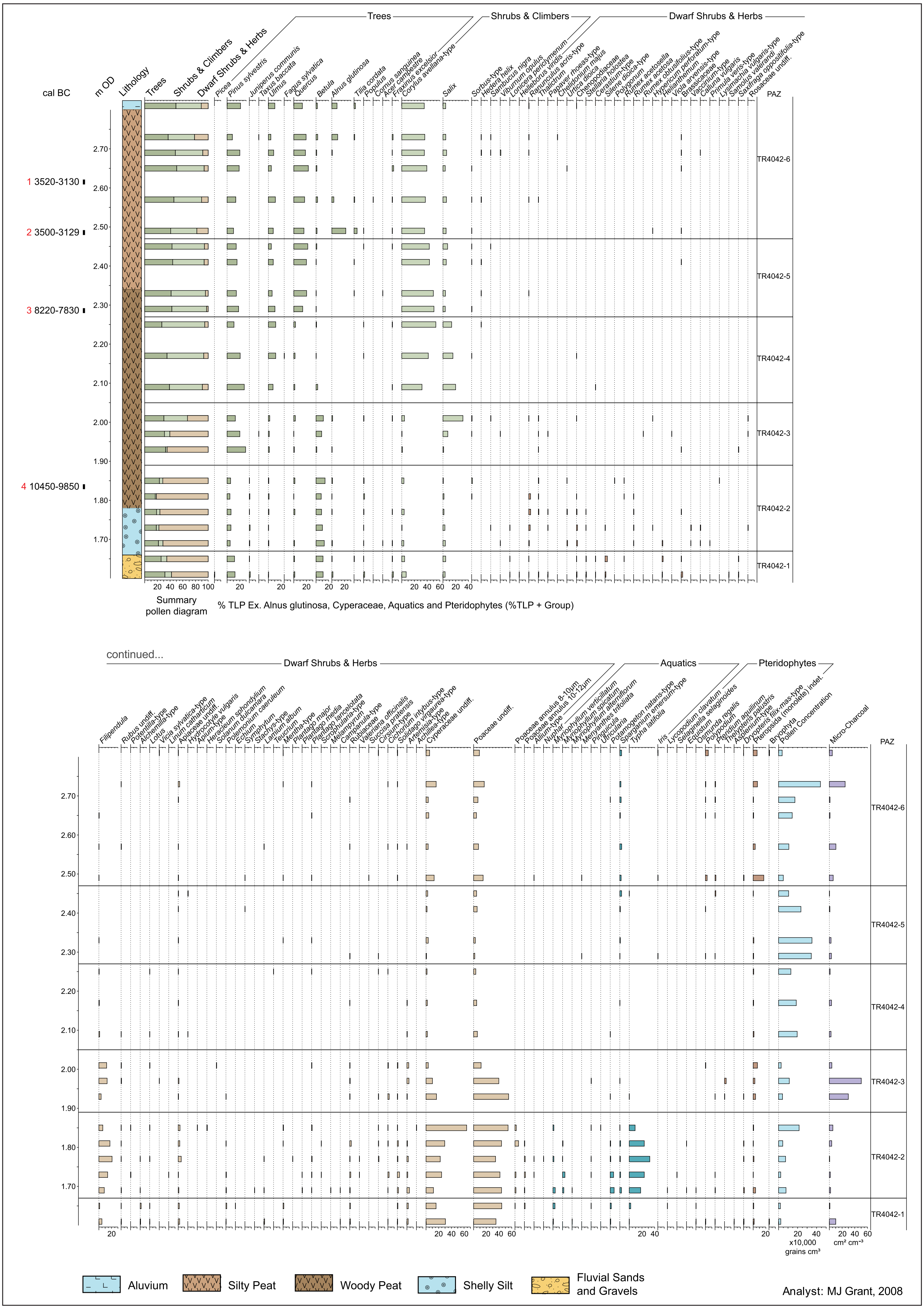

Figure 38 Pollen diagram from 4042TT

the slow increase in values representing expansion away from its glacial refuge. It is also possible that *C. avellana*-type pollen is derived from similar processes to *Quercus*. However, *C. avellana*-type also incorporates pollen derived from *Myrica gale* (bog myrtle), as it is often difficult to separate these two species (Edwards 1981) especially if they are poorly preserved. The earliest (albeit tentative) record of *M. gale* in the UK is from the Late Glacial (Skene *et al* 2000, 1090), with leaves of *Myrica gale* found locally at the Crown Wharf Ironworks site on the opposite side of the Lea Valley dating to *c* 9000–8000 cal BC (Stephenson 2008). The modern distributions of *M. gale* indicates an abundance in areas of swamp, often associated with *Phragmites australis* (common reed), *Cladium mariscus* (great fen sedge) and *Carex* sp. (Skene *et al* 2000, 1081), similar to the vegetation community represented in this sequence. It is therefore possible that small patches of *M. gale* may have existed at this time within the Lea Valley, accounting for the early low presence of *C. avellana*-type pollen.

The shelly silt also contained waterlogged plant remains (*Table 15*) of mainly aquatic species including *Chara oogliana* (stonewort), *Ranunculus* subg. *Batrachium* (water-crowfoot), *Ceratophyllum demersum* (hornwort), *Potamogeton* sp., *Schoenoplectrus lacustris* (bristle club-rush) and *Cirsium/Carduus* sp. (thistle), representing vegetation growing towards the waters' edge. *Chara* sp. are submerged aquatic algae found in still brackish or fresh bodies of calcareous water, such as ponds, lakes and ditches. As they thrive in low nutrient conditions they are often characteristic of the first colonisers of newly formed water bodies, and normally later displaced by vegetation as nutrient levels increase. Similarly *C. demersum* is more characteristic of pond, ditches or very slow flowing rivers.

The freshwater ostracod assemblage from the shelly silt is shown in *Table 16*. Eight species were recorded but the assemblages were very similar between samples. Ecologically, the ostracods seem to suggest a permanent pool with lots of vegetation. Although all the ostracod species live in Britain today, several are characterised by Meisch (2000) as cold stenothermal forms (species linked to permanently cold waters) – *Candona candida*, *Fabaeformiscandona protzi* and *Pseudocandona rostrata* – and make up the bulk of the fauna. Moreover, these species, together with *Eucypris pigra*, are northern European and Holarctic forms which are rare in southern Europe today. This could be construed, therefore, as supporting a cold climate during the end of the Late Glacial; although some other characteristic species thought to have become extinct at this time (eg, *Leucocythere batesi*, *Ilyocypris schwarzbachi*, *Limnocythere falcata* and *Amplocypris tonnensis*) are notably absent from the assemblage.

A single rich mollusc sample from context 420004 produced a freshwater dominated assemblage, with terrestrial elements only accounting for 1% of the total (*Table 17*). The freshwater snails are dominated by three species: *Valvata piscinalis*, *Gyraulus laevis* and *Gyraulus crista*. *V. piscinalis* favours larger bodies of slowly flowing or still water, with a preference for muddy or silty substrates, while *G. laevis* is found very locally in clean, quiet water usually among weeds. *G. crista* lives in most kinds of lowland aquatic habitats apart from those liable to dry up. The high number of opercula (mouth coverings) to shells of *Bithynia* spp. in this sample, a ratio of 13:1, may indicate that the context was laid down under fairly low energy fluvial conditions at this location. The occurrence of *Lymnaea truncatula*, *Succinea oblonga* and *Pupilla muscorum* in the assemblage is likely to indicate the local presence of poorly vegetated areas, such as bare mud in marshes. Although possibly intrusive from the overlying peat, a small number of shells (less than 2% of the assemblage) were identified as specimens of *Gyraulus albus*, *Planorbis carinatus* and *Bithynia leachii*, three species believed to be introduced in the Early Holocene period. These species would all be found in the slowly flowing, permanent, well vegetated aquatic environment generally indicated by the assemblage.

Peat

Subsequently, organic input increased and peat (context 420003) formed in shallow standing water in the deepest (central) part of the channel. This peat was exposed in trench 4042TT and, to a lesser extent, 4043TT. A carr/fen environment is indicated by large quantities of wood and some *Phragmites* within the peat, the latter suggesting emergent reed communities. A date of 10,450–9850 cal BC (KIA-24051, 10,305±50 BP), from the base of the silty clay peat in 4042TT indicates that peat formation began during the end of the Late Glacial. At the top of the sequence there are two upper radiocarbon dates of 3500–3120 cal BC (NZA-30301, 4589±30 BP) and 3520–3130 cal BC (KIA-24052, 4610±35 BP), derived from a twig fragment and *Phragmites australis* stem respectively. However this dating appears too young, especially when the pollen from the top of the sequence is compared to the contemporary pollen sequence in the base of Trench 4044TT. The problem of dating the top of these early sequences in the Lea Valley is also encountered at the nearby sites of Omega Works (Spurr 2006), Enfield Lock (Chambers *et al* 1996), and on the Olympic Park (Trench 71; Powell 2012) and it is probable that later intrusive material might be responsible for the dating issues encountered at these sites (see chapter 8 in Powell (2012) for details). Therefore the length of peat formation is unclear, though it can be assumed, based upon the pollen assemblage (emerging *Alnus glutinosa* and consistent presence of *Pinus sylvestris* at the top of the sequence), that it is only likely to extend up to *c* 7000–6000 cal BC. Raised gravel areas to the west, east and north, not subject to peat accumulation, may have been relatively dry at this time, allowing use and access to the fen and aquatic resources. However, no clear indication of an old (buried) land surface was been identified at the top of the sands and gravels and below the overlying alluvium during examination of the monoliths.

Pinus sylvestris pollen expands (obtaining values of greater than 20% TLP) at the start of PAZ TR4042–3 towards the base of the peat. An early expansion of *P. sylvestris* has been recorded in number of sequences from other lowland sites across southern Britain. Increases of *P. sylvestris* to values above 20% TLP occur at Bagshot, Surrey (Groves 2008), and Silvertown, London (Wilkinson *et al* 2000), at *c* 9550 cal BC, at Pannel Bridge, East Sussex (Waller 1993) prior to *c* 9550 cal BC and at Gatcombe Withy Bed, Isle of Wight (Scaife 1987) prior to 9450 cal BC. A threshold of 20% TLP is commonly applied to *P. sylvestris* to indicate local presence as the tree produces a large amount of pollen that is well dispersed (Bennett 1984).

However, the low sustained values of *P. sylvestris* in preceding levels may indicate small isolated stands rather than the pollen being derived purely from long-distance transport.

The increase in *Pinus sylvestris* coincides with a peak in micro-charcoal which may be the result of deliberate on-site burning, possibly to promote reed growth, as has been found in other lowland sites of a similar age (eg, Thatcham, Barnett 2009; Star Carr, Mellars and Dark 1998). At Star Carr, Mellars and Dark (1998, 231) suggest that the burning of reedswamp could have been undertaken to either improve the production of certain lakeside plants as a food resource, or alternatively is related to hunting strategies by attracting animals to graze on the new growths of reeds and other plants. The pollen assemblage contains a number of changes associated with this peak in micro-charcoal, including an increase in *Pteridium aquilinum* (bracken) with a temporary drop in *Filipendula* and *Betula* values, suggesting disturbance located along the wetland edge. The increase in *P. sylvestris* coinciding with the increase in micro-charcoal could suggest that fire may have played an important role during its expansion, as it is known to positively respond to a moderate-severity fire regime (Agee 1998), and could suggest a natural source of the burning rather than being purely of anthropogenic origin (eg, Grant *et al* 2009). The formation of an underlying mat of peat would have also made the local reed beds more susceptible to burning. The decrease in micro-charcoal coincides with an increase in *Betula*, *Filipendula* and *Salix*, but no recovery to high values of Cyperaceae and Poaceae. The local vegetation is now very different from that found previously, with *Salix* and *P. sylvestris* being more extensive within the floodplain environment, colonising dryland areas between the palaeochannels and also forming damp woodland upon the peat deposits within these channels.

At the base of PAZ TR4042–4 there is an expansion of *Ulmus* (elm) and *C. avellana*-type upon the local dryland. This is later followed by the expansion of *Quercus* that has been dated to 8220–7830 cal BC (NZA-30332, 8865±30 BP; base of PAZ TR4042–5). During this time the amount of *Salix* reduces, possibly with additional reductions caused by its distancing from the sample site. *Pinus sylvestris* still remains an important component, though does undergo some reduction in its abundance and/or distribution. The arrival of deciduous trees would have restricted the habitats available to *P. sylvestris*. However, *P. sylvestris* values show little change suggesting that it remains competitive, though it is likely that a large amount of this pollen is derived from *P. sylvestris* growing within or on the edge of the floodplain zone.

Upper alluvial deposits

Minerogenic input increased towards the top of the peat, with clay added by fluvial activity. A further increase in river activity is then indicated by the deposition of a thick amorphous gleyed alluvial clay unit across the site (contexts 420001/2). The raised gravel areas were also affected, showing the same alluvial unit, perhaps deposited directly by channel flow, although deposition by overbank sedimentation is not discounted. A wide, active river channel is, therefore, indicated with channel (and possible overbank) deposits extending across the area assessed. A broad N–S channel orientation, as identified during geotechnical investigation (Fig 34), is supported. The channel is suggested to have formed a tributary of the River Lea.

Pollen from base of PAZ TR4042–6 records an initial expansion of *Alnus glutinosa*, *Tilia cordata* (small-leaved lime) and *Fraxinus excelsior* (ash). However, as stated above, the associated radiocarbon date (3500–3120 cal BC, NZA-30301, 4589±30 BP) is thought to be erroneous, especially as the neighbouring sequence from Stratford Box (Barnett *et al* forthcoming) shows the presence of *Tilia cordata* and dominance of *A. glutinosa* locally by 6000–5790 cal BC (NZA-32948, 7014±40 BP, *cf* Powell 2012). Typical dates for the expansion of these taxa at other sites across southern Britain are *c* 7500 to 5000 cal BC for *A. glutinosa* and *c* 6000 to 4000 cal BC) for *T. cordata* and *F. excelsior* (eg, Birks 1989).

The expansion of *A. glutinosa* coincides with a peak in micro-charcoal. The occurrence of fire is commonly associated with the expansion of *A. glutinosa* at a number of sites across the UK (eg, Smith 1970; Bennett *et al* 1990; Edwards 1990; Edwards and McDonald 1991; Grant *et al* 2009; Grant and Waller 2010), but it is still unclear whether this is a natural process or the result of anthropogenic activity. Fluctuations in *A. glutinosa* values prior to its successful establishment are common in sequences from southern Britain (eg, Pannel Bridge; Waller 1993), often interpreted as reflecting fluctuating ground water levels in addition to burning and disturbance factors. Changes in the ground water level are supported by increases in Cyperaceae, Poaceae, Pteropsida (monolete) indet. and *Sparganium emersum*-type suggesting wetter conditions. The increase in the minerogenic component of the silty peat unit towards its top would suggest that overbank flooding became increasingly common, allowing more rapid sediment deposition and incorporation into the peat. This is followed by the deposition of thick overlying amorphous gleyed alluvial clays, including deposition over raised gravel areas, and likely indicating extensive flooding.

At some UK sites the expansion of *Alnus glutinosa* occurs at the expense of *Pinus sylvestris* which Bennett (1984) suggests is due to *A. glutinosa* being more competitive than *P. sylvestris*, leading to the latter's demise. At this site, however, *P. sylvestris* continues to play an important role within the local vegetation with no clear sign of succession occurring, though in part this may be related to fluctuating water levels affecting the successful establishment of *A. glutinosa* on-site initially limiting competition. *P. sylvestris* values are greater than 20% TLP at several levels – though there is the possibility that some of the *P. sylvestris* pollen towards the top of the sequence in 4042TT may be derived from reworked sediments, as the amount of minerogenic sediment increases upwards. However, the taxa present within the pollen assemblage do not indicate a strong presence of reworked pollen, with pollen concentrations and preservation both good, so it is likely that the *P. sylvestris* is of a contemporary nature.

An immature (azonal) soil has been identified at the top of the palaeochannel sequence and in one profile (4038TT) was found to contain 17th/18th century pottery, brick and tile fragments, indicating relatively recent formation and use as a stable land surface. The soil was formed on alluvium, which itself showed indications of desiccation and terrestrialisation, notably extensive movement and redeposition of iron oxides through the profile. Disturbance by bioturbation below the soil was, however, apparently minor, with humified root voids in occasional recovered sequences, notably in the upper alluvial clay. In 4038TT, this soil (context 380002) was eroded/truncated by another unit of gleyed alluvial clay (context 380001), indicating formation or redirection of an existing river channel relatively recently.

Trench 4044TT

Interbedded sand and peat

A woody peat (context 440006) was identified interbedded with sand (context 440005) at the south end of 4044TT, palaeochannel sequence 2 (Fig 36). The base of the peat dated to 3330–2920 cal BC (KIA-24591, 4435±40 BP), slightly younger than the upper radiocarbon date from the top of the peat in 4042TT. The pollen assemblages are very different between these two assemblages further supporting the assertion of erroneous radiocarbon dates from the top of the sequence in 4042TT. The basal sandy peat sequence was overlain by a more extensive peat (context 440004).

The sand (context 440005) produced a rather small assemblage of insects (*Table 13*). The majority of these are not very helpful in terms of reconstructing the landscape. However, there are a few species present which provide limited evidence for water conditions and the surrounding environment. A range of species of Elmid 'riffle beetles' were recovered, which are typical of fast flowing waters, often flowing over clear sands and gravels. Taxa such as *Hydraena riparia, Macronychus quadrituberculatus* and the Oulimneus species are frequently recovered from these habitats (Hansen 1986; Holland 1972). *M. quadrituberculatus* appears to be particularly associated with larger fast flowing rivers in the archaeological record where gravel river beds and deep pools are present (Greenwood and Smith 2005; Smith and Howard 2004). Slow flowing areas of water, or still waters along river banks, are also suggested by the presence of the 'reed beetle' *Plateumaris braccata* which is associated with *Phragmites australis*. Finally, there is limited evidence from the insect fauna for the nature of the surrounding vegetation in the area at the time of the deposits formation. This is indicated by *Hylesinus crenatus* which is associated mainly with *Fraxinus excelsior* and *Phleoephagus lignarius* which is found in the deadwood of a range of hardwood trees (Koch 1992). There are many earthworm granules in this context which signifies a local source of a more terrestrial nature.

A total of 1257 shells from a relatively wide range of species (24 taxa) were also retrieved from this context (*Table 17*). The terrestrial element only represented 2% of the total assemblage, with shells generally from species which favour shady grassy or marshy environments. There is an indication of some marshy areas, which may well have been liable to dry out at times, together with poorly vegetated areas on the channel margins. These environments would have been exploited by *Lymnaea truncatula, Anisus leucostoma* and the terrestrial species. The fresh water element of this assemblage is dominated by *Valvata piscinalis* and *Bithynia tentaculata*, with significant numbers of *Gyraulus crista, Valvata cristata* and *Bithynia leachii*. The occurrence of *Ancylus fluviatilis*, although only in small numbers, within this assemblage may indicate small patches of quick-flowing or even turbulent water, in the vicinity of this area of the channel, such as scour along the channel edge. The ratio of 1:3.5 of opercula to shells of *Bithynia* spp. in this sample is again indicative of low energy fluvial conditions at this location, though perhaps slightly faster flowing than associated with sample 421003. The two dominating species thrive in large bodies of slowly-moving, well-oxygenated water with a preference for muddy or silty substrates with dense growths of aquatic plants, also suitable for the other significant mollusc species found.

The pollen sequence from 4044TT (Fig 39) contains much higher values for *Alnus glutinosa* than at the top of 4042TT, indicating that by the time the peat began to form it was well established and has probably formed alder carr woodland on-site. The dryland woodland is also better represented in 4044TT, with higher values for *Tilia cordata*, *Quercus* and *Fraxinus* excelsior, but lower for *Ulmus* and *Corylus avellana*-type.

While the sediments from 4044TT demonstrate significant fluvial activity there is little variation in the pollen assemblage during these phases. *Corlyus avellana*-type is found to be slightly higher during the main phase of peat accumulation (Zone TR4044–2) with reductions in Poaceae and Cyperaceae. There is also a reduction in *Polypodium*, Pteropsida (monolete) indet. and *Pinus sylvestris*, now a minor component of the local vegetation. This may suggest that the sediments in PAZ TR4044–1 contain some reworked pollen, as these taxa are more resistant to damage and are easier to recognise when corroded than other pollen types. Low pollen concentrations also help to support the suggestion of possible over-representation of damage resistant pollen and spores. There are occurrences of disturbance indicators such as *Plantago lanceolata* (ribwort plantain) and *Pteridium aquilinum* throughout PAZ TR4044–2, yet there are no distinct disturbance phases recorded within the dryland or wetland assemblages. Micro-charcoal values remain low supporting the suggestion of limited disturbance. The high *Alnus glutinosa* values, indicating the presence of alder carr, may account for the limited local disturbance. Although alder carr can provide useful resources, the vegetation is often of a closed nature with wet and boggy ground, hindering easy movement. The closed nature of the alder carr canopy would have also resulted in a certain amount of pollen and micro-charcoal filtration, reducing any observable disturbance signals from the dryland or the wetland–dryland edge.

The main peat body in the trench (context 440004) contained large fragments of apparently *in situ* mature wood of *Alnus glutinosa* (mainly twig and branch material) that clearly demonstrate the presence of alder carr in the immediate area. A bed of sand-sized tufa with occasional oncoliths (context 440003) rested on the peat at the northern end of the trench and suggests moving water for a time at least. This unit thinned considerably to the south where it was only 60mm thick. The occurrence of wood and a fire-cracked flint in this horizon suggests that the surface of this unit may have been exposed for some time as a land surface, which was used by local populations. The layer has been dated to 2140–1920 cal BC (KIA-24588, 3650±35 BP), of Early Bronze Age date, not uncommon for the peat units of Central London (Sidell *et al* 2000; Sidell *et al* 2002). A thin peat layer above indicates that the immediate area became marshy once again.

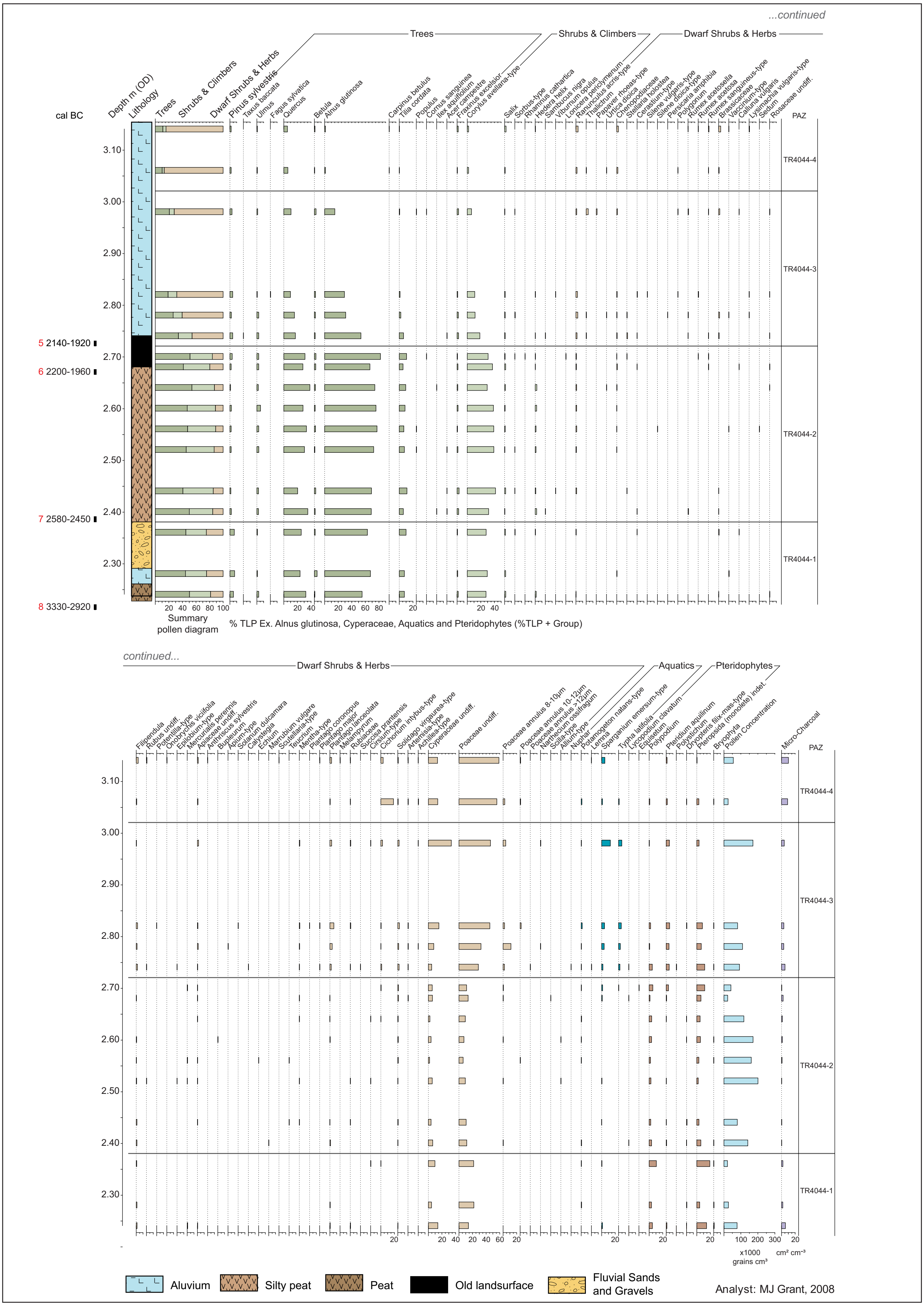

Figure 39 Pollen diagram from 4044TT

Upper alluvial deposits

Subsequent deposition of the massive alluvial silts and clays (context 440002) indicate a return to channel influenced sedimentation, the fine deposits indicative of a low energy regime and/or overbank sedimentation during flood events.

Only one species of ostracod, *Cypria opthalmica*, was noted in the upper part of the deposit. These were preserved as flexible organic valves, the calcium carbonate presumably having been decalcified. *C. ophtalmica* is remarkably tolerant to a wide range of environmental factors (Meisch 2000), including high organic pollution. It occurs in permanent and temporary, stagnant and flowing waters. Its occurrence in ponds and streams choked with leaf-litter is also well known. Its single occurrence may be an artefact, however, as other ostracod species, if present, may have been totally destroyed by the acidic nature of the water or sediments. The occurrence of ostracods in the upper part of context 440002 is mirrored by the occurrence of cladocerans (water-fleas), as indicated by the preservation of their organic-walled ephippia (egg-cases). Both ostracods and cladocerans have the same ecological requirement. Towards the middle part of the context testate amoebae belonging to one species of *Difflugia* have been noted. They live in all manner of moist and fresh water habitats from moss, soil, peat, to standing water (Ogden and Hedley 1980).

The main changes in the pollen diagram from 4044TT occur over the PAZ TR4044–3/4 boundary, associated with the buried surface at the top of the peat prior to its inundation by minerogenic alluvium. This transition of Early Bronze Age date contains a reduction in trees and the expansion of Cyperaceae, Poaceae, large Poaceae grains and aquatic pollen types. There are increases in *Plantago lanceolata* and *Pteridium aquilinum* that coincide with the reduction in tree pollen. This could suggest (along with the burnt flint from the landsurface) some human activity and disturbance upon the site during the Early Bronze Age. Human activity in the Lea Valley area is known to have been extensive during the Bronze Age (Corcoran *et al* 2011) and so human impact within the woodland is to be expected around the Temple Mills site. *Tilia cordata* is known to have been extensive across the Greater London area and existed as a major component until its demise during the Late Neolithic–Bronze Age (eg, Scaife 2000, 113–115; Rackham and Sidell 2000, 23; see Grant *et al* 2011), though a later Roman decline has been found at the Lodge Road site, Epping Forest (Grant and Dark 2006). This has often been attributed to human activity, supported by increases in *Cerealia*-type pollen grains and other anthropogenic indicators. However, Waller and Grant (2012) have demonstrated in the Lower Thames that these changes can be the result of wetland changes alone, with the apparent increases in *Cerealia*-type pollen grains actually derived from local wetland grasses that increase in abundance as the alder canopy reduces and the wetland makes a transition from alder carr to open marsh. Investigations on the Olympic Park (Powell 2012) also demonstrated that many of the large Poaceae grains attributed to cereals were derived from wetland grasses, increasing as the canopy opened. The only occurrences of *Cerealia*-type pollen grains found on the Olympic Park were directly associated with settlement sites on the floodplain edge. At the Temple Mills Depot the decline in *T. cordata* does coincide with the transition from organic (peat) to minerogenic sedimentation and may indicate, as suggested above, that the clastic sediment deposition, lateral wetland expansion and transition in the wetland vegetation is responsible for the observed decline in *T. cordata* values.

The increasing Poaceae values are likely to be derived from vegetation within the floodplain, such as *Phragmites australis*, with Cyperaceae also growing along channel margins and cut-offs. The large Poaceae grains, as already stated, are most likely to be derived from wetland grasses such as *Glyceria* rather than cultivated cereals. The aquatic pollen present is indicative of slow-moving water and marshy conditions with *Typha latifolia*, *Sparganium emersum*-type and *Potamogeton natans*-type present. Although there is a sharp stratigraphic boundary between the old land surface and the overlying alluvium, the decline in *Tilia cordata* (and other trees and shrubs) occurs gradually (over multiple sample depths) suggesting that the wetland vegetation transition upon the floodplain is also gradual and that the sequence does not contain a large hiatus (though the development of an immature (azonal) soil does suggest that some form of stasis in sedimentation had occurred).

The decline in *Tilia cordata* recorded in 4044TT (Fig 39) can therefore only be interpreted as an apparent decline due to the changes in local processes rather than actually relating to its decline upon the dryland itself. A decline in *T. cordata* and other woodland taxa probably occurred around the site at this time due to dry land clearance but it is not possible to reliably identify this within the pollen sequence due to the dominance of the wetland pollen signals, particularly Poaceae and Cyperaceae. However, the opening up of the floodplain vegetation (transition towards open marsh) would have made this area more suitable for pastoral activity, as shown by the construction of timber structures (platforms and trackways) and evidence of animal husbandry along the Thames Estuary at this time (Meddens 1996; Meddens and Sidell 1995; Stafford *et al* 2012; Carew *et al* 2009).

Waterlogged plant macrofossils also indicate more open conditions in context 440002, including the presence of species of disturbed/open ground, including *Chenopodium album* (fat-hen), *Atriplex* (orache), *Ranunculusacris/repens/bulbosus* (buttercup), *Persicariahydropiper* (water pepper), *Rumex* sp. (dock) and *Carex* sp. Indications of scrub are also present with fruits of *Alnus glutinosa*, *Rubus* sp. (bramble) and thorns of *Crataegus/Prunus* sp. (hawthorn/sloe).

Discussion

The palaeoenvironmental evidence from the two trenches at Temple Mills Depot provides a record of landscape and vegetation change dating from the Late Glacial through to the Bronze Age. Detailed analysis of the pollen record suggests a considerable chronological break between the two sequences, even though the radiocarbon dates could suggest closer continuity. Alternations between fluvial activity and peat formation dominate the record, with vegetation associated with channel activity present at the start, developing into alder carr as fluvial activity weakened (possibly through the channel becoming an abandoned cut-off) in this location. Channel flow shifted in this area of the floodplain prior to the development of open marshy conditions and increased overbank flooding. The evidence also indicates that through time the foci of deposition shifted across the floodplain and consequently infilling of channels may have occurred in one place prior to deposition commencing elsewhere. However, at the site level the Temple Mills Depot sequence seems to provide an intact record of the Late Glacial to Early Holocene transition, with the introduction and expansion of temperate woodland observable.

Among the key points identified are the following:

- The presence of Late Glacial/Early Holocene pollen of *Alnus* sp. coincides with the presence of a seed of *Alnus* sp. which is likely to be *in situ*. This suggests an early presence of *Alnus* in the landscape, and may indicate the local presence of *Alnus incana*. This adds to a growing amount of evidence that indicates the presence *Alnus* sp. in the British Isles at this time (eg, Waller 1993);
- Micro-charcoal analysis has identified that fire coincides with vegetation transitions in both trenches (Figs 38 and 39). It is possible that during the Early Mesolithic reedbeds were being burnt, either to improve plant yields or to attract game;
- The decline of *Tilia cordata* around Temple Mills during the Early Bronze Age, although occurring at the same date as other declines attributed to anthropogenic drivers, is related to changes in floodplain dynamics that affect the pollen load rather than an actual decline of woodland upon the dryland;
- The presence of Early Holocene insect faunas is significant because the archaeoentomology of London is particularly under-researched. Although a range of Roman, Saxon and medieval deposits from Central London have produced insect faunas (ie, Smith 1997; 2002; 2006a; Smith and Chandler 2004) very few date from the earlier Holocene. This paucity is more significant because despite a range of investigations of Early Post-glacial deposits throughout the area of Greater London (ie, Chambers *et al* 1996; Lewis *et al* 1992; Sidell 2000; Sidell *et al* 2000; 2002; Thomas and Rackham 1996) none of these sites, except for a very small fauna from Bramcote Green (Thomas and Rackham 1996), Olympic Park (Powell 2012) and Runnymede Bridge (Robinson 2000a), has included any reports on any associated insect remains. This situation gives the possible Early Holocene insect fauna from Temples Mills some regional importance despite its deficiencies;
- Insect faunas of the later Holocene, particularly the Neolithic from the area that is now Greater London, are also under-researched. The only sites with proven Neolithic insect faunas in the Greater London area are at Runnymede Bridge, Surrey (Robinson 2000a), West Heath Spa, Hampstead (Girling 1989) and Altas Wharf, Isle of Dogs (Smith 1999) (though also see Elias *et al* 2009). Again, despite its limitations, the Neolithic insect faunas from Temple Mills are of some importance. Locally, the only other sites in the area that have produced insect faunas are that of the Anglo-Saxon deposits examined at Glover Drive, Edmonton (Smith 2006b) and the Olympic Park (Powell 2012).
- A picture of a dynamic and often unstable landscape has been presented. This mosaic environment offered rich wetland resources to local populations, with temporary stable landsurfaces becoming available and exploited during the Neolithic and Bronze Age.