C263 LATE EAST

GEOARCHAEOLOGICAL DEPOSIT MODEL: PLUMSTEAD PORTAL

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1 Purpose and Scope

This document reports on a geoarchaeological deposit model undertaken for the site of the Plumstead Portal. It utilises geotechnical data obtained from the, Pk9, Pk10, Pk20, and Pk31 ground investigations. Additional data was also obtained from the geoarchaeological monitoring of the utility enabling works (Crossrail 2010) and from a previous geoarchaeological deposit model undertaken by Martin Bates of Lampeter University (Crossrail 2008). Geoarchaeological monitoring was previously carried out and reported on for the Pk10 (Crossrail 2006) and Pk20 (Crossrail 2009) ground investigations works.

This report aims to draw together the various observations and conclusions of these reports and phases of work to create a revised and detailed deposit model of the buried sub-surface stratigraphy. It is required in order to assess the archaeological and palaeoenvironmental potential of the buried deposit sequence and to contribute to the archaeological mitigation strategies.

2 Introduction

2.1 Deposit model construction and Landscape Zones

In order to create the deposit model the geotechnical data was entered into a digital (Rockworks 2006) database. A total of 54 sedimentary logs from boreholes, window samples and test pits were included in the deposit model. The distribution of the geotechnical data is illustrated on Fig 1. The geotechnical data was entered into the database with the prefix XRail_Pk'x' with 'x' denoting the package number. The utilities works were entered with the prefix XRail_U, with U denoting utilities.

Each identified lithological unit (gravel, sand, silt etc) was given a unique colour and pattern allowing cross correlation of the different sediment and soil types across the site. By examining the relationship of the lithological units (both horizontally and vertical) correlations can be made between soils and sediments, and associations grouped together on a site-wide basis. The grouping of these deposits is based on the lithological descriptions, which define distinct depositional environments, coupled with a wider understanding of the Thames floodplain sequence gained from non-Crossrail archaeological and geoarchaeological investigations undertaken in the surrounding area. Thus a sequence of stratigraphic units, representing certain depositional environments, and/or landforms can be reconstructed both laterally and through time for the site. By this method a series of Landscape Zones (LZ's) can be defined which are determined by characteristic types of deposit sequences made up of one or more of these stratigraphic units. The landscape zones are illustrated on Fig 6.

The vertical deposit succession is illustrated on the transect drawn across the site (Fig 4). This figure illustrates a straight line correlation between the stratigraphic units identified within each data point. A modelled section of this transect is also presented (Fig 5). This is based on interpolating the surfaces of the stratigraphic units in order to create a smoother model. This figure is intended to give a clearer overview of the deposit succession, indicating the general trends and morphology of the stratigraphic units across the site.

The deposit modelling identified 7 major stratigraphic units. These units are summarised in the table below, and listed in stratigraphic order from the oldest to the most recent.

Table 1: Summary of stratigraphic units

Stratigraphic unit	Lithology/Description	Chronology	Environment of deposition
Tertiary deposits, Woolwich Beds, Thanet sands	Predominately fine grained sands and silts with occasional gravel	Pre-Quaternary, Palaeocene, c 65 Million years ago	Marine deposits
Shepperton Gravel formation	Coarse grained sands and gravels	Late Devensian, c 18–15,000 BP	Cold climate braided river regime
Late Glacial fluvial deposits	Sands and silts	Late Glacial/Early Holocene 15–10,000 BP	Temperate climate partially braided and/ or anatomising channel system
Late Glacial to mid Holocene channel fill complex	Sands and silts, often laminated, organic muds, peat lenses	Late Glacial to mid Holocene 15–3,000 BP	Freshwater single thread meandering channel
Wetland peats	Wood and reed peats, organic muds	Neolithic to Bronze Age *c* 5–3000 BP	Alder carr floodplain woodland, reed swamp and marshland
Alluvium	Gleyed clays and silts	Iron Age to historic, *c* 2000 BP	Overbank flood deposits and intertidal muds
Recent channel and tidal creeks	Gleyed clays, silts and fine sands	Iron Age to historic, *c* 2000 BP	Tidal creeks, anthropogenic channels

An important aspect of the vertical deposit succession is the identification of the pre-Holocene surface. This is essential in defining the major landforms present within the floodplain that may have influenced later sedimentation rates, depositional environments, landscape development and by consequence areas of anthropogenic activity. In the case of the present study area, by plotting the surface of the basal Pleistocene gravels and earlier Tertiary deposits an indication is given of the undulating topography which existed at the beginning of the Early Holocene (*c* 10,000 BP, Fig 3). This is archived by transferring the Rockworks data to Arc GIS v.9 where the Spatial Analyst module is used to generate a surface plot.

The synthesis of the data sets available from the previous observations has enabled a more detailed understanding of the deposit characteristics to be reached. Although the area of the portal footprint only covers LZ2 and 3, the other zone helps to place the site within a wider landscape context.

2.2 Reliability of the model

Along the line of the portal itself the spread of geotechnical data is well spaced and numerous giving a good indication on the nature of the deposits and topography likely to be encountered. The data set forms an east to west linear spread, allowing the deposits to be characterised along what is essentially a single vertical slice. This results in difficulty when ascertaining the alignment of the landscape zone boundaries towards the north and south. This is particularly relevant when trying to attribute an orientation to the channel features identified within LZ3 and the edge of the high ground defined by LZ1. However, despite these difficulties a high level of confidence can be given to the interpretation of the deposits within the vicinity of the portal itself. Many of these geotechnical interventions were monitored by geoarchaeologists and recorded according to standard sedimentary criteria. This focuses on interpreting the depositional environments and therefore ascertaining the level of palaeoenvironmental and archaeological significance. In general the data points within the direct vicinity of the portal provide an accurate and well recorded window into the sub-surface stratigraphy, and therefore contribute to a reliable model.

3 Landscape Zone discussion

Across the study area 3 major landscape zones were identified. These are;

- **LZ1** consisting of outcropping Tertiary deposits and gravel units that form the high ground of the valley sides.
- **LZ2** defines the typical Thames Holocene floodplain succession, characterised by Late Pleistocene/Early Holocene basal sands and gravels, overlain by prehistoric wetland peats, and sealed by late prehistoric to historic estuarine deposits.
- **LZ3** characterising a complex set of deposits infilling a large palaeochannel feature of Early to mid Holocene date.

These landscape zones are discussed in greater detail in the sections below.

3.1 High ground of the valley sides (LZ1)

LZ1 is located *c* 400m from the western end of the portal. It consists of an area of high ground with an elevation ranging from *c* 106m TD in the west sloping eastwards to *c* 102m TD. This higher relief topography is created by raised Tertiary deposits consisting of the Woolwich Beds, underlain by Thanet sands. This zone correlates well with the BGS mapping of the area (BGS, sheet no 271) which indicates Woolwich and Reading Beds occurring within this landscape position.

The Woolwich beds are predominately found to consist of fined grained silts and sands. However, a number of the boreholes within this zone also recorded an anomalous gravel unit at the top of the sediment profile (see Xrail_B312 and XRail_B577, Fig 4). The previous deposit model (Crossrail, 2008) suggested these gravel units may represent surviving remnants of earlier Pleistocene terrace gravels, or the accumulation of sediment derived from colluviation and hill wash processes. However, the majority of the sedimentary logs for the boreholes within this zone recorded virtually no sedimentary information to accurately assess the provenance of these deposits. The gravels of the Thames terraces are usually found to consist of coarse gravels within a orangey brown ferruginous sandy matrix, caused by sub-aerial weathering and oxidation. Where the colouration of these gravels was noted it was reported to be dark brown/black in colour. This suggests that the gravel deposits could be nothing more than modern fill, rather than naturally derived sediments.

Despite the uncertainty regarding the nature of these gravels, hill wash sediments can be expected to occur within this zone, particularly at the base of the valley slope near to the interface of the valley floor defined by LZ2. These sediments will be derived from material located further upslope (i.e. the Tertiary Woolwich Beds) and can be expected to consist of poorly sorted sands and fine grained sediments mixed with gravel inclusions. The agency of deposition may be related to episodes of high run off, or solifluction processes occurring during the freeze/thaw seasonal cycles of the glacial periods.

Older remnants of Pleistocene terrace gravels are also a possibility. The majority of the gravels within the area of the portal are attributed to the Late Devensian Shepperton Gravel formation. The sites position close to the valley sides means that earlier floodplain surfaces were eroded by successive phases of downcutting and incision following the transition from glacial to interglacial periods.

Whatever the true provenance and chronology of the gravel units these deposits should be regarded as having **low to moderate archaeological and palaeoenvironmental potential for Palaeolithic remains**. If the gravels are related to earlier terrace formations they may contain Palaeolithic artefacts (i.e. flint hand axes) and possibly fossil animal bones. The Palaeolithic potential of the pre-Devensian river terraces has been well attested to by past investigations in the Thames basin (Wymer, 1968, 1999) However, given the fluvial and/or colluvial nature of these sediments any such material within these units is likely to be reworked and *ex-situ*.

By the beginning of the Holocene any major colluvial and/or fluvial forces acting on this zone would have largely receded, leaving the zone as a stabilised area of high and dry ground immediately adjacent to the wetlands and channels of the lower lying floodplain. This would have made the zone a very favourable location for settlement and occupation due to its ecotonal position between the dryland and wetland zones. This zone should be regarded as having **moderate potential for prehistoric to historic archaeological remains**. Such evidence could be expected to consist of negative features (i.e pits, ditches, etc) cut into the surface of the Tertiary deposits and the 'anomalous' gravel units.

3.2 Prehistoric peats and wetland floodplain deposits (LZ2)

LZ2 covers the majority of the study area and defines a zone of alluvial/fluvial sediments and organic wetland deposits mainly associated with the Holocene floodplain. The western and eastern end of the portal footprint falls within this zone.

The basal deposits consist of coarse sandy gravels that can be attributed to the Late Devensian Shepperton Gravel formation (Gibbard, 1994). The main phase of aggradation for these sediments occurred between 18,000 to 15,000 BP following the Last Glacial Maximum of the Dimlington stadial, although reworking of these sediments did continue into the Late Glacial/Early Holocene period. The sediments are indicative of a cold climate braided river regime, which consisted of higher relief channel bar macroforms interspersed with low lying multiple channel threads. Such river regimes are characteristically unstable and prone to sediment reworking and redeposition during episodes of seasonal peak flow discharge (Gibbard and Lewin, 2002). By the Late Glacial/Early Holocene, periods of high sediment flux and high discharge rates began to diminish. The irregular gravel topography created by the mosaic of gravel bars and low lying channel threads influenced later channel patterns and morphology across the floodplain.

The surface of this undulating gravel topography lies at between *c* 98–99m TD, although a few individual data points do indicate a surface level of just under 100m TD in some areas. Where the lowest levels of around 98m TD occur, the sedimentary records note an accumulation of sands and fine silts above the gravels. These sediments display a graded interface with the underlying Shepperton Gravels indicating a continuous phase of sedimentation, albeit within a channel system where stream power, sediment supply and discharge rates were reduced.

These sediments are certainly attributable to the Late Glacial/Early Holocene interface, and reflect a change in the fluvial conditions and channel morphology influenced by climatic forcing and amelioration (Törnqvist, 2007). During this time the Thames would have adopted fewer channels within an anastomising or partially braided channel system, constrained within the banks created by the former raised gravel bars. These multiple threaded sand and silt filled channels are clearly shown occupying the low lying areas of the gravel surface topography within the modelled transect (Fig 5, highlighted in yellow).

With continued climatic stabilisation into the Early Holocene, a period of relative floodplain stability existed. An overall reduction in discharge into the fluvial system resulted in fewer channel threads forming the main route of flow. Many of the Late Glacial/Early Holocene sand and silt filled channels would have been short lived, becoming rapidly redundant and abandoned. Many of these former channel threads may have formed isolated pools of standing water and marshy areas across the floodplain surface.

Across the majority of this zone it is likely that the gravel and sand deposits formed a fully terrestrial land surface by the Mesolithic period. By the Early Neolithic this dry floodplain surface would have begun to experience the upstream impact of allogenic forcing (i.e. Holocene climate change, and relative sea level rise) on the lower Thames basin. Previous time depth estimates for this process of increased ground waterlogging due to rising sea level have suggested that by 5,600BP land surfaces above 97–96m TD started to become waterlogged (Bates and Whittaker, 2004). The 'ponding back' effect of rising sea levels in the lower Thames estuary, caused ground waterlogging in the upper freshwater reaches of the basin, leading to widespread peat formation by a process of paludification.

This ubiquitous peat unit has been well studied in past investigations on this stretch of the Thames. Pollen analysis has shown that the lower part of the peat unit displays evidence of fully terrestrial Neolithic woodland consisting predominately of oak, elm and hazel. The upper part of the peat, which is commonly dated to the Bronze Age, represents a transition to wetter floodplain woodland dominated by alder with some oak still surviving (Sidell et al, 2000, Grant et al, 2011).

Across LZ2 this peat unit measures up to *c* 1m in thickness, with the upper horizon occurring at between 99–100m TD. The log descriptions commonly describe this peat as woody and fibrous testifying to its formation within densely wooded floodplain environments. Other descriptions note 'reed' peat or organic clays indicating the presence of wetter reed swamps within this extensive floodplain woodland.

The sediment logs across this zone record a gradual transition from Neolithic/Bronze Age peat formation to alluvial minerogenic sedimentation from about 99m TD. This marks a switch to fully estuarine conditions, and the formation of mudflat or saltmarsh environments within an intertidal zone. Previous studies of the Thames alluvial deposits (Sidell et al, 2000, Wilkinson, 2000)has demonstrated that by the Iron Age the rate of seal level rise was outstripping the rate of peat formation. The majority of the floodplain became fully intertidal, with woodland cover now restricted to the drier interfluves and raised terrace areas.

This estuarine inundation continued into the historic periods, gradually raising and levelling the flooding surface and removing any topographic relief that remained. As the surface topography was raised regular tidal inundation became less frequent in some parts of the floodplain. Tidal mudflats were therefore gradually transformed into seasonally inundated accretionary floodplain soils. This gradual transition is reflected in the upper minerogenic deposits across the zone. The lower deposits consist of massive, gleyed, sticky and plastic clays and silts deposited within a regularly inundated tidal mudflat environment. The upper part of the profile displays evidence of pedogenesis in the form of a blocky ped structure, occasional rooting and mottles of manganese and iron oxides. This is indicative of a semi terrestrial accretionary floodplain soil, such as may be expected in a grassland floodplain meadow. These upper alluvial deposits can measure up to 2m in thickness and appear to survive to a level of 100m TD within the vicinity of the portal footprint.

The sequence described above, from Late Glacial/Early Holocene fluvial sands and silts, to Neolithic/Bronze Age wetland peats, overlain by Iron Age intertidal deposits, can be regarded as the most representative and expected depositional sequence of the Thames Holocene floodplain. Local differences within this sequence can tentatively identify discrete features. Towards the western end of the portal footprint, no true peat deposits were recorded. The sequence was generally found to consist of relatively high Shepperton Gravels (at 98.5m TD), overlain by minerogenic gleyed deposits and occasional organic clays.

These deposits are likely to have accumulated within channel areas. A chronology for these channels is difficult to determine. These may represent freshwater channels contemporary with the peat formation, Iron Age (or later) intertidal creeks which truncated the earlier peats, or even Medieval drainage cuts. Consideration should also be given to the landscape position of this zone. The site lies very close to the margins of the floodplain, flanking the higher ground further towards the south. Channels running off this higher ground, draining into the lower lying floodplain, are likely to occur within this area. Evidence of a least one major tributary channel running off the higher ground is shown on the modern day OS maps, and indicated by the erosion of the underlying Tertiary deposits on the geological mapping (Fig 2). This channel is discussed further in the next section.

There is **low potential for Mesolithic material**, such as lithic and animal bone scatters, to occur within the dryland soils that developed on the surface of the Pleistocene sands and gravels within this zone. Any Early Holocene soil horizons which formed above the gravel and sand surface are likely to be very ephemeral, and possible not even discernible as an archaeological context. Later peat formation and alluviation can often mask these ephemeral soils, and only by using soil micromorphological techniques can such horizons be identified.

The peat deposits have a **moderate potential to contain evidence of Neolithic to Bronze Age wetland exploitation**. This may take the form of timber structures such as trackways, bridges, jetties and wharfs constructed to access and traverse the wetlands. However, given the landscape position of the site this potential should be regarded as relatively higher when considered with similar sequences elsewhere on the Thames floodplain. This is because the wetlands of LZ2 form part of an ecotonal zone with the fully terrestrial ground represented by LZ1. Within the Thames basin, prehistoric trackways are predominately found in ecotonal landscape positions, close to the valley sides, particularly in areas such as Beckton, Erith and Bermondsey (Brown & Cotton, 2000). Two Neolithic timber structures were also recently discovered *c* 400m to the north of the portal within the grounds of Belmarsh prison. One of these structures was thought to be a north to south aligned trackway, and may have been linking up to the higher ground of the Tertiary outcrops just to the south of the portal footprint.

The upper alluvial deposits have **low potential for evidence of archaeological activity from the Iron Age onwards.** Artefactual material in the form of boats, and subsistence equipment related to fishing and exploitation of the Thames floodplain could be found within these sediments.

Although evidence of anthropogenic activity within this zone may be limited, the sedimentary sequence does provide a useful resource in determining changes to the wider floodplain landscape, the evolution of river morphology and identifying the allogenic and autogenic factors (i.e. changes to climate, sediment supply and hydrology) influencing floodplain development, particularly with reference to the upstream influence of Relative Sea Level rise (RSL) and the migration of the tidal head.

These sediments have **high potential for palaeoenvironmental and topographic evidence.** The peats and organic deposits will preserve pollen and plant macro fossils useful for past landscape and palaeoecological reconstruction on both an intra and inter site basis, and provide dating material to ascertain a chronological framework. The minerogenic deposits will preserve molluscs, ostracods, diatoms and foraminifera which can be utilised to reconstruct the fluvial depositional environments and identify the transition from freshwater to brackish river systems.

3.3 Channel feature (LZ3)

LZ3 represents a major feature within the floodplain landscape that covers the central part of the portal footprint. Although minor channels and creeks of unknown chronology have been identified within LZ2, the fills of these 'discrete' features are largely indistinct from the alluvial intertidal deposits. LZ3, in comparison forms a large incised channel measuring in excess of 200m across, infilled with a complex set of variable deposits. The topographic plot of the early Holocene surface (Fig 3) clearly defines the boundaries of this feature where the underlying gravel surface drops to around *c* 96.5m TD. A small cluster of boreholes aligned north to south within this zone, indicate that this channel feature may extend on a roughly north to south axis.

This feature undoubtedly formed a major part of the floodplain landscape from the Early Holocene, and probably became a major route of drainage when the other early Holocene channels identified in LZ2 became abandoned. The basal sediments within this channel fill complex consist of relatively coarse silts and sands. Further up the channel fill profile, the deposits are extremely variable and difficult to correlate between boreholes. However, these generally consist of alternating beds of very fine sands and silts, with thin beds of peats and organic clays, measuring in the order of 10^{-1}m in thickness. The minerogenic sands and silts were often noted to contain detrital organic inclusions. Internal lamination structures were also present in many of the individual sand and silt beds. Overall the full depth of the channel fills measure up to *c* 3m in thickness.

The channel fills are indicative of in-channel sedimentation interspersed with short lived episodes of channel abandonment. The finer sands and silts are likely to represent a series of in-channel morphological features, such as the formation of dune and ripple structures along the channel bed, and larger scale structures such as point and mid channel bars. The organic lenses by contrast indicate episodes of channel shift, avulsion or abandoned, with the development of partially vegetated backswamp areas, distal to the main channel flow, or within abandoned former threads. It is difficult to identify whether these deposits represent a single large contemporary channel thread, or a sequence of intercutting channel threads.

The north to south alignment of this feature can be tentatively associated with a tributary channel running off the higher ground towards the south. OS mapping shows the course of the 'Great Breach Dyke' running north off the higher ground, turning in a north easterly direction where its meets the floodplain. The geological mapping (Fig 2) illustrates a significant level of erosion down to the level of the Cretaceous chalk within the channel belt, suggesting that a channel may have existed here from the Pleistocene epoch. It is possible that the channel defined within LZ3 forms an abandoned arm of a former course of the Great Breach Dyke, which existed from the Early Holocene into the Bronze Age period. Interestingly a large palaeochannel was also identified on the Belmarsh site also flowing on a north south axis. This could lead to speculation that the Belmarsh channel and the LZ3 channel are associated.

The complex of channel fills is overlain by peat deposits which measure up to 1m in thickness with an upper surface occurring at *c* 99m TD. These peats are likely to be contemporary with the Bronze Age peat formation, given the similar elevation. However, whereas the peats within LZ2 formed as a result of allogenic forcing and resultant paludification, the peats across LZ3 may have developed by a different agency. These peats appear to seal the channel fills across the majority of the zone suggesting that the channel finally became completely abandoned and subsequently infilled with peats. Eventually this peat formation ceased, as the zone was inundated by intertidal muds. The characteristics and chronology of these intertidal deposits are the same as in the LZ2. These alluvial units measure just over 1 in thickness and occur to a little over 100m TD.

The sequence of deposits within this zone has **no potential for any archaeological remains associated with dryland occupation**. However, this feature was a major waterway and would therefore have provided a useful means of transport and access through the wetlands and out into the wider Thames estuary. Therefore this zone has **a moderate to high potential for timber structures and artefacts associated with river management and exploitation.** Such structures can be predicted to occur on the margins of this channel, particularly at the interface of LZ2 with LZ3.

The channel fills and overlying deposits within this zone may measure up to 4m in thickness and therefore potentially preserve a long record of palaeoenvironmental change extending back to the early part of the Holocene. The channel fills have the potential to contain good levels of chronological resolution, especially within channel areas which became rapidly abandoned and infilled gradually with sediments. Highly active parts of the channel are more likely to have reworked and disturbed earlier sediments, giving less resolution and reliability to palaeoenvironmental reconstructions. Despite these potential problems and uncertainties this zone should be regarded as containing a **high level of palaeoenvironmental potential** based simply on the depth of the deposit sequence and the inferred length of the chronology. The organic and minerogenic deposits will preserve a wide range of proxy palaeoenvironmental indicators useful for reconstructing past landscape palaeoecology, channel morphology, environmental change and depositional history.

4 Conclusions

The deposit model has refined the interpretations of the deposit sequence within the portal footprint gathered from earlier monitoring work and the previous model. The model has determined that the portal lies within an area that could be considered an ecotonal zone of the floodplain. The majority of the portal covers a large palaeochannel (LZ3) flanked either side by the extensive wetlands of the Thames floodplain (LZ2). Possible tidal creeks may be cutting through these peat wetlands at the far eastern and western ends of the portal. The ecotonal landscape position is determined by the close proximity of the elevated Tertiary deposits (LZ1) which appear to occur towards the west and south of the portal.

Although the possibility of dryland occupation is generally low within the area of the portal footprint itself, the large watercourse would have been a dominant feature in the prehistoric landscape and provided an important route of access into the outer wetlands and into the wider Thames basin, especially given the close proximity of the valley sides that provided dry areas of ground suitable for occupation and settlement. Therefore the probability of encountering timber structures and artefacts constructed to utilise, exploit and manage this watercourse should be regarded as significantly higher than in other wetland and channel areas located further out into the wetlands.

5 References and glossary of terms

5.1 References

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5.2 Glossary

Anastomising channel	The division of a river into a stable system of several smaller channels which successively meet and redivide, with levées and backswamps with large, stable islands between the channels. Anastomising channels tend to avulse as the channel threads age and lose transport efficiency.
Avulsion	A lateral shift in stream channels typically occurring when the existing channel is incapable of carrying all of the water and sediment supplied to it. Streamflow spills out of the banks of an existing channel and a new channel may be eroded. This may occur abruptly or gradually and is common in braided and meandering rivers systems.
BP	Years before present, conventionally taken to be 1950
Braidplain	The active extent of a braided river, which consists of multiple channel threads, separated by raised in-channel bars. Braided channels have high sediment loads and are typical of arctic regions today.
Bronze Age	*c* 2000–650 BC
Carr	North European wetland, a fen overgrown with trees
Colluvium	Colluvial or hillwash sediments eroded and transported down-slope, mainly by gravity. Colluvium often accumulates at the break of slope on valley sides, at the junction of valley side and valley floor and can interleave with alluvium deposited by a river on the floodplain.
Devensian	The last major cold stage of the Pleistocene dating from 70,000 to 10,000 BP
Ecotone	A transition area between two adjacent ecological communities (ecosystems). Changes in the physical environment may produce a sharp boundary, as in the example of a shoreline or the interface between areas of forest and cleared land, or a more gradually blended interface area where species from each community will be found together as well as unique local species.
Eyot	A small island (in this work, one within the existing or former courses of the Thames or its tributaries)
Gley	Greenish grey and bluish waterlogged soil or sediment. The greenish colour indicates the presence of iron phosphates or secondary iron alumino-silicates, and bluish tints are caused

	by the formation of vivianite (ferrous phosphate). Groundwater gleys are influenced from underneath by groundwater, surface water gleys are water-saturated from above, often with water ponding on the surface.
Holocene	Geological epoch from 10,000 BP to the present day, defining a temperate interglacial
Interfluves	A ridge or area of higher drier ground separating two or more channels which belong to the same drainage/catchment system
Iron Age	*c* 650 BC–AD 43
Late Glacial	The period following the Last Glacial Maximum and lasting until the climatic warming at the start of the Holocene, c 15,000 to 11,000BP. In Britain this period is subdivided into a warm 'interstadial' episode the Windermere Interstadial, followed by a renewed cold ('stadial') episode, in which local ice advances occurred (the Loch Lomond Stadial).
Last Glacial Maximum	The last major cold stage of the Devensian Glaciation known as the Dimlington Stadial which reached its peak at *c* 20 000–18 000 BP
m OD	Metres above Ordnance Datum (Newlyn). To obtain Tunnel Datum heights (m TD) add 100m to OD heights.
m TD	Tunnel Datum (Crossrail project datum, same as LUL datum, see above)
Mesolithic	*c* 12,000–4000 BC
Neolithic	*c* 4000–2000 BC
Paludification	Process of peat formation caused by ground watrelogging of previously terrsetrail land surfaces. Onset of peat formation occurs withput a fully aquatic pahse.
Palaeochannel	Deposits representing a former stream channel
Ped	A unit of soil structure
Pedogenesis	Soil formation, due to biological and chemical weathering
Pleistocene	Geological epoch from 2,000,000 to 10,000 BP, characterised by fluctuating cold (Glacial) and warm (Interglacial) climatic cycles
Post-medieval	AD 1485 to present
Quaternary	The most recent major sub-division (series) of the geological record, extending from around 2.6 million years ago to the present day and characterised by climatic oscillations from full glacial to warm episodes (interglacial), when the climate was as warm as if not warmer than today. The observed pattern is of long glacial stages with cold and warm perturbations (stadials and interstadials) and short interglacials (usually less than 10,000 years). Human evolution has largely taken place

	within the Quaternary period.
Roman (Romano-British)	AD 43–*c* 410
Saxon (early-medieval)	AD 410–1066
Solifluction	In periglacial environments, surface thawing results in a saturated surface layer overlying a frozen substrate. Where this occurs on valley sides it can result in the surface layers sludging down-slope over the frozen subsoil.
Tertiary	A geological Period from approximately 65 to 2.6 million years ago (mya) between the Cretaceous and the Quaternary Periods. The term ‘Tertiary’ (third age) covers the Palaeogene and Neogene and marks the beginning of the Cainozoic (from the Greek ‘new life’).

Annex 1 – Figures

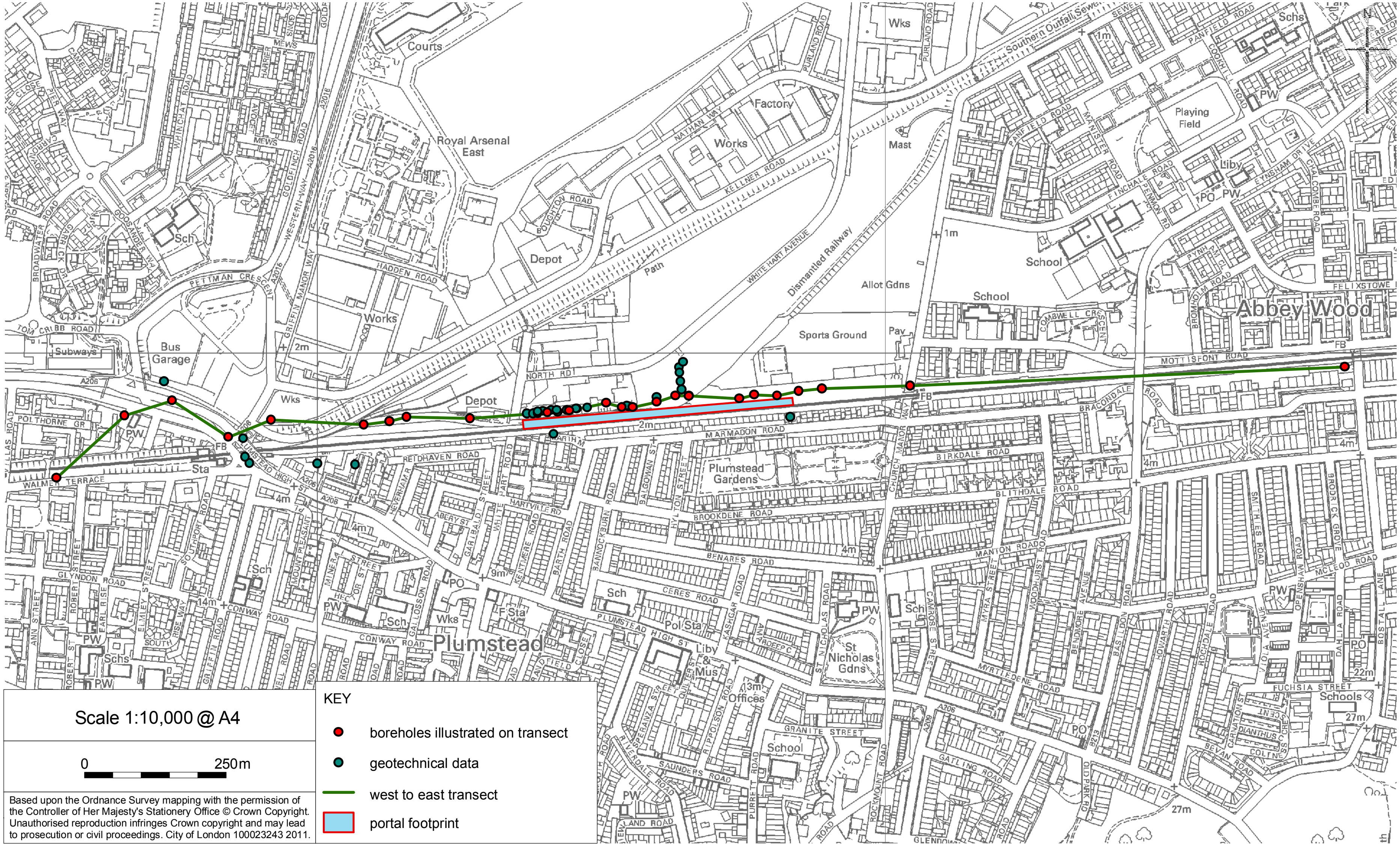

Fig 1 Location of geotechnical data and borehole transect

Geoarchaeological deposit model, Plumstead Portal

MULTI1051GEO11#01

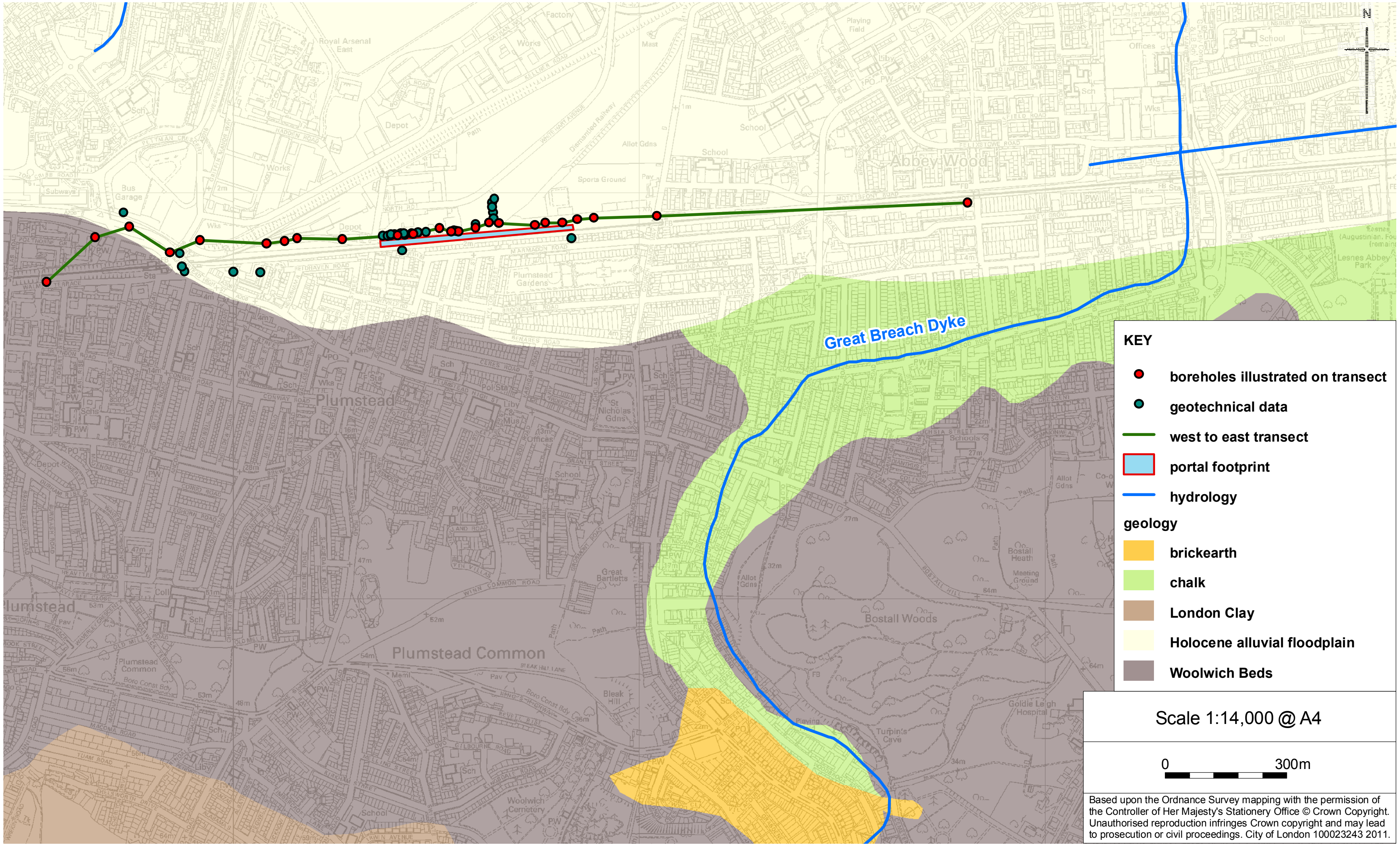

Fig 2 Local geology and hydrology

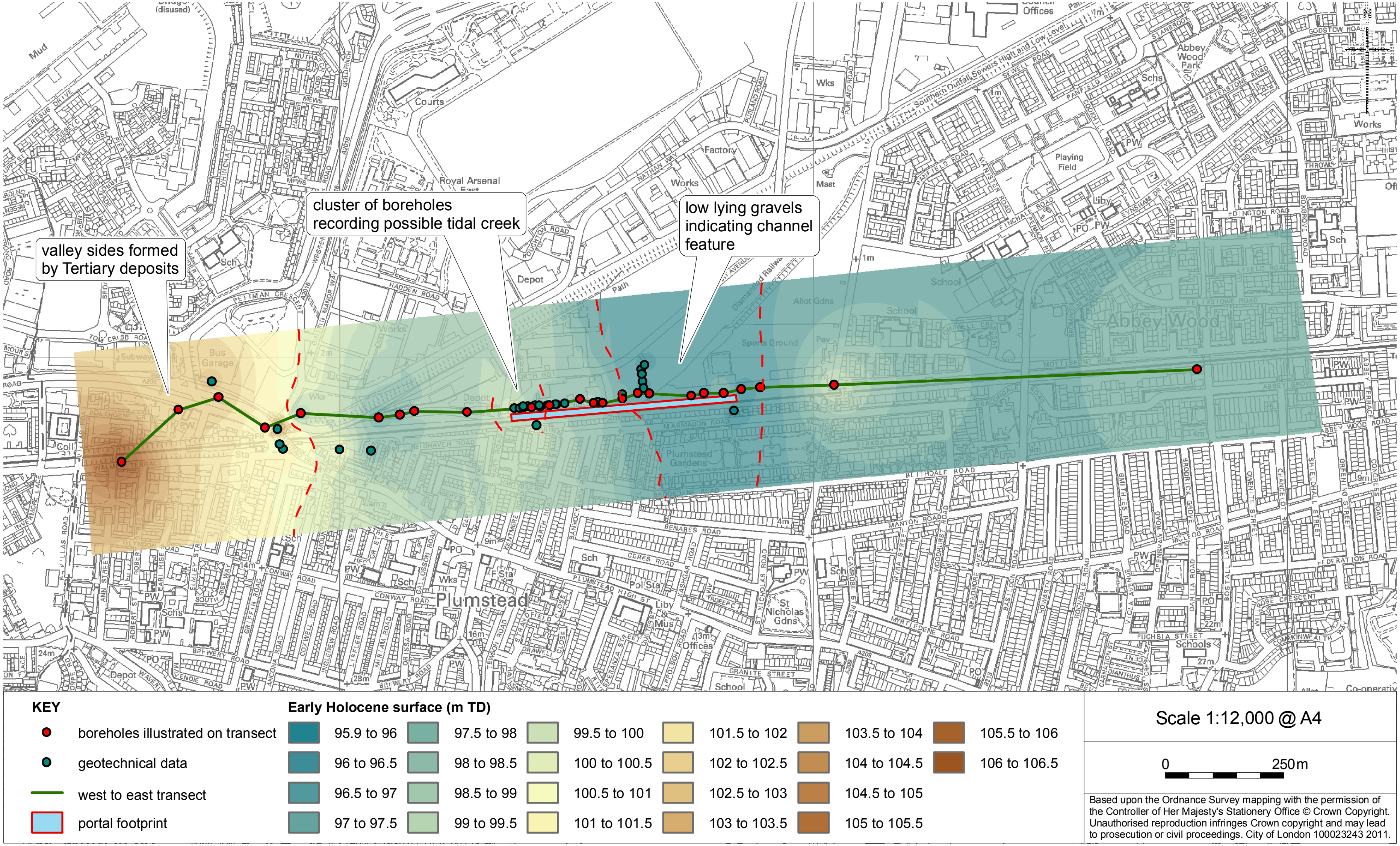

Fig 3 Buried topography of the Early Holocene

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Geoarchaeological deposit model, Plumstead Portal

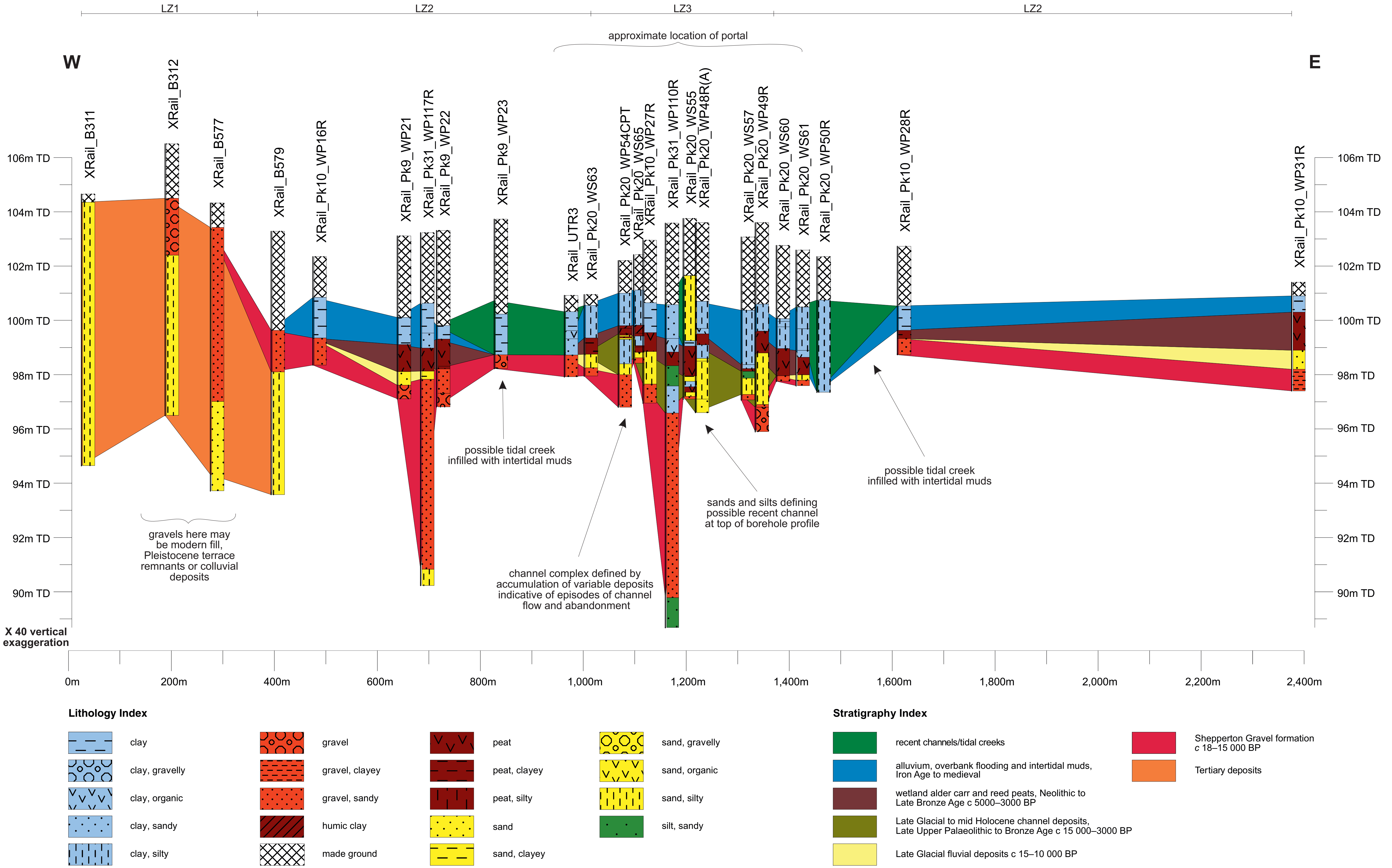

Fig 4 West to east transect

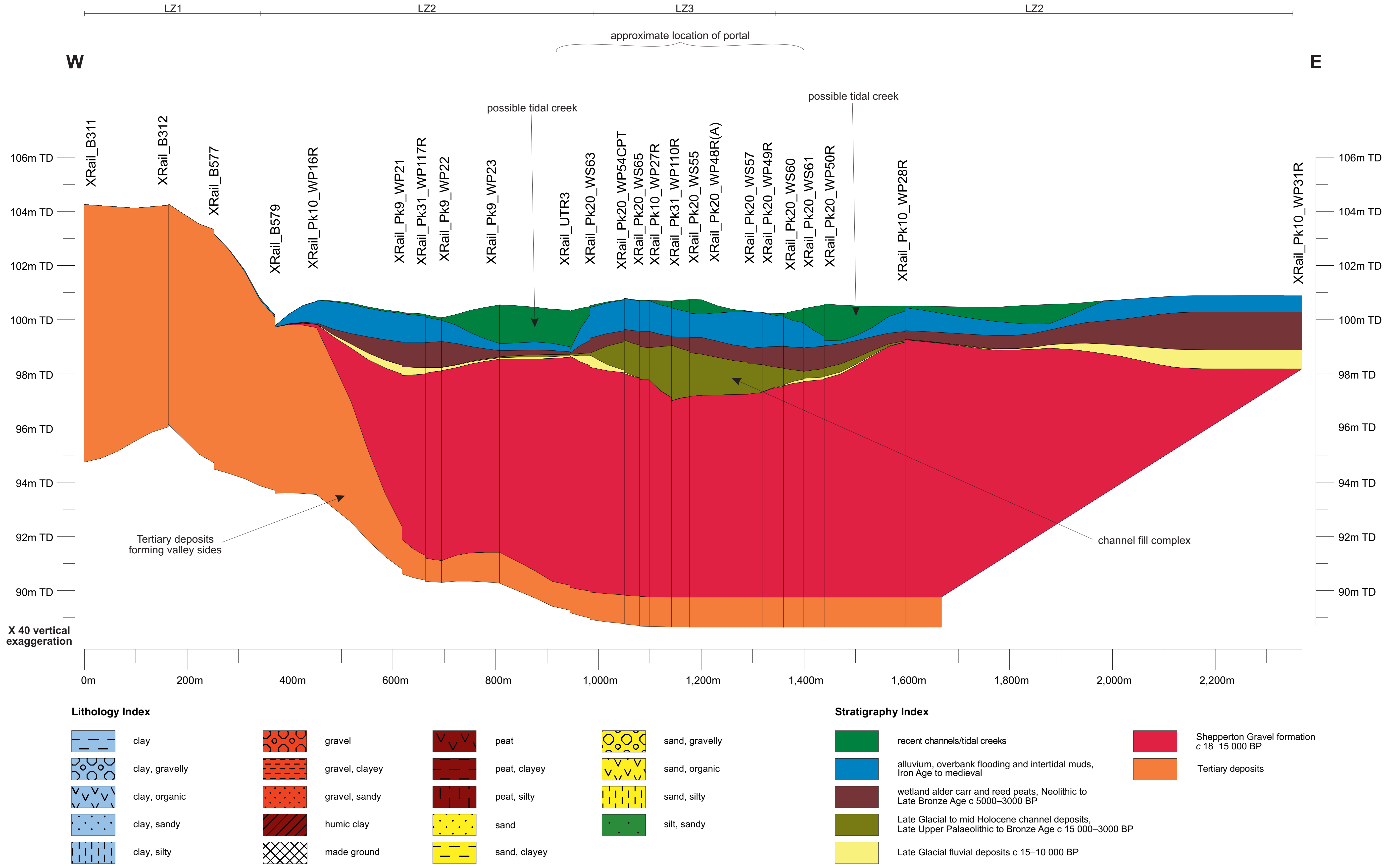

Fig 5 Modelled section of the sub-surface buried stratigraphy

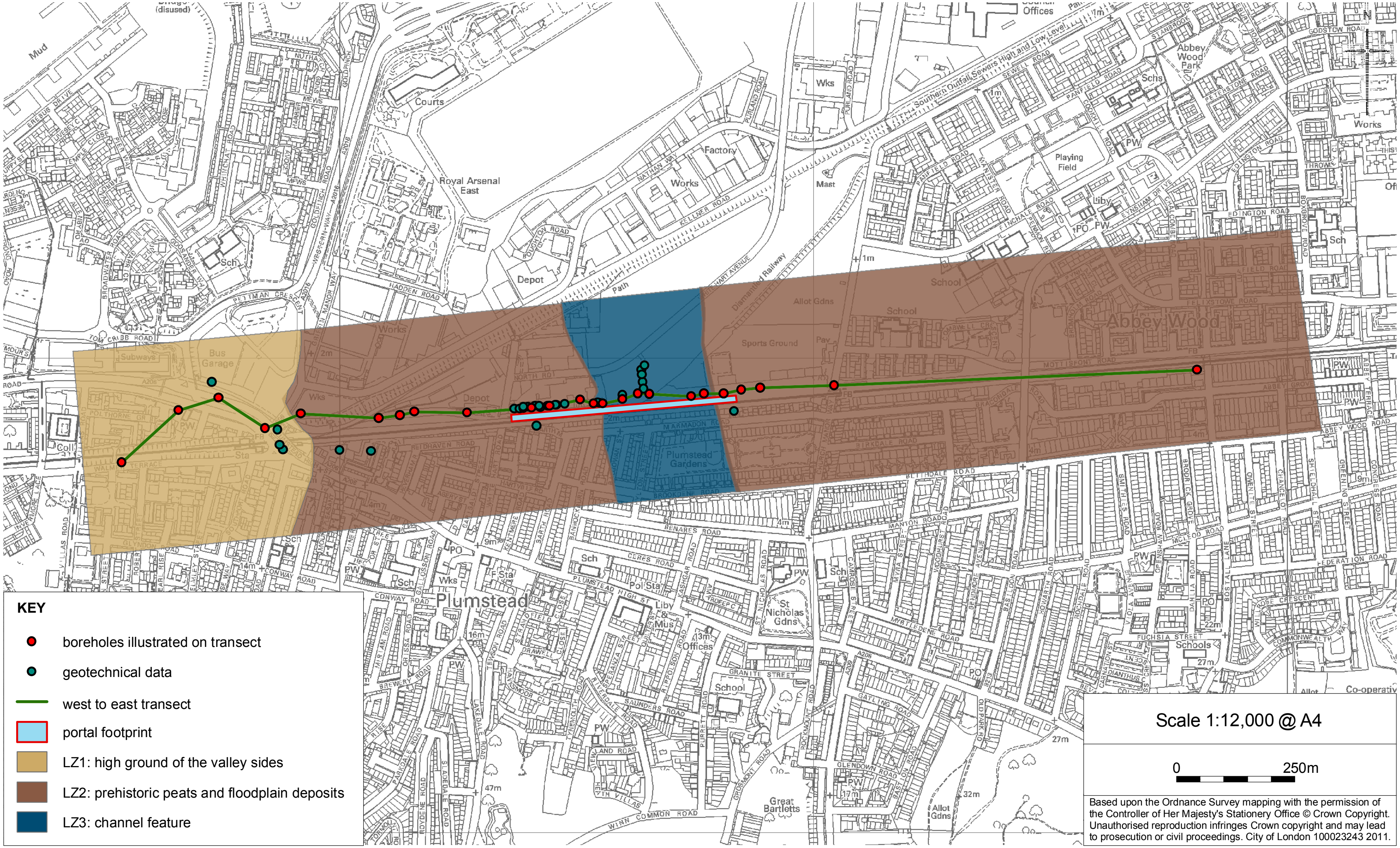

Fig 6 Landscape zones

Geoarchaeological deposit model, Plumstead Portal

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