PART III: DISCUSSION

Chapter 8: Landscape and environment

The sediment sequences and environments of deposition (Fig. 8.1)

Several recurring sedimentary units and facies types were identified throughout the route sections during the initial fieldwork stages, correlated through detailed lithological description as well as associated features and artefactual assemblages (Appendix 2). Interpretation of the sequences was enhanced during the assessment and analysis stages with a programme of radiocarbon dating (Appendix 1), together with detail provided by the examination of palaeoecological indicators (Appendix 3).

Superficially the Holocene sequences can be correlated with the typical Thames tri-partite sequence of clay-silt, peat and clay-silt as described by Long *et al.* (2000) and in general there are similarities with profiles recorded in other areas of the Lower Thames floodplain (for example Devoy 1979; 1982). For the purposes of this discussion general correlations have been made within and between sites and with the Cultural Landscape Model (CLM) of Bates and Whittaker (2004) referred to in Chapter 2 (Table 1.3), in order to contextualise the associated archaeological remains (Table 8.1). There are, however, differences, as the sequences from the A13 sites can be traced into edge marginal sequences that abut the rising gravel terraces. The investigations have demonstrated that significant complexity exists within the sediment sequences at terrace edge locations and in the vicinity of palaeochannels, particularly at Movers Lane. Here, sequences are a reflection of complex local as well as regional factors. Figure 8.1 provides a summary of the key sample sequences examined from each site and Figure 8.2 shows the site locations.

The following section briefly describes the key characteristics of each CLM Stage as presented in Bates and Whittaker (2004), followed by a summary of the evidence recorded during the A13 investigations.

Late Pleistocene (Fig. 8.3)

The sequence of Pleistocene river terrace formation in the Thames is relatively well-documented (eg Bridgland 1994; Gibbard 1977; 1985; 1994). The deposition of sand and gravel sequences associated with the East Tilbury Marshes Gravel, which forms

Plate 19 Braided river, Denali National Park, Alaska (photo by Nick McPhee)

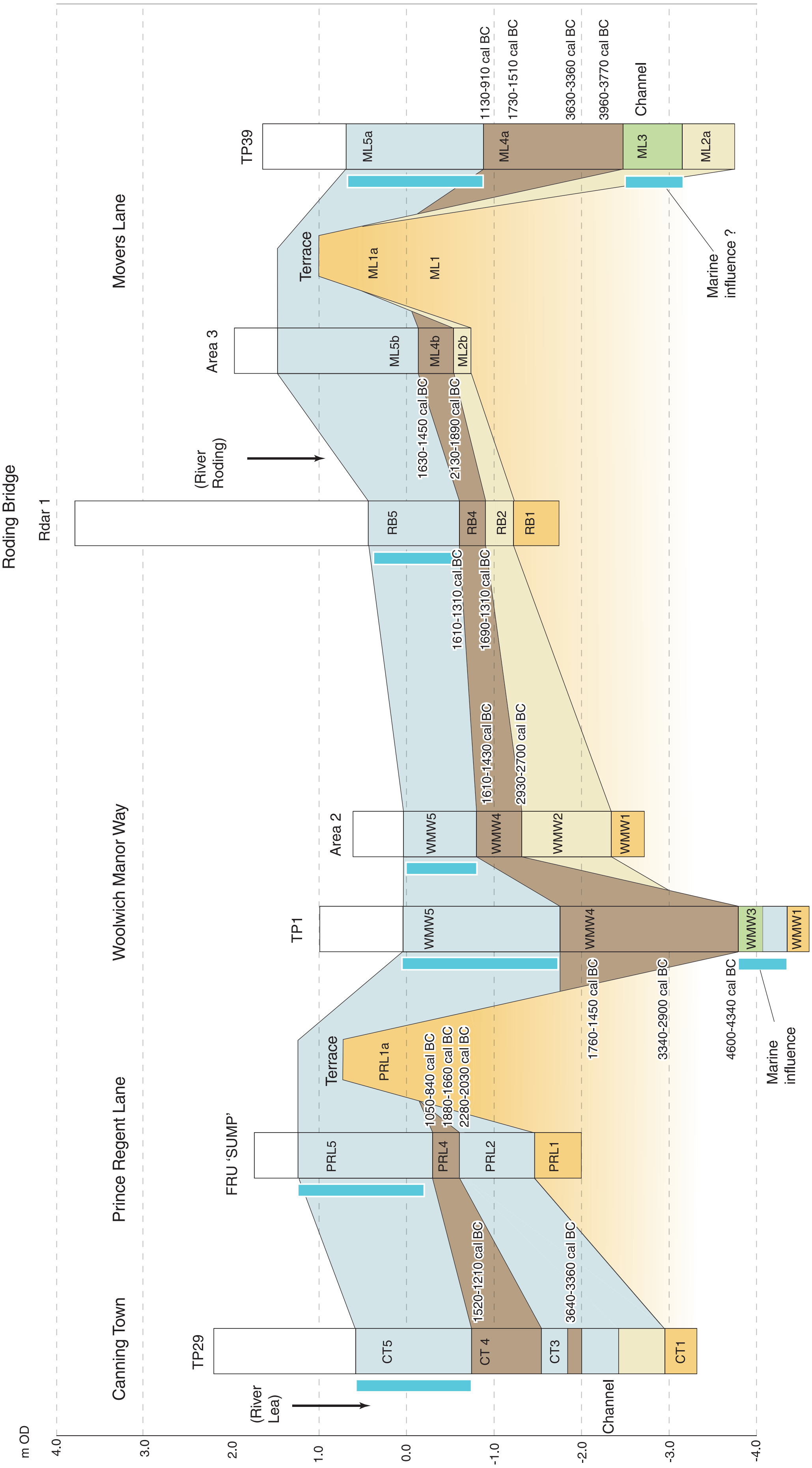

Fig. 8.1 Summary of the route-wide sampled sequences

the higher terrace in the vicinity of the A13, occurred during MIS 6 through 5e (Ipswichian Interglacial) to MIS 3. This terrace includes both temperate and cold climate deposits which accumulated in a range of environments, from braided to meandering river channels and estuarine situations. From *c* 30,000 BP (CLM Stage 1a, Bates and Whittaker 2004; Fig. 8.3), prior to and during downcutting under the sea-level lowstand associated with the Last Glacial Maximum (LGM: 18,000-19,000 BP), reworking of the surface of the East Tilbury Marshes Gravel occurred by cold-climate solifluction processes. The Shepperton Gravel deposited following the LGM (CLM Stage 1b, Bates and Whittaker 2004, Fig. 8.3) forms the terrace that lies beneath Holocene sequences. Aggradation of the Shepperton Gravel is likely to

Fig. 8.2 Location of sites referred to in Chapter 8

Table 8.1 Summary of route-wide sediment sequences

Lower Thames tri-part sequence	*General description*	*Environments of deposition*	*Inferred date*	*CLM*	*Sediment units* *Ironbridge-Canning Town*	*Prince Regent Lane*	*Woolwich Manor Way*	*Movers Lane*	*Old Roding Bridge*	*Associated archaeology*
Upper alluvium	Blue-grey clay silt mostly structureless. Occasionally laminated with occasional coarse flint gravel horizons	Low energy wetland environment initially fresh or brackish water conditions, giving way to salt marsh/inter tidal mudflats. Possible post-depositional pedogenic activity	Post 3ka B.P.	5-6	CT5	PRL5	WMW5	ML5	RB5	Seals features of Neolithic to Roman date at higher elevations.
Organic complex	Highly variable organic silts and peats extending across low-lying area.	Alder carr wetland with phases of minerogenic input. Up-profile possibly becoming reedswamp or brackish marshland. Rapid lateral changesin sediment and vegetation/species composition.	3-6ka B.P.	4	CT4	PRL4	WMW4	ML4	RB4	BA trackways, structures and associated artefact scatters
Lower alluvium	Blue grey or light brown clays silts or sandy silts and sands, sometimes well sorted, weakly laminated sands grading upwards into silts, with occasional gravel clasts Frequently exhibit evidence of rooting on upper weathered surface	Sand bars in meandering channel systems or sand sheets reworked by surface run-off, followed by sea-level rise resulting in sediments from backed up freshwater systems, grading upwards to salt marsh surface/inter tidal channel systems (ML and WMW) Post depositional pedogenic activity/upper surface weathered	? Pre 6ka B.P.	2/3	CT3	PRL2	WMW3 WMW2	ML3 ML2	RB2	Reworked and *in situ* artefact scatters. Mesolithic, Neolithic and Bronze Age located on upper weathered surface A concentration of early Neolithic Neolithic flint, ceramics and charred plant remains, located on a possible sand-bar (WMW) Features cut into upper weathered weathered surface. Particularly at higher elevations at edge of terrace Isolated possible Neolithic features Bronze Age activity indicative of domestic and agricultural activities. Roman field system? (PRL)
Gravels	Sand and gravel horizons, clear bedding of sands, sandy gravels and silts. Occasionally grading upwards into fine silty sand	Severe cold with frozen ground. Periodic washing of erosion of higher sands, solifluction and erosion processes alternating with more stable surfaces	? Pre-15ka B.P.	1a-1b	-	PRL1a	-	ML1a	-	
	Soft brown clay, pockets of fibrous peat or dark brown organic clay	Low energy channel infill features, probably Late Glacial		-	CT1b	-	-	-	-	
	Poorly sorted coarse flint gravels	High energy fluvial environment, probably braided stream channels	>30ka to 10-15ka B.P.	1b	CT1	PRL1	WMW1	ML1	RB1	

have occurred under cold-climate conditions in high-energy fast flowing braided river channels accompanied by continued down slope erosion of the higher terrace. The braided river probably comprised a network of transient channels with sand and gravel bars, similar to those that flow in areas of Alaska today (Plate 19).

Pleistocene gravel deposits were exposed throughout the A13 route, although due to problems with ground water and trench collapse they were rarely exposed to any great extent. The deposits largely comprised coarse flint sandy gravels and sands of fluvial origin (CT1, PRL1, WMW1, RB1 and ML1), although sand, silt and gravel horizons, possibly deposited by sub-aerial erosion, were recorded at Movers Lane and Prince Regent Lane

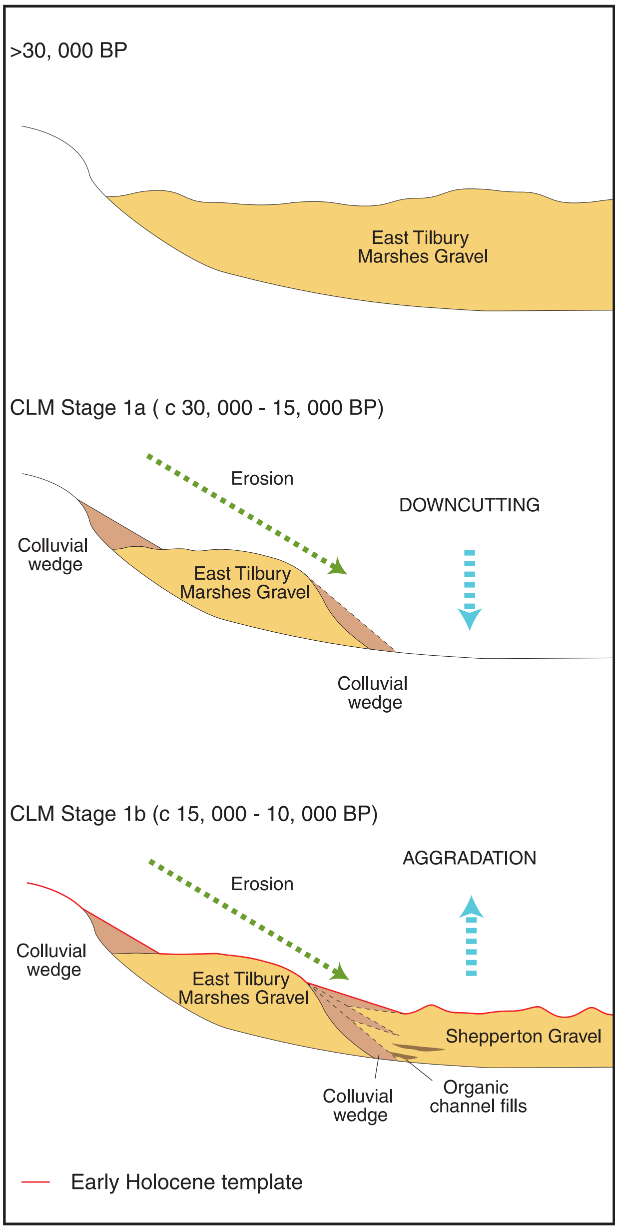

Fig. 8.3 Cultural Landscape Model (CLM) Stages 1a and 1b

(ML1a and PRL1a). Although there was an absence of associated palaeoenvironmental material within this latter group of sediments, their character suggests that they probably represent slopewash, colluviation and solifluction during intervals of severe cold when frozen ground dominated. Periodic washing of the surface and erosion of sands from higher gravel terraces is likely to have contributed to the sediment stack and slope erosion may have alternated with periods of relative surface stability. These sediments would have accumulated on a slope southwards towards the contemporary Thames channel (a braided system across the valley floor at this time) and active downward erosion would characterise this phase of fluvial activity away from the immediate site vicinity. At Movers Lane these deposits demonstrated considerable complexity grading upwards into fine silty sand and were dated by luminescence techniques from 15,800±850 BP to 23,900±1300 BP, clearly indicating accumulation immediately prior to and following the LGM. At Prince Regent Lane extensive deposits of bedded sand, sandy gravels and silts overlying the fluvial gravels were dated from 15,800±840 BP to 16,300±820 BP (see Appendix 1).

At Canning Town, a sediment unit identified at the base of gravels, or associated with the upper part of the Shepperton gravels, comprised soft brown clay, pockets of fibrous peat or dark brown organic clay (CT1b). Although these deposits were identified in geotechnical boreholes, unfortunately they were not sampled by the purposive geoarchaeological boreholes and no sediment was available for analysis. Organic deposits of similar description occur at the base of the lowermost gravels in the Lea Valley and are well known from sites in Temple Mills and Edmonton (the Lea Valley Arctic Beds described by Warren 1912; 1916; 1938). They represent severely cold climate deposits dated 21,530 to 28,000 BP, comprising broken rafts of peaty material, frequently rich in plant macrofossils and molluscs. Sediments of this type are rarely penetrated in the Lea Valley and are of considerable interest as they have the potential to provide regional palaeoenvironmental records and age estimates for this period (see Corcoran *et al.* 2011, 145-9 for the most recent assessment). The elevation of the deposits identified during this study, however, would perhaps suggest channel infill features of Late Glacial date is a more appropriate interpretation. Similar channel deposits occurring within the valley floor gravel were most recently identified during borehole work at the Olympics Park in Stratford (Fig. 8.2), spanning both the Windermere Interstadial (warm phase) and Loch Lomand Stadial (cold phase) at *c* 11,000 -13,000 BP (Corcoran *et al*. 2011, 150).

Early–mid Holocene (Fig. 8.4)

The surface of the Pleistocene deposits described above would have defined the topography of the early Holocene landscape, which in turn would

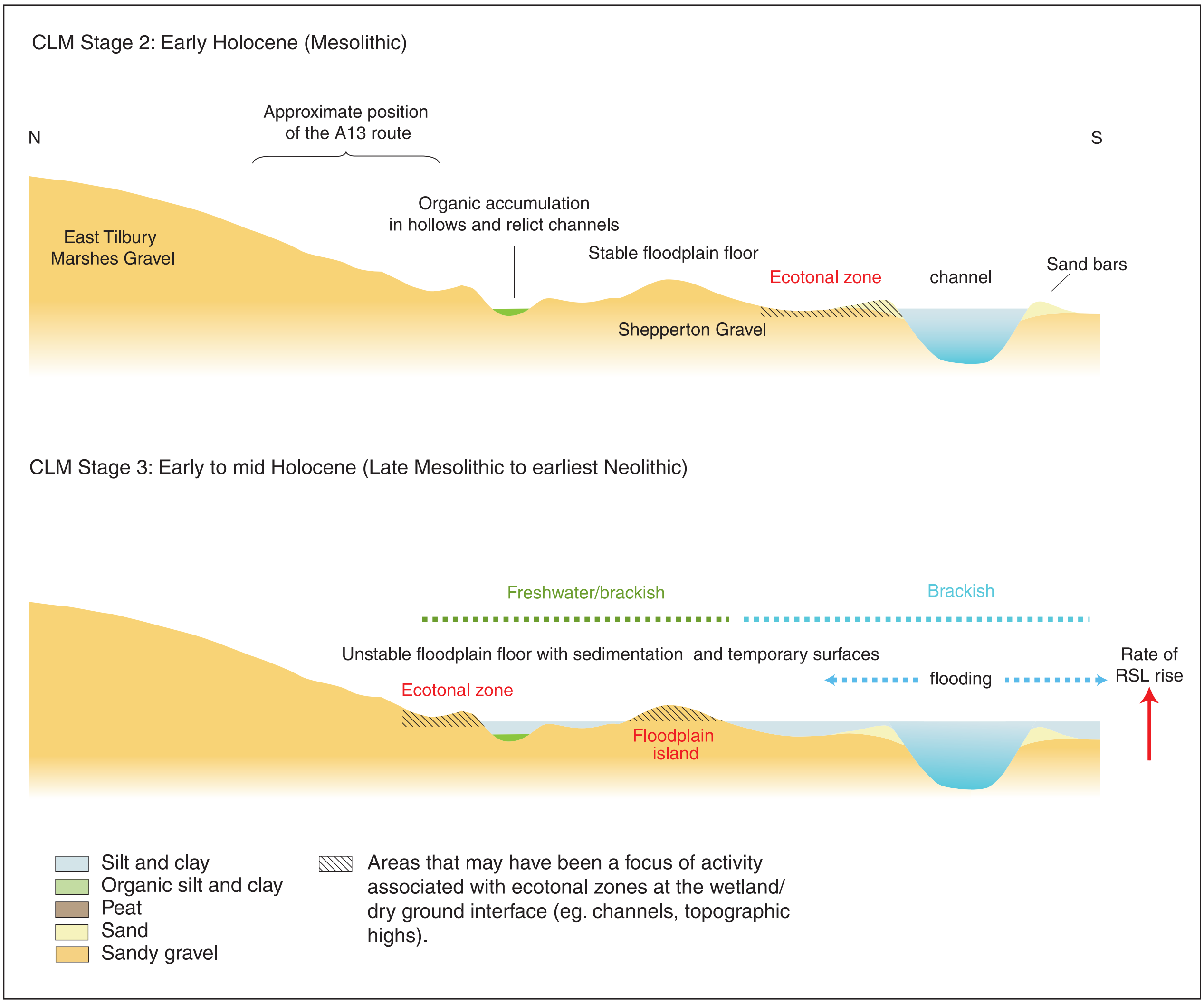

Fig. 8.4 Cultural Landcape Model (CLM) Stages 2 and 3

have influenced patterns of later sediment accumulation. During CLM Stage 2 (Bates and Whittaker 2004; Fig. 8.4) following climatic amelioration but prior to sea-level rise attaining near present day levels, the area is likely to have been characterised by relict Late Glacial features, but with a stable channel within the old Late Glacial main channel. The floodplain of the river adjacent to the main channel would have stabilised with the development of the Holocene vegetation. Local pockets of sediment accumulation are likely to have accrued during this time in channels and hollows on the gravel surface, for example at Bramcote Green (Thomas and Rackham 1996). A key ecotonal area probably existed adjacent to the main Thames channel and floodplain tributaries. Higher ground would have provided additional landscape resources within different environments.

During CLM Stage 3 (Bates and Whittaker 2004; Fig. 8.4) sea-level rise resulted in inundation of the former dry land surface and began to influence sedimentation and fluvial dynamics within the valley floor area. As the sea-level rose, channel stability will have decreased causing the start of flooding of low-lying areas. The floodplain surface is likely to have become unstable due to widespread flooding and rapid sedimentation. Minerogenic sedimentation probably characterises this phase. While sediment accumulation during this stage will have begun under freshwater conditions, it would have been subsequently transformed by the onset of estuarine conditions as marine inundation occurred. During this period the ecotonal zone between wet and dry ground will have migrated inland and risen in datum across the flood surface. Thus wetland environments began to expand at the expense of the dry ground areas. Temporary landsurfaces may have existed within the flood area but these are likely to have been ephemeral and of local significance only. Activity would probably have remained focused on channel marginal situations and areas of the floodplain not inundated. Later more extensive inundation would eventually focus activity on the floodplain margins and any

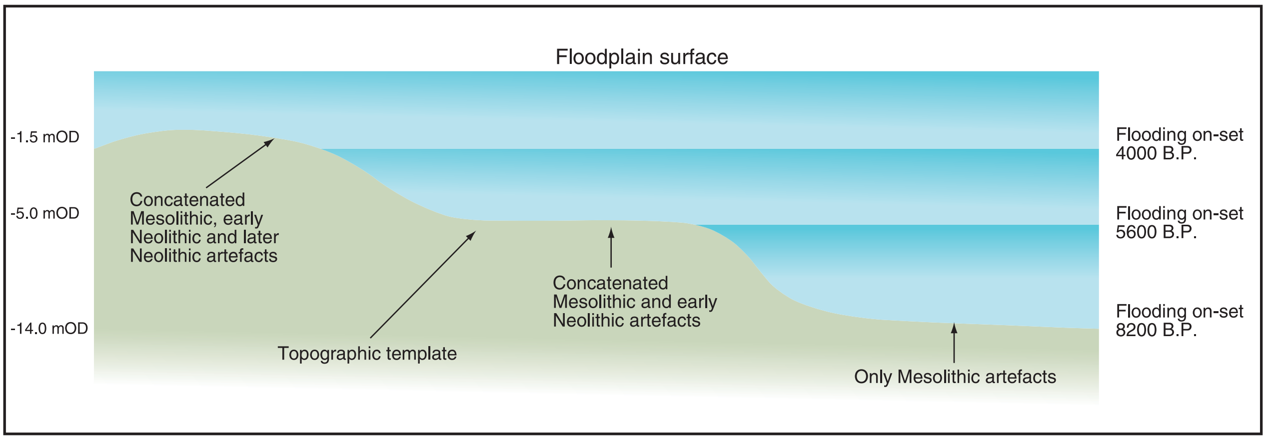

Fig. 8.5 A model for temporal separation of artefact assemblages below the floodplain surface, after URN and URS (1999)

remnant islands of sand and gravel within the floodplain.

Deposits relating to these landscape stages were identified throughout the A13 route corridor. They can be variously described as blue grey or light brown clays, silts or sandy silts and sands, sometimes well sorted, weakly laminated sands grading upwards into silts, with occasional gravel clasts. In general they lie between the basal fluvial gravels and the overlying organic complex.

The presence of a weathered horizon and associated archaeological remains at the upper contact of the sandy facies at Prince Regent Lane, Movers Lane and Woolwich Manor Way indicates that the sands at these locations were exposed as a landsurface prior to inundation. The landscape associated with this horizon, after climatic amelioration but prior to the onset of sedimentation onto the topographic template, is assumed to have been one of relative stability. There would have been minimal sediment deposition and little chance of stratigraphic development, resulting in the concatenated assemblages of Mesolithic and Neolithic artefacts in low lying areas, with the addition of artefacts from later periods at higher elevations, where burial by sedimentation occurred later (Fig. 8.5).

At Canning Town a series of blue grey clay silts or sandy silts (CT3) were recorded at the base of TP29. These pre-date *c* 3600 cal BC and appear to have accumulated in freshwater conditions, in or adjacent to an active channel. The deposits included opercula of the freshwater mollusc *Bithynia* as well as the remains of bank vole, amphibians and cyprinid (the carp family). At Prince Regent Lane in the western part of the site, blue grey clay-silts or sandy-silts (PRL2) beneath the organic complex also accumulated under freshwater conditions, evidenced by the presence of oogonia (calcified fruiting bodies) of stonewort and water flea eggs. Investigation of the top of the sequence in the 'sump' at Freemasons Road indicated that an environment of damp alder carr and sedge had developed prior to around 2000-2300 cal BC.

A possible early phase of marine incursion was recorded at both Woolwich Manor Way and Movers Lane. At Woolwich Manor Way deposits beneath the main peat body contained pollen of the goosefoot family, which includes species found in saltmarsh environments (Plate 20). This, together with dinoflagellate cysts, sponge spicule fragments and a single example of the brackish diatom *Cyclotella striata*, hint at the proximity of intertidal conditions. Radiocarbon age determinations from the overlying peat suggest that the deposits accumulated during the late Mesolithic period, prior to about 4600 cal BC. In the eastern palaeochannel at Movers Lane (TP39) a gradual change from sand to organic silt accumulation suggests a shift to slow moving conditions during the Mesolithic, prior to about 4000 cal BC. Although pollen was poorly preserved, the presence of goosefoots, together with dinoflagellates, perhaps suggests some marine influence with local saltmarsh and some coastal woodland. Estuarine conditions were not recorded at the Roding Bridge site, located between Woolwich Manor Way and Movers Lane, probably due to the much higher elevations recorded from the surface of the Pleistocene gravels.

Mid Holocene (Fig. 8.6)

CLM Stage 4 (Bates and Whittaker 2004; Fig. 8.6) is characterised by apparent fluctuating sea-levels in which alterations between organic and inorganic sedimentation dominate the area. A major expansion of freshwater wetlands is associated with this phase and the temporary emergence of surfaces to or above flooding level will have stimulated the growth of organic sediments and led to peat growth. The ecotonal zone between wetland and dryland continued to move inland, causing loss of topographic variation. During times of peat accumulation complex boundaries between peat

Plate 20 Saltmarsh, Fambridge, Essex (photo by Andy Roberts)

and non-peat wetland ecosystems will have emerged within the wetland. Wetland would now dominate in the floodplain area as dry ground zones shrank rapidly.

Inter-bedded peat or organic deposits were recorded extensively along the A13 route. These deposits in general represent alder carr wetland (Plate 21) with phases of minerogenic input, up-profile becoming reedswamp and brackish marshland. Radiocarbon dates for the accumulation of these organic deposits broadly place them within the Neolithic and Bronze Age. This compares well with the model for estuary contraction at around 4900-1250 cal BC proposed by Long *et al.* (2000) and data from nearby Crossness, where the channel was estimated to have contracted from 4700m to 670m between 3600-2000 BC (Devoy 1979). The sequences also broadly fit within the time range for Devoy's Tilbury III (3550-2050 BC) and IV (1450 BC-AD 200) peat.

Considerable variation occurs, however, within and between route sections within this organic complex, with peat formation occurring within different timeframes at differing elevations. This may be a response to local factors. It is likely that pools of water existed on the floodplain between stands of alder, willow and hazel. Peat will have built up non-uniformly as pools were gradually filled in and new pools formed. Seasonal flooding, and probably an increase in river levels generally, may have deposited sediment, particularly in those locations adjacent to tributaries.

At Canning Town, on the floodplain of the River Lea, deep organic silt and peat units (CT4) accumulated over a period of about 2500 years between *c* 3650 to 1210 cal BC, from the early Neolithic to middle Bronze Age period. At Prince Regent Lane, located at a higher elevation at the interface between the terrace edge and the Thames floodplain, the peat/organic silts (PRL4) were much reduced in thickness. Radiocarbon dates suggest accumulation here occurred over a significantly shorter period of time of about 1500 years. The earliest organic sedimentation in the vicinity of Freemasons Road appears to have occurred in the slightly lower lying hollows, followed by more widespread peat formation. Radiocarbon dating of the base of the peat in the 'sump' sequence suggests that accumulation occurred between about 2300 and 800 cal BC. At Woolwich Manor Way peat and organic sediments (WMW4) varied considerably along the route corridor. A lower woody peat and an upper amorphous peat were noted towards the west, replaced by more minerogenic sediments to the east where this group of sediments wedged out against the rising gravel surface. Radiocarbon dates from the thickest sequence in TP1, at the western extent of the route section, indicate accumulation between about 4600 and 1450 cal BC, from the late

Plate 21 Flooded alder carr, Brownsea Island, Poole Harbour (photo by David J Glaves)

Mesolithic to middle Bronze Age. The peat appears to have accumulated throughout the Neolithic and Bronze Age, gradually encroaching onto the higher ground to the east. At Movers Lane radiocarbon dates from peat deposits (ML4) in TP39 indicate that accumulation at this location occurred between *c* 4000 to 900 cal BC; from the early Neolithic to the late Bronze Age.

Late Holocene (Fig. 8.6)

CLM Stage 5 (Bates and Whittaker 2004; Fig. 8.6) is characterised by the final submergence of the former floodplain topography and the loss of much of the floodplain diversity. Typically organic sediment growth appears to cease after topographically elevated areas became buried, and brackish water conditions dominated. Sporadic occupation for economic use of the floodplain will have continued through hunting/shell fish gathering as well as use of the river and tributaries for transport purposes. Eventual land reclamation and drainage allowed occupation of the land for farming and habitation.

Sediments associated with this phase of landscape development were recorded at all of the A13 sites, evident by the accumulation of predominantly minerogenic silt-clays from the latter half of the 2nd millennium BC. These deposits occurred in every profile examined and represent an ingress of tidal waters as a result of rising sea levels.

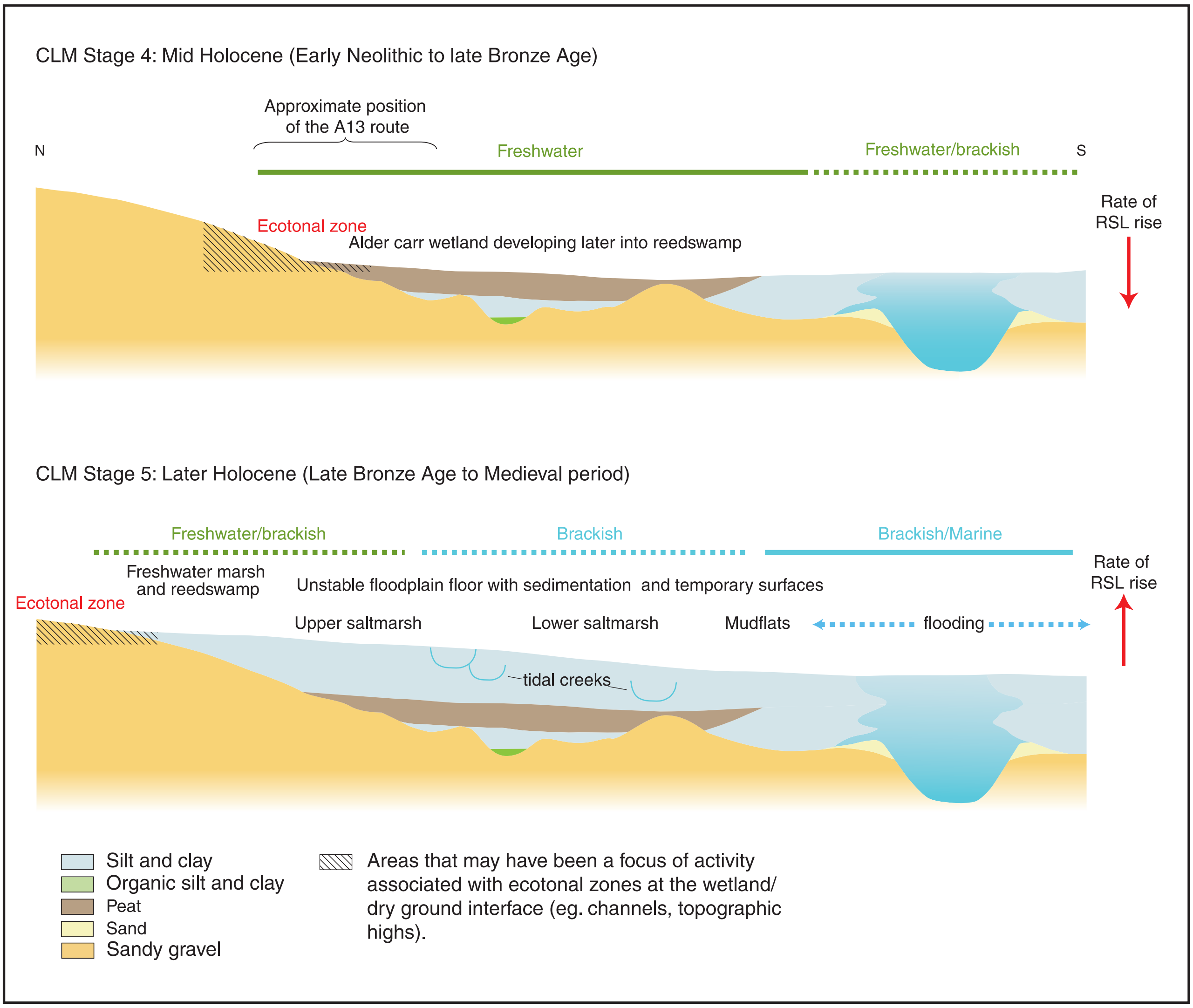

Fig. 8.6 Cultural Landsape Model (CLM) Stages 4 and 5

The onset of minerogenic sedimentation at Freemasons Road (PRL5) dates from the late Bronze Age to early Iron Age. The pollen from the 'sump' sequence at Freemasons Road, immediately above the peat interface, shows little change apart from a slight rise in pollen of the goosefoot family, which includes species that grow on saltmarshes. However, several erosion channels cutting into the top of the peats in the main excavation area contained common sponge spicule fragments, as well as marine and brackish diatoms, which suggests encroaching estuarine conditions. The upper part of the alluvium from the excavations was not analysed in detail but pollen work from the evaluation stage in T23 indicated the gradual development of open saltmarsh vegetation, with freshwater marshes on the inland edge. Foraminifera and ostracod evidence suggests mixed brackish and freshwater conditions, in which the introduction of freshwater species probably derives from influxes of freshwater from streams draining the inland marshes. On the higher ground at Prince Regent Lane this sedimentary complex directly overlay Pleistocene colluvial deposits, but also sealed ditches of Roman date. This implies that the higher ground remained relatively dry ground well into the historical period.

At Woolwich Manor Way, minerogenic sedimentation (WMW5) occurred slightly earlier during the middle to late Bronze Age. Accumulation appears to have continued throughout the later prehistoric and into the historic period with evidence of Roman occupation occurring within the alluvium in T15 and TP13 in the east of the site. The environmental evidence indicates that these deposits similarly formed in a predominantly open estuarine environment, with tidal creeks and saltmarsh, although high in the tidal frame with freshwater environments co-existing nearby. A similar change is in evidence at Movers Lane with the deposition of clay silt (ML5) across the whole site, sealing the earlier palaeochannels and the middle and late Bronze Age features on the higher terrace.

The nature and speed of landscape change (Fig. 8.7)

Despite the apparent variation in the date and elevations for the main period of peat accumulation, Figure 8.7 (updated from Bates and Whittaker 2004) illustrates that the onset of accumulation at the three key A13 sites generally compares well with other sites in the vicinity (the location and details of each site is presented in Table 8.2 and Fig. 8.2). For a more comprehensive review of data derived from unpublished grey literature reports the reader is referred to Batchelor (2009) and Chapter 10. The plot (Fig. 8.7) demonstrates a steep trend associated with rising sea-level prior to 6000 BP, with the gradient reducing following sea-level attaining close to modern elevations. Calculation of the slope of regression lines allows a time-depth model to be produced which can be used to estimate the speed at which dry ground areas were lost to the expanding wetland front during the mid Holocene. This model was applied by Bates to the Barking Reach area, immediately to the east of Movers Lane (Fig. 8.2), demonstrating 75% of dry ground was lost in low lying areas of about -6m to -3m OD over around 700 years during the later Mesolithic period (4700-4000 cal BC, approximately 4.3mm/year datum) (Bates 1998; 1999; Bates and Whittaker 2004). With reference sites at higher elevations, including A13 sites, the plot broadly shows the slower rate of expansion of the wetlands onto higher terrace edge locations from approximately -3m to 0m OD over a period of around 2500 years from the beginning of the Neolithic to middle Bronze Age (1.2mm/year datum). These figures, although approximations, suggest the loss of dry ground areas to the encroaching alder carr and associated changes in flora and fauna may have been perceptible to local communities within a few generations.

Evident at all of the A13 sites was a rising water table within the upper parts of the peat profiles followed by a change to minerogenic sedimentation during the later prehistoric period. This development has been recorded at many other East and Central London sites and represents a gradual change from a predominantly freshwater regime to a tidal river (see Sidell *et al.* 2000). The primary factors initiating this change may be attributed to increases in the rate of sea-level rise combined with isostatic downwarp (Devoy 1979; Fairbridge 1983; Shennan 1987 cited in Sidell *et al*. 2000, 109). However, the precise timing of this change at individual sites is most likely to have been influenced by more local factors such as the location of palaeochannels, elevation and position relative to the main Thames channel.

Table 8.2 Radiocarbon age estimates for selected sites in the Lower Thames where age estimates are available for contexts overlying non-compressible sediments (after Bates and Whittaker 2004)

Site	*Elevation mOD*	*^{14}C yr BP*	*Lab code*	*Reference*
Tilbury	-13.32	8170±110	Q1426	Devoy 1982
Ebbsfleet Valley	-0.7	4540±40	Beta-108114	Wenban-Smith *et al.* forthcoming
Ebbsfleet Valley	-2.32	4926±35	NZA-29080	Wenban-Smith *et al.* forthcoming
Broadness	-8.57	6620±90	Q1339	Devoy 1982
West Thurrock	-8.45	6450±120	IGS-C14/153	Devoy 1982
Stone	-8.82	6970±90	Q1334	Devoy 1982
Slade Green Relief Road	-2	4390±70	Beta-726204	Bates and Williamson 1995
Crossness	-5.3	5850±70	Beta-76991	Pine *et al.* 1994
Dagenham Vale (HS1)	-3.88	5751±40	NZA-16264	Bates and Stafford forthcoming
Ripple Lane Portal (HS1)	-3.75	5773±40	NZA-28794	Bates and Stafford forthcoming
Movers Lane (A3)	-0.6	3950±35	SUERC-25572 (GU-19431)	This volume
Movers Lane (TP39)	-1.9	4680±35	SUERC-25567 (GU-19426)	This volume
Woolwich Manor Way (A2)	-1.3	4265±35	SUERC-25563 (GU-19425)	This volume
Woolwich Manor Way (T16)	-3.13	5460±80	Beta-152740	This volume
Woolwich Manor Way (T17)	-3.19	5510±70	Beta-152741	This volume
Woolwich Manor Way (TP1)	-3.65	5630±60	Beta-147956	This volume
Freemasons Road (Sump)	-0.6	3745±35	SUERC-24600 (GU-18961)	This volume
Fort Street, Silvertown	-2.52	4750±70	Beta-93683	Wilkinson *et al.* 2000
Fort Street, Silvertown	-3.3	5660±100	Beta-93689	Wilkinson *et al.* 2000
Westmoor Street	-0.3	3280±80	Beta-81970	Bates unpublished
Borax Works	-8	6850±70	Beta-76200	Bates unpublished
Canning Town	-1.5	4030±60	Beta-70248	Bates unpublished
Bellot Street	-0.6	3600±70	CIB-325	Unpublished archive
West Ferry Road	-3.2	5460±80	Beta-84317	Pine *et al.* 1994
Phoenix Wharf	0.3	3110±40	BM-2766	Sidell *et al.* 2002

Plate 22 Thames Barrier at Woolwich (photo by Herry Lawford)

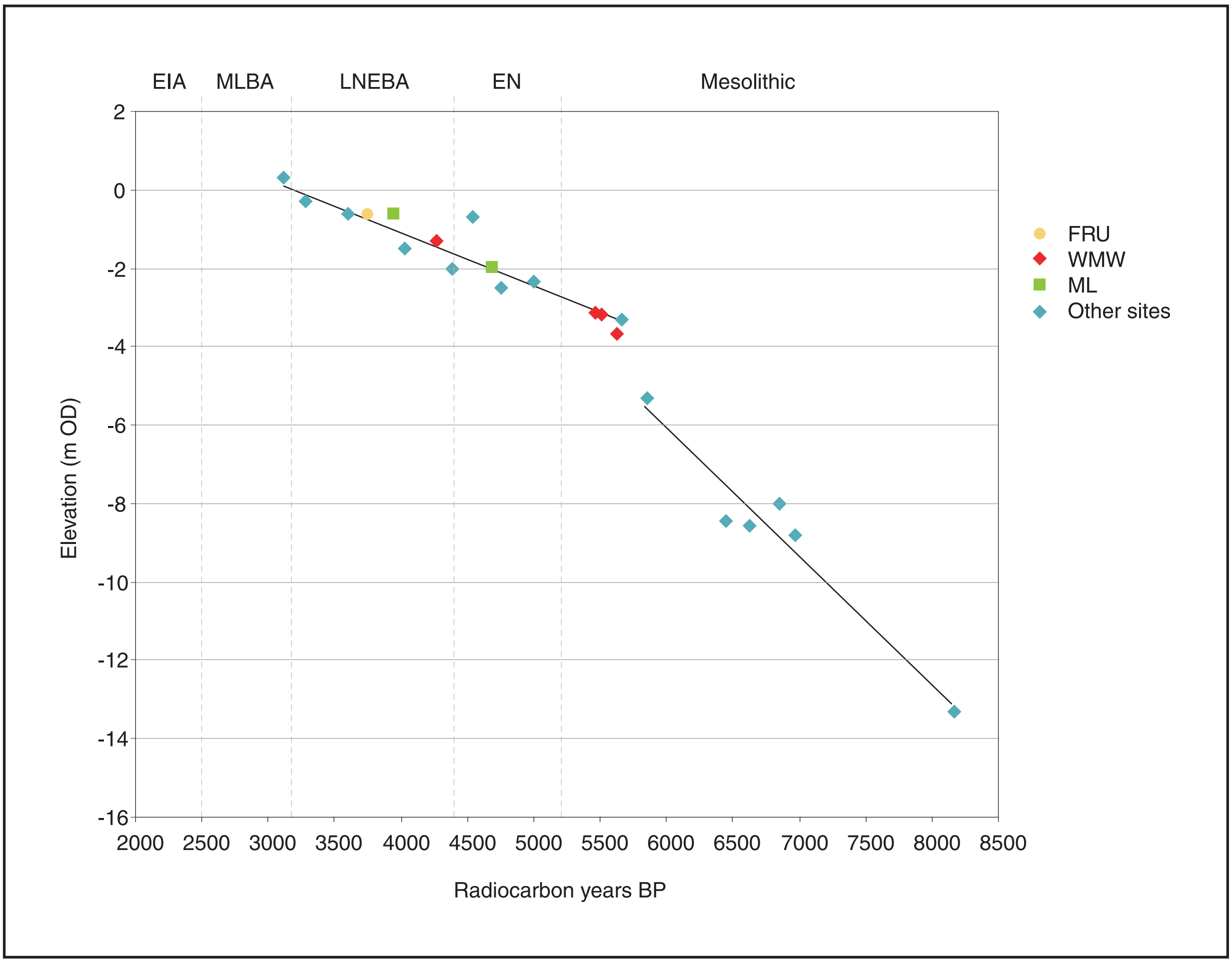

Fig. 8.7 Conventional radiocarbon age estimates plotted against depth for organic onto gravel situations in the Lower Thames (mid estuary) area (after Bates and Whittaker 2004)

Plate 23 Flood defences at Barking Creek on the River Roding (photo by Lars Plougmann)

At Crossness, located well into the floodplain on the opposite side of the Thames to the A13 sites, estuarine conditions are evident much earlier; from the late Neolithic at 2800-2400 cal BC (Devoy 1979). Immediately adjacent to the current Thames channel a sequence from the Isle of Dogs was dated to the early Bronze Age at 2200 cal BC (Wilkinson 1995). The middle to late Bronze Age dates from the A13 sites probably relate to their position at higher elevations, close to the margins with the terrace edge. Similarly late dates were apparent during the investigations associated with the construction of High Speed 1 to the east (formerly known as the Channel Tunnel Rail Link); at Ripple Lane Portal, Dagenham and East of Ferry Lane, Rainham the onset of brackish water conditions was apparent from the middle Bronze Age to middle Iron Age (Bates and Stafford forthcoming). In central London evidence from sites along the Jubilee Line Extension indicates the development of full tidal conditions from the late Bronze Age (*c* 1000 BC), leading Sidell *et al.* to suggest an average movement of the tidal head upstream from Crossness of 5.4m a year (Sidell *et al.* 2000, 109; 2004, 41).

Deposition of estuarine sediments, however, which may represent earlier episodic inundations, was noted during the late Neolithic (*c* 2800-2550 cal BC) period at both the Union Street and Joan Street sites in Southwark (ibid). Similar evidence for estuarine flood events was noted within the parts of the peat sequences at Woolwich Manor Way, for example in TP1, which contained rare valves of the marine and brackish water diatoms (*Pseudostelligera westii*, *Cyclotella striata*, *Diploneis didyma* and *Actinoptychus senarius*) as well as sponge spicule fragments. The building of the trackways during the latter half of the Bronze Age, such as those recorded along the A13 at Woolwich Manor Way and Movers Lane, may be seen as a response by local communities to increasingly wet conditions and seasonal flooding to maintain access routes though the marshes. However, the evidence at Movers Lane suggests repeated episodes of high energy flooding, erosion and sand deposition in close proximity to active channels during this period. It is possible that some of these flood events may be related to higher magnitude tidal surges, to which historically the Thames estuary is particularly vulnerable. It should be noted, however, that prior to extensive floodplain reclamation the river is likely to have been much wider and shallower than it is today. During the 1st century AD the tidal range is likely to have been approximately 2m and the width of the river at high water was close to a kilometre (Graham 1978, Milne *et al.* 1983 cited in Sidell *et al.* 2000, 17). Extensive areas of flanking marsh and creek systems along the estuary are likely have facilitated the dissipation of flood waters. Drainage and reclamation through the construction of embankments from the medieval period onwards has, however, substantially narrowed the width of river. This together with an increased depth due to dredging activities has resulted in an increase in tidal flow and funnelling effect, producing a modern tidal range of up to 7m in central London (Haughey 2008). During the medieval period there are numerous historical records of flood events affecting the Thames estuary. A period of increased storminess during the 13th to 15th centuries caused repeated breaches of the river walls. Recurrent flooding affected the lands of the Abbess of Barking, and other breaches occurred near Rotherhithe and in the stretch of the Thames between Woolwich and Greenwich (Galloway 2009). The devastating flood of 1953, caused by a tidal surge in the North Sea, affected extensive areas of the Thames Estuary and was one of the factors that led to the construction of the Thames barrier at Woolwich (opened in 1982) and maintenance of around 300km of associated sea defences. As recently as September 2000, however, the River Roding overflowed its defences and flooded 320 properties in the Wanstead and Woodford areas of East London. Since the 1980s, growing awareness of global warming and sea-level rise has led to a reassessment of coastal defences along the estuary with alternative strategies focused on managed realignment schemes in Kent and Essex and increased flood storage capacity.

Vegetation patterns and human influences (Fig. 8.8)

Information on vegetation patterns along the route is largely gleaned from the pollen assemblages recovered from the A13 sites (see Haggart, Peglar and Druce in Appendix 3), although more site-specific data is provided by other categories of material such as macroscopic plant remains (Pelling in Appendix 3) and insects (Smith in Appendix 3). The earliest deposits that produced useful information date from the late Mesolithic to early Neolithic, from sequences at Woolwich Manor Way and Movers Lane. The sequence at Freemasons Road is a little later, dating from the early Bronze Age.

Mesolithic woodlands

Evidence for the vegetation of this area of the Thames Valley in the earlier part of the Holocene has been reviewed in Sidell *et al.* 2000 and more recently by Batchelor 2009; suffice to say sites with good pollen preservation are sparse. Overall it appears that an initial phase of birch and pine woodland was superceded by the mid Holocene with lime, oak, elm, hazel and alder, which is evident at sites such as Hampstead Heath and Runneymede Bridge (Scaife in Sidell *et al.* 2000, 111). Prior to its decline, associated with later prehistoric clearance, lime was of great importance and there is increasing evidence to show that as well as being a major constituent of the woodland on better drained sandy soils of the terraces, lime may also have been growing in damp woodland on peaty substrates (ibid) and this may have been the case in the early phases of peat development at Woolwich Manor Way where

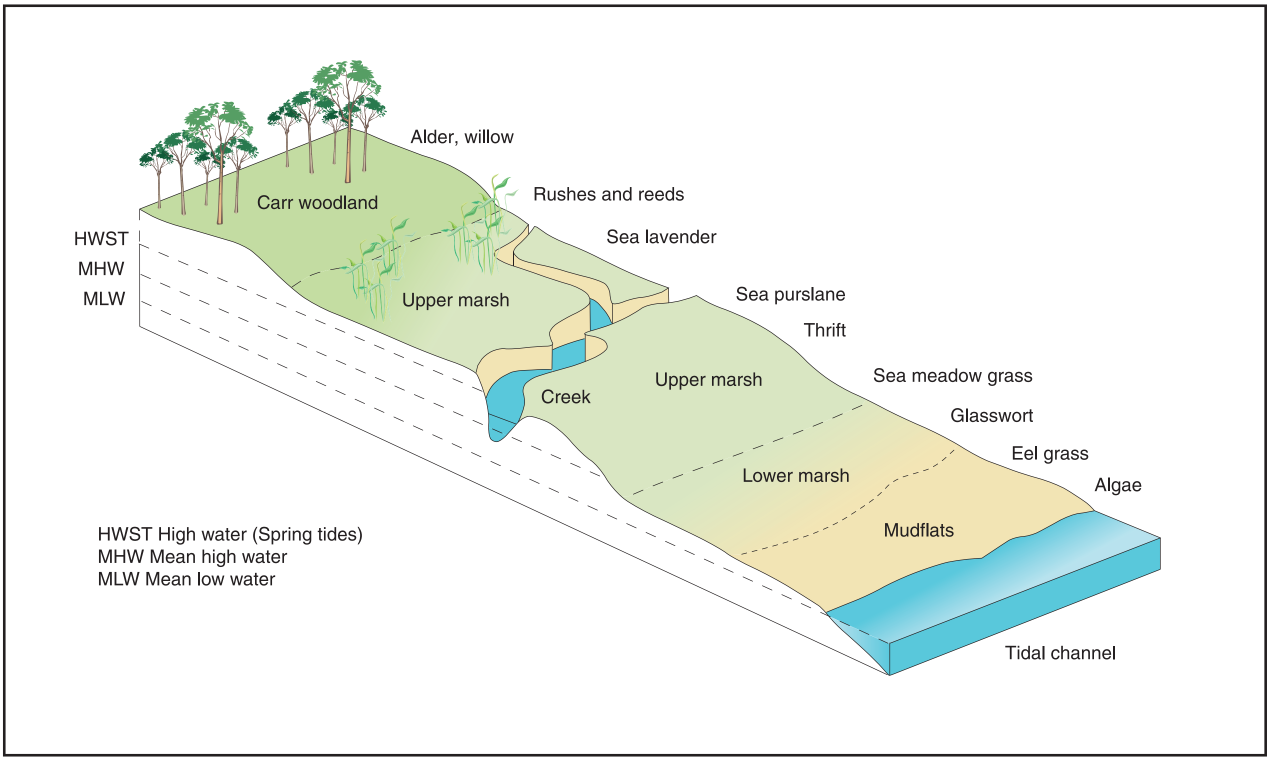

Fig. 8.8 Generic model of wetland zones

high levels of lime pollen have been recorded (Haggart in Appendix 3).

Late Mesolithic to early Bronze Age alder carr

Along the A13 alder carr wetland environments appear to have developed in the low-lying areas from very early in the sampled sequences and are associated with deposition of both the lower minerogenic alluvium and the main period of peat formation. At Woolwich Manor Way the sequence begins in the late Mesolithic period, prior to 4580-4350 cal BC (Beta-147956: 5630±60 BP), which is the date from the base of the main peat unit in TP1 in the western part of the site. The pollen assemblages from the lower alluvial deposits beneath the peat, although poorly preserved, suggest a wetland environment was present in the western part of the site (Haggart in Appendix 3). The eastern part of the site, which lay at higher elevations, remained relatively dry ground and this is reflected in the poorly preserved waterlogged plant remains recovered from the sandy palaeosol and the large assemblage of charred emmer wheat (Pelling in Appendix 3). Locally the environment appears to have been initially rather open with the total herb pollen reaching 73%. The vegetation was dominated by sedges and grasses, with some bracken and ferns. As the alluvium became more organic approaching the interface with the overlying peat, alder began to dominate the assemblages (60% TLP). This, along with willow and hazel, suggests a carr environment with perhaps oak growing at higher elevations. However, the occurrence of pollen of the goosefoot family, together with dinoflagellate cysts, sponge spicule fragments and a single example of the brackish diatom *Cyclotella striata,* hint at the proximity of intertidal conditions. Increasing wetness and the formation of alder car is also suggested by the improved preservation of waterlogged plant remains, with the remains of alder and seeds from plants typical of wet grassy ground such as rushes, sedges, celery-leaved crowfoot and gypsywort (Pelling in Appendix 3). The very base of the peat contained unusually high percentages of lime pollen (> 30% TLP). The pollen grains of lime, however, are very resistant to decay which tends to mean it is well-represented in mineral soils. This together with the presence of fungal spores indicative of dry mesotrophic conditions suggests initially a rather dry alder carr environment. The main body of the peat was dominated by alder, oak, and hazel, with lime at low but constant frequencies; sedges and grasses were few. This suggests that the alder carr became very dense. It is during this period that early Neolithic activity was occurring on the higher ground in the vicinity of T15. Sporadic occurrences of yew, buckthorn and viburnum (probably *Viburnum lantana,* wayfaring tree) pollen occur, a finding mirroring that of Scaife, who comments on the species richness of fen carr peats during the Neolithic and early to middle Bronze Age at the Union Street and Joan Street sites in Southwark (Scaife in Sidell *et al.* 2000). At Woolwich Manor Way the pollen assemblages from the late Neolithic to early Bronze Age peat, from the excavation areas further to the east, produced similar results to TP1 but also a diverse range of seeds of wetlands plants: sedges, crowfoots, water dropwort and water pepper/mite. Disturbed ground species were also present and included chickweeds, black nightshade and brambles (Haggart and Pelling in Appendix 3).

The pollen sequence analysed from TP39 at Movers Lane begins in the early Neolithic period, in an organic silt at the base of the main peat bed, dated to 3960-3770 cal BC (SUERC-25568: 5055±35 BP). Similar to Woolwich Manor Way, tree and shrub pollen dominated, with alder again being the most abundant. Other important trees included lime, oak and hazel. Ferns were also present and charcoal particles were quite high. Overall this suggests that during the early Neolithic, freshwater alder carr was growing locally in wet places and along riverbanks, with deciduous woodland on the drier ground, but as at Woolwich Manor Way the alder carr eventually became quite dense (Peglar in Appendix 3).

The presence of yew (*Taxus baccata*) in the pollen sequences is of particular note. Yew was also utilised in some of the Bronze Age timber trackways at Woolwich Manor Way as well as the platform structure at the adjacent Golf Driving Range site (Carew 2010, Goodburn 2003b). A small scatter of yew wood chips was recovered from Bronze Age deposits at Movers Lane and an axe trimmed section of yew at Freemasons Road (see Chapter 10). Yew was apparently a major component of coastal woodland at this time and timber has been identified at several floodplain sites within Greater London, for example at Wennington (Sidell 1996), Dagenham (Divers 1994) and Beckton (Meddens and Sidell 1995; Scaife 1997). Sidell (1996) has suggested that yew was an important woodland taxon, and that the low pollen representation was due to taphonomic factors and Scaife (2000) goes on to suggest suggests that this species rich alder carr/coastal woodland may have no modern analogue. Yew is also frequently found within lowland wetland coastal and estuarine peat in Belgium, Germany and The Netherlands (Deforce and Bastiaens 2004). Across Europe there is a recognised shift in yew from lowland wetlands to upland dryland during the Holocene, which may be attributed to a change in ecological preference (Pelling in Appendix 3).

There is little evidence from the A13 sites for human impact on vegetation of the area during the Neolithic period. The analysed pollen profiles do not show a marked elm decline despite the two profiles from TP1 at Woolwich Manor Way and TP39 at Movers Lane potentially containing sediments spanning the event. An early Neolithic elm decline has been recorded at other sites in the region and constitutes a broadly synchronous event dated to around 4300-3800 BC (see discussion of Scaife in Sidell *et al.* 2000, 112). It is a now widely accepted view, first proposed by Girling for Hampstead Heath, that the demise of elm was mainly due to a disease carried by the elm bark beetle *Scolytus scolytus,* although the spread of the disease was probably aided by Neolithic woodland clearance (Girling and Grieg 1977; 1985; Grieg 1989; 1992). The absence of evidence on the A13 sites may be due to the floodplain location where local site conditions such as increased waterlogging and alder carr formation diluted the influence of nearby dryland tree taxa including elm. However, this is hard to reconcile with a date for an elm decline from nearby Silvertown which was placed at 5070 ± 70 BP (Wilkinson *et al*. 2000).

There was some tentative evidence in the pollen record of cereal cultivation from the early Neolithic onwards. However, the similarity of cereal pollen with some wild grasses such as *Glyceria* (sweet-grasses) means that the evidence remains equivocal (Haggart in Appendix 3). At Movers Lane cereal-type pollen was identified in the basal part of the peat in TP39 dated to the early Neolithic (*c* 4000-3600 cal BC) and here there was some also evidence for open areas with grassland, possibly used for pasture prior to the alder carr becoming quite dense (Peglar in Appendix 3). An early decline in lime pollen, along with other trees was also noted at the junction of the silty peat and wood peat, dated to 3600-3360 cal BC, although this could be attributed to human activity it could also have been related to increased water levels. The latter interpretation was also suggested for an lime decline observed in early Neolithic peat deposits from the Ebbsfleet Valley (Huckerby *et al.* in Wenban-Smith *et al.* forthcoming). Alternatively the thick alder carr may have prevented other pollen from reaching the site. The lime decline is normally associated with the Neolithic/Bronze Age activity and this is thought to have led to the absence of lime in the Thames valley at this time (Devoy 1979; 1980; 2000; Scaife in Sidell *et al.* 2000; Scaife in MoLAS 2001; Scaife 2006; Wilkinson *et al.* 2000; Druce in Appendix 3). In the Thames Valley there is an increasing body of evidence at a number of sites suggesting an earlier temporary decline in lime during the early Neolithic (Huckerby *et al*. in Wenban-Smith *et al.* forthcoming). In TP1 at Woolwich Manor Way cereal-type pollen was also present in low frequencies in the upper levels of the peat dated to between the early Neolithic and early Bronze Age (3400-1500 cal BC), and the recovery of an assemblage of charred emmer wheat from T15 at Woolwich Manor Way provides clear evidence for cultivation in the vicinity. At Freemasons Road, although the sediment sequence is a little later, the basal alluvial deposits pre-dating 2300-2000 cal BC also produced cereal type-pollen. An increase in fern and bracken spores and pollen of grassland plants accompanied by a temporary decline in lime pollen may suggest a clearance episode (Druce in Appendix 3).

Reedswamp, sedge fen and marsh environments of the 2nd millennium BC

There is evidence towards the top of the peat of increasingly wet conditions and more open environments developing in many of the sequences examined during the first half of the second millennium BC. This is evident at Woolwich Manor Way from increases in pollen of plantains (including sea plantain) and pondweeds. This period is also characterised by a gradual decline in arboreal pollen, most notably alder and oak, and an increase in pollen of grasses and goosefoots as well as seeds of meadow buttercup and rushes, suggesting more open areas of damp grassland (Haggart in Appendix 3).

At Movers Lane the upper part of the peat also shows a rapid increase in herbs and fern spores and a concomitant decrease in tree and shrub pollen, mainly due to a large drop in alder, and increases in grasses and sedges (Peglar in Appendix 3). The plant assemblage provided evidence for alder (seeds and cones); wet ground species such as water-dropwort, fool's water-cress, gypsywort, watermint, common spike-rush, branched bur-reed, crowfoots, water-worts, water-plantain, red-shank, meadowsweet, sedges and rushes suggest marshy grassy conditions, and a small number of seeds of duckweeds and caddisfly larval cases may point to some open bodies of water. The drier ground species were relatively limited but indicate a background of scrubby vegetation, ruderal and disturbed habitats with plants such as bramble, fat hen, stinging nettles, orache, knotgrass, cinquefoils, chickweed/stitchworts, black nightshade and thistle growing in the vicinity (Pelling in Appendix 3).

At Freemasons Road alder carr gave way to damp species-rich sedge fen and grassland developed immediately at the site. Freshwater pools and streams were prevalent with green algae, aquatics, and bulrushes (Druce in Appendix 3). The macroscopic remains produced broadly similar results to the pollen: seeds and cones of alder and fruit of branched bur-reed indicate carr or fen conditions. Aquatic species included crowfoots, water-plantain, water-pepper and occasional seeds of duckweed, as well as oogonia (calcified fruiting bodies) of stonewort and the larval cases of caddisfly. Seeds of waterside vegetation which might have included species growing within the shallow muddy water include branched bur-reed, club-rushes, water dropwort, fool's water-cress, gypsywort and water-mint. Seeds of elder and bramble may indicate shrubby disturbed ground. Certainly disturbed habitats and nitrogen-rich soil are suggested by fat hen, stinging nettle, black nightshade, hairy buttercup and docks. Wet or damp grassland is indicated by meadow species, including possible meadow rue, ragged robin, and buttercups (Pelling in Appendix 3).

The changing hydrological conditions at the sites during the 2nd millennium would undoubtedly have affected the local vegetation in terms of the reduction of alder, encroachment of wetter conditions onto drier ground and more open conditions developing as a result of a reduction in the local alder canopy. The more open environment is likely to have increased the pollen catchment by allowing pollen from plants growing on the dryland, which was previously masked by the abundant alder pollen, to be better represented. Further increases in cereal-type pollen during this period, along with an increase of microscopic charcoal and seeds of disturbed ground species such as nettle and bramble, may point to increased clearance and cultivation on the nearby higher terraces, although as mentioned above the distinction between cereal-type pollen and the pollen from some wild grasses found growing in freshwater and coastal situations is problematic. The evidence from the plant remains at all three sites is equally enigmatic as seeds from disturbed, open and wet ground with some aquatic plants have all been recorded. At Freemasons Road, along with cereal type pollen, a significant decline in lime woodland on the surrounding slopes was evident during this period, accompanied by a decline in fern spores and a slight increase in those from bracken. The latter may be indicative of increased grazing (Behre 1986) or alternatively recent burning episodes, as bracken is known to rapidly invade areas cleared by fire (Druce in Appendix 3). The presence of small numbers of 'dung beetles' (eg Plate 24) and 'chafers' may also suggest that some of the landscape in the vicinity was cleared of woodland or used as pasture (Smith in Appendix 3). At Movers Lane there was a small background assemblage of charred plant remains, a significant quantity of charcoal in some samples, and waterlogged plant remains suggestive of scrubby vegetation and disturbed ground.

Plate 24 Dung beetle (Aphodius granarius) *modern specimen and elytra (photo by Professor Mark Robinson)*

The interpretation of environmental proxies identified in estuarine and fluvial situations, particularly pollen, is not easy. The sources of the pollen are likely to be widespread and grains will have arrived on site in a variety of ways. Some pollen is likely to have come from the local plant communities, while wind dispersed pollen will represent plants from further afield and grains may also be transported by water from both river and sea. The local human and animal populations may also have introduced pollen and other plant and invertebrate remains into the sediments. At Woolwich Manor Way, Movers Lane and Freemasons Road the evidence is perhaps best summed up in the insect report which states that 'one major difficulty with these faunas and their archaeological circumstances is the degree to which they can be used reliably to reconstruct woodland surrounding the site' (Smith in Appendix 3). The same could be said of both the pollen and other plant remains when used to distinguish individual plant communities in isolation, but when considered together with the insects they suggest the nature of both the very local wetland and the surrounding dryland vegetation.