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C262
PUDDING MILL LANE PORTAL (XPM09)

Geoarchaeological Assessment Report

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Summary

Wessex Archaeology was commissioned by Crossrail Limited, under Contract 262, to monitor a programme of geotechnical borehole survey and trial pitting, and to undertake a subsequent geoarchaeological assessment of land in the area of the proposed Pudding Mill Lane Portal, Newham, E15, centred on NGR 537750 183400. The Site, located within the Lea Valley, comprises a slightly irregular rectangular parcel of land, aligned south-west to north-east and immediately adjacent to the existing overground railway line from London Liverpool St to the east coast, and which borders the south-west edge of the London 2012 Olympic Park. The Site was subject to preliminary geoarchaeological assessment by MOLA in 2008.

In total, 65 geotechnic investigations (including re-drills) were carried out within the Site footprint, comprising 62 boreholes and three trial pits. 13 of these boreholes retrieved sleeved sedimentary sequences for geoarchaeological assessment. All geotechnic logs were combined with the existing Olympic Park geotechnical dataset to allow detailed deposit modelling of the proposed development.

Deposit modelling demonstrated a typical sequence for this area of the Lea Valley, comprising Made Ground, overlying alluvial Holocene deposits, undifferentiated Pleistocene Terrace deposits (river gravels) and Lambeth Group geology, with London Clay where present. The Site was shown to be straddling a roughly north-south oriented ridge of raised gravel sub-surface topography, with the eastern and western ends of the Site dropping off into lower areas.

Description of sedimentary sequences sampled via borehole showed that in areas of lower gravel topography to the west of the Site, the lower sequence was dominated by organic alluvial deposits indicative of a channel edge environment. These sediments will have been laid down in the well-vegetated margins of meandering channel(s) of probable later prehistoric date. Higher up the sequences in this same area conditions were only seasonally wet, and mineralogenic alluvium dominates in the form of an accretional floodplain soil, which is then overlaid by sediments indicative of a return wetland conditions as a marshy environment developed as a result of rising basal water levels, most probably in the post-Roman /Saxon period.

Over areas of raised gravel in central parts of the Site the sedimentary sequences were varied, but included indications of a dryland soil overlying the gravel (such as was found in some areas of the Olympic Park) and in some areas marshy deposits directly overlay the gravel.

Zones of raised potential were identified with regard to archaeological and palaeoenvironmental remains respectively. The central portion of the Site can be considered to be of good potential to contain prehistoric settlement archaeology, most probably in the form of cut features at around or just above the level of the gravel surface. The south-western part of the Site contains thick organic and peat deposits of good palaeoenvironmental potential, which may be contemporary with nearby archaeological activity.

Recommendations were made for extensive, informed and targeted sampling of the deposits on Site during any future intrusive works in order to allow full detailed assessment and analysis to take place.

Acknowledgements

Wessex Archaeology would like to thank Crossrail Limited, who commissioned the project (Contract No. 262), and in particular Mike Court of Scott Wilson, the consulting archaeologist. Special thanks are also due to the Norwest Holst drilling engineers for their assistance during fieldwork, and Jay Carver (Crossrail Project Archaeologist) and David Divers (GLAAS) for their review of the initial draft of this report. Finally, Wessex Archaeology would also like to acknowledge Russell Pottrill of the Olympic Delivery Authority for his kind permission to allow data from the Olympic Park project to be utilised.

Fieldwork monitoring and description on Site was carried out by John Powell. The sediments were described in the laboratory by David Norcott (Senior Geoarchaeologist, MSc, BA, MIfA) and Nicki Mulhall (Assistant Geoarchaeologist). David Norcott also carried out the geoarchaeological modelling and compiled this report, which was reviewed by Andrew Crockett and Karen Walker. The project was managed on behalf of Wessex Archaeology by Damian De Rosa, and the illustrations were prepared by Rob Goller.

1 Introduction

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by Crossrail Limited (The Client), under Contract 262, to monitor a programme of geotechnical borehole survey and trial pitting, and to undertake a subsequent geoarchaeological assessment of land in the area of the proposed Pudding Mill Lane Portal, Newham, E15, centred on NGR 537750 183400 (hereafter 'the Site'; **Figure 1**).

1.1.2 The Site comprises a slightly irregular rectangular parcel of land, aligned south-west to north-east and immediately adjacent to the existing overground railway line from London Liverpool St to the east coast, and bounded by Blackwall Tunnel Northern Approach to the south-west. In a wider context, the Site is located within the Lea Valley, about 1km south-west of Stratford Station, predominantly within the London Borough of Newham, though the most south-westerly extent adjacent to Blackwall Tunnel Northern Approach falls within the London Borough of Tower Hamlets.

1.1.3 In the context of associated development and/or infrastructure, the Site is located immediately adjacent to, and indeed overlaps at its northern extent with the London 2012 Olympic Park. Specifically, the Site borders Olympic Park Planning Delivery Zone (PDZ) 3 to the north-west, and overlaps with PDZ8 to the north-east. This overlap has already resulted in archaeological investigations within the Site footprint during works associated with the Olympic Park, and as a result the proposed area for Crossrail archaeological evaluation comprises a smaller zone within the Site footprint, primarily (but not exclusively) restricted to the central and south-west portion of the Site outside the Olympic Park boundary. To place the Site into a wider context, and specifically for deposit modelling purposes, a broader Study Area has also been defined, measuring approximately 600m square, effectively framing the Site from south-west to north-east (**Figure 2**).

1.1.4 In total, 65 geotechnic investigations (including re-drills) were carried out within the Site footprint (**Figure 2**), comprising 62 boreholes (including 41 window sampling drills) and three trial pits (**Appendix 1**), all of which have been incorporated into the Study Area deposit modelling (see below). Of these investigations, a total of 14 boreholes and window sample drills were also sampled using sleeved cores for archaeological recording purposes, of which 13 successfully retrieved sediment sequences (**Appendix 2**).

1.2 Scope of document

1.2.1 This document represents a geoarchaeological assessment of the Site based on observations in the field, description and interpretation of retrieved borehole cores, and deposit modelling of the subsurface sediments; using this data in conjunction with that from the wider PML geotechnical coring programme, together with available data from the adjacent Olympic Park site (Wessex Archaeology 2009a) and taking into account previous modelling work on the Site by MoLA (Crossrail 2008b).

1.2.2 This report has been compiled according to the *Archaeology Specification for Evaluation & Mitigation* (Document CR-PN-LWS-EN-SP-00001), the *Detailed Desk Based Assessment* (Crossrail 2008a), and *Written Schemes of Investigation* (Wessex Archaeology 2009b and 2009c).

1.2.3 In format and content this report conforms with current best practice and to the guidance outlined in *Management of Archaeological Projects* (English Heritage 1999) and the Institute for Archaeologists' *Standards and Guidance for Archaeological Watching Briefs* (as amended 2008).

1.3 Project Aims

1.3.1 As specified in the WSI (Wessex Archaeology 2009c), the key aims of this assessment were to:

- *Determine the palaeoenvironmental potential of the site (with regard to addressing the research themes derived from A Research Framework for London Archaeology 2002 (Nixon et al, 2003) as identified in the Crossrail Specialist Technical Reports (Crossrail 2005);*

- *Update the geoarchaeological deposit model of the site; and*

- *Inform the next phase of field evaluation (trial trenching), and in particularly trench location and/or potential*.

1.4 Geology

1.4.1 The British Geological Survey Sheet 256 demonstrates the Site geology as Holocene alluvium overlying Lea Valley (also known as Shepperton) Gravels of Pleistocene date, in turn overlying solid geology comprising Tertiary London Clay and Lambeth Group deposits. A more detailed picture of the geology of the Site, partly a product of the deposit modelling process undertaken for the Olympic Park Planning Delivery Zones (PDZ1-15) (Wessex Archaeology 2009a), is described below.

1.4.2 The Site lies within the regional scale geological structure known as the London Basin. Smaller scale geological structures are present within this basin and it is these structures that control the occurrence and distribution of the solid strata beneath much of London. As a result, the solid strata in this area exhibit a gentle southerly dip, which results in strata being encountered at shallower depths in the north, and progressively greater depths towards the south.

1.4.3 Specifically within the River Lea valley, across most of the northern reaches the younger London Clay has been uplifted and removed by subsequent erosion, together with some of the upper units of the Lambeth Group, and as a result, the majority of the valley is underlain by an outcrop of Lambeth Group sediments with no London Clay present. However the London Clay deposits do seem to survive in the area of the Pudding Mill Lane Portal, albeit apparently in a relatively thin layer (<2m).

1.4.4 The overlying Quaternary River Terrace Deposit is present throughout the valley, sitting directly on top of the London Clay and/or the Lambeth Group sediments if London Clay is not present. The gravel was deposited following the scouring-out of the valley floor during the late Pleistocene, and is the most recent in a series of Pleistocene Terrace Deposits, which today form an irregular 'flight of steps' in the valley side (see *Pleistocene Terrace Deposits* below), descending from earliest to most recent. In some parts of the valley these superficial deposits have been exploited for gravel extraction.

1.4.5 The youngest naturally occurring superficial drift deposits in the area (the alluvial deposits) are confined to the floodplains of the River Lea, the River Roding and the

River Thames. These are typically found immediately above the River Terrace Deposits and beneath the Made Ground. Topsoil is generally only present in those areas that have not been used for industrial purposes and associated infrastructure, primarily restricted therefore to residential and open space areas.

1.5 Pleistocene Terrace Deposits: formation of the modern Lea Valley

1.5.1 The Anglian ice sheet, 420-500 ka BP (ka=1000 years), was the most extensive of the Pleistocene glaciations in the United Kingdom, reaching as far south as East Finchley in North London. Prior to the expansion of the ice sheet, the proto-Thames river system flowed north-east across the Vale of St Albans, and the river situated within the location of the modern Lea Valley was the *northward* flowing Mole-Wey-Wandle system, which drained into the proto-Thames. The southern expansion of the Anglian ice sheet forced the proto-Thames to divert southward through the Goring Gap in Oxfordshire, to more or less follow its current course through London; the River Lea was initiated at this stage as a result of south-flowing outwash from the ice front.

1.5.2 The Lea and Thames Valleys subsequently evolved to their current positions, with multiple glacial and interglacial stages adding to the development of these valleys. With each cold and warm stage, floodplain deposits were deposited in each valley, with subsequent down-cutting resulting in the formation of raised gravel terraces on the valley edge. With the repeated cycles of cold and warm periods, further floodplain deposition and erosion occurred leading to step-like marginal terrace deposits being left. The upper terraces are thus oldest, with lower terraces becoming progressively younger until reaching the most recently deposited gravels and sands within the modern floodplain (Wessex Archaeology 2009a).

1.5.3 The River Terrace Deposits are associated with the floodplain of the River Thames and its major tributaries, such as the Rivers Lea, Roding, Fleet *etc*. Gravel terraces within the Lea Valley can therefore be correlated with those from the Thames, as shown in **Table 1**. These Pleistocene Terrace Deposits are not considered further in this report, but are discussed in detail by Bridgland (1994) for the Thames sequence and Gibbard (1994) for the Lea Valley.

Table 1: Outline Quaternary stratigraphy of the London Basin (from Burton *et al*, 2004)

Oxygen Isotope Stage	Quaternary Stage	Approximate Date (ka yrs BP)	Middle Thames (after Bridgland 1994)	Lea Valley (after Gibbard 1994)
1	Holocene	10 to present	Tilbury Deposits (Alluvium)	Alluvium
2-4	Devensian	15 to 10	Shepperton Gravel	Lea Valley Gravel
		17	Langley Silts	Enfield Silts
		30 to 20		Arctic Beds
		140 to 30	Kempton Park Gravel	Leyton Gravel
5e	Ipswichian	128 to 117	Trafalgar Square Deposits	
6-8	Wolstonian (Saalian) Complex	280 to 128	Taplow Gravel	Leytonstone Gravel
8-10		350 to 280	Hackney Gravel	Hackney Gravel
			Lynch Hill Gravel	?Stamford Hill Gravel

Oxygen Isotope Stage	Quaternary Stage	Approximate Date (ka yrs BP)	Middle Thames (after Bridgland 1994)	Lea Valley (after Gibbard 1994)
11	Hoxnian	420 to 350	Boyn Hill Gravel	?Stamford Hill Gravel
12	Anglian	500 to 420	Ware Till	Ware Till

1.6 On-site deposits

1.6.1 From the previous geotechnical investigations undertaken throughout the adjacent Olympic Park, it is known that the major stratigraphic units present within this part of the Lea Valley can be characterised as follows.

Made Ground

1.6.2 Made Ground forms the most recent deposit over the majority of the lower River Lea valley. The depth and composition of the Made Ground can be highly variable, ranging from inert engineering fill beneath specific building plots, to more general fill used for land-raise in the Lea floodplain, and quarry overburden and waste material (inert and non-inert) dumped within former gravel pits. It can consist of mixed gravelly, sandy, clayey material along with brick and concrete rubble, ash and other industrial wastes, primarily associated with 19th century and later land uses.

Alluvium

1.6.3 The Holocene Alluvium is associated with the floodplain of the River Lea. Although shown to fill the entire valley on both the BGS sheet 256 and through modelling, it is known that Alluvium has been wholly removed in some locations by sub-surface excavations (e.g. for basements *etc*), as recently demonstrated at the site of the proposed Orbit structure (Wessex Archaeology 2010) on Olympic Park. Alluvium generally consists of locally variable deposits of soft to firm, dark grey and black or light greenish grey and brown sometimes organic silts and clays, with a little flint gravel and pockets and thin layers of peat or sand/ gravel.

1.6.4 In the vicinity of the Site, the thickness of Alluvium ranges from less than 1m to around 2.5m in the south-west of the Site, although a thickness of around 1m to 1.5m is more typical. Thicker Alluvium tends to occur where the underlying River Terrace Deposits are thinner, and vice versa. Alluvium is characteristically a very weak, compressible material, especially where it has a high organic content, and the clay may also be of high plasticity, making it susceptible to shrinkage and swelling with changes in moisture content.

River Terrace Deposits

1.6.5 The lowest (and therefore youngest) of the river terraces present in the area are likely to be Ipswichian (Kempton Park Gravels, locally known as Leyton Gravels (Gibbard 1994)) and Devensian (Shepperton Gravel, locally known as the Lea Valley Gravel (*ibid*.)) in age. The upper river terrace present in areas beyond the Site boundary is likely to be Wolstonian in age (Taplow Gravels - locally known as Leytonstone Gravel (*ibid*.)).

1.6.6 These gravels typically consist of medium dense to dense, brown or grey, fine to coarse sub-angular to sub-rounded flint gravel with occasional flint or sandstone cobbles with variable amounts of medium to coarse sand. However, the grading can vary considerably both horizontally and vertically. Regionally the River Terrace Deposits vary considerably in thickness over short distances, and can measure up to

6m to 7m. Within the vicinity of the Site they are generally between 2.0m and 5.0m in thickness.

London Clay

1.6.7 Where present, the London Clay consists of a stiff to very stiff, over-consolidated, fissured, blue-grey clay with variable silt content, which weathers to a firm orange-brown clay. Common found within the clay are hard, calcareous cemented nodules (claystone bands) and sulphates in the form of selenite crystals, resulting from the breakdown of iron pyrite (much pyrite is still present, often in the form of nodules).

Lambeth Group

1.6.8 The Lambeth Group consists of two interbedded formations, namely the Reading and the Woolwich Formations, which in turn consist of a number of lithologically distinct units. Within the vicinity of the Site the Lambeth Group have an estimated total thickness of up to 20m, and appear to consist of the following units:

- *Laminated Beds - Woolwich Formation*

1.6.9 On the adjacent Olympic Park site, the uppermost unit of the Lambeth Group was the Laminated Beds. These have not been encountered in the northern extents of the valley where uplift and erosion has generally resulted in the removal of this material, with only a few specific recordings during geotechnical investigations further south. Where present, this unit consists primarily of thinly interbedded fine to medium grained sand, silt and clay with scattered intact bivalve shells. Where present these are a maximum of 3m in thickness, but more generally less than 1m thick and typically finely laminated. The sand is commonly pale olive to pale brown, medium-grained, well sorted and cross-laminated.

- *Lower Shelly Beds - Woolwich Formation*

1.6.10 The Lower Shelly Beds consist of very stiff, dark grey-green and brown, very shelly clay with some medium sand, some interbedded sand horizons and occasional layers of finely comminuted shell debris which may form weakly cemented limestone up to 0.5m thick.

- *Lower Mottled Beds - Reading Formation*

1.6.11 The Lower Mottled Beds consist of soft, mottled dark or light grey, dark green, purple, red and brown, slightly sandy to sandy clay with a little rounded fine to medium flint gravel. With depth this becomes grey to dark grey sandy clay with occasional gravel size shell fragments. Within the Stratford area this unit is in the order of 1 to 3m thick.

- *Upnor Formation*

1.6.12 The Upnor Formation forms the lowest unit of the Lambeth Group and generally consists of very dense, dark grey-green, highly glauconitic, slightly clayey to clayey or silty fine to coarse sand with variable amounts of clay and gravel. Within its upper and basal layers it may consist of black or grey rounded medium to coarse flint gravel with some slightly sandy clay, upper pebble beds consist mainly of rounded black flint gravel in a sand/ clay matrix.

Thanet Sands

1.6.13 Within the Site the Thanet Sand Formation is encountered at around 20-30m below Ordnance Datum (70 – 80m ATD). The Thanet Sand is generally around 10m thick in the area of the Site and consists predominantly of dense to very dense dark grey-green, glauconitic, silty, fine grained sand becoming grey slightly sandy very clayey silt towards its base.

1.6.14 The lower boundary where the Thanet Sands overly the Upper Chalk is locally often marked by the Bullhead Beds, comprising firm grey very silty clay with variable amounts of angular to rounded fine to coarse flint gravel and occasional cobbles.

Upper Chalk

1.6.15 The Upper Chalk occurs at approximated depths of 35m below OD (65m OTD). It is generally a white, low to medium density, weak to moderately weak limestone with abundant layers of flint occurring as either discrete nodules or in the form of thin sheets. It has been proven to a thickness in excess of 50m below the Olympic Park site, and is regionally up to 220m thick.

1.7 Archaeological and palaeoenvironmental background

Introduction

1.7.1 The archaeological background of the area has been considered previously in the *Desk Based Assessment* (Crossrail 2008a), and will not repeated in detail here.

1.7.2 However, the results of more recent archaeological and geoarchaeological work from the adjacent Olympic Park site - especially that from PDZ3 and 8 (**Figure 2**) - provides a useful context for the immediate environs of the Pudding Mill Lane Portal, both archaeologically and palaeoenvironmentally, and a brief summary of the results from this area of the Olympic Park site is given below.

1.7.3 Several sedimentary sequences were analysed from this area during post-excavation works for the adjacent and overlapping Olympic Park site (Wessex Archaeology 2009a), and summarised below. Levels are provided both in metres above Ordnance Datum (OD: Newlyn), and metres above Tunnel Datum (ATD). ATD is 100m below OD, and was originally designed for the London Underground to avoid height/ depth calculations involving negative numbers.

1.7.4 In Trench PDZ8 5.41 (**Figure 2**) basal gravels of probable Pleistocene date were recorded at 0.65m OD (100.65m ATD), above which was a fine organic alluvium to 1.8m OD (101.8m ATD), with horizontal laminations and plant remains, indicative of a probable marsh environment with shallow standing water. Repeated inwashes of sand were the result of higher energy alluvial (flood) events. Fine overbank alluvium in the form of an accretional floodplain soil overlay the organic alluvium, to 2.29m OD (102.29m ATD) and above.

1.7.5 Radiocarbon dating indicated that this alluvium accumulated relatively rapidly, within 200-300 years maximum in the 7th to 9th centuries AD, with analysis confirming a marshy or channel-edge environment in the immediate vicinity at this time. Pollen from the same sequences indicated a very open area, with a general reduction in sedges and rushes with time. Horsetail was present, and the presence of beech tallied well with the Saxon date. Grassland with clover and other species indicative of possible grazing were also present. The insect and mollusc fauna confirmed that the area contained slow flowing water and bankside vegetation, and the plant macrofossils indicated a wet marsh/ bog environment although with some representation of dryland species.

1.7.6 Evidence for prehistoric activity, albeit most likely transient, of Mesolithic to Early Neolithic date is indicated by the recovery of diagnostic flintwork throughout the wider area, and specifically PDZ8.

1.7.7 Settlement features of Middle to Late Bronze Age date have been recorded occupying areas of raised gravel within the footprint of the Site in Olympic Park trench PDZ8 8.04/5.35, and also on raised gravel areas 250m to the north-west in trenches PDZ3 3.17/18 and 3.22 (**Figure 2**). After a brief period of alluviation overlying these settlement features there is some evidence for limited re-occupation (further settlement features) in the Middle-Late Iron Age (MoLAS-PCA 2008).

1.7.8 There is very little evidence for Romano-British remains from the Olympic Park site as a whole, although the projected line of the London to Colchester Roman road does cross the River Lea Valley some 500m to the north of the Site. Elsewhere within the area, modelling has indicated that Trench PDZ8 5.36 (**Figure 2**) was located at the interface of a raised gravel area and a channel feature. Basal gravels were not reached in this trench, which in a deeper sondage reached a depth over four metres (0.38m OD; 100.38m ATD). A very humic silty clay loam, indicative of a channel-edge environment, was overlain by a moderately calcareous alluvium representing shallow water conditions.

1.7.9 No radiocarbon dating results are available from this trench, but the lower part of the sequence seems likely to be of Iron Age to Romano-British date based on the pollen evidence. This showed largely open vegetation with small patches of local alder and grasses, reeds and sedges becoming more sparse over time. Pollen from several species indicative of open disturbed grassland was interpreted as the result of probable grazing, and possible cereal pollen was noted from the top of the sequence.

1.7.10 The results of the geoarchaeological investigations suggest that by the Saxon period most of the Olympic Park site - including the gravel high areas previously the focus for prehistoric activity - was very marshy and thus unsuitable for settlement (Wessex Archaeology 2009a). The rich wetland resources are still be likely to have been exploited however, if only for such activities as fishing and wildfowling.

2 Methodology

2.1 Boreholing

2.1.1 Boreholing was undertaken by Norwest Holst, the geotechnical contractors on site. This work was commissioned and organised by Crossrail. Boreholing was monitored on-site by an archaeologist from Wessex Archaeology during August and September 2009.

2.1.2 A shell and auger percussion rig was used to extract cores, which was capable of coring and casing to a depth of >20m below ground level through a variety of sediment including sand and gravel. Where necessary sleeved cores were used to allow sampling of the deposits.

2.1.3 The WSI (Wessex Archaeology 2009c) details the methodology employed for fieldwork. In summary:

- *65 locations were investigated by borehole and/or trial pit;*

- *On-site logging was carried out by both the geotechnical engineers, and the archaeologist;*

- *Sealed aluminium U100 cores (100mm x 450mm) were retained from 14 boreholes designated as archaeological, in order to allow detailed description and further laboratory-based examination; and*

- *The boreholes were reinstated by the geotechnical contractors;*

2.1.4 The cores were taken back to the Wessex Archaeology laboratories, where the U100 tubes were opened and the sediments subjected to geoarchaeological description and interpretation (**Appendix 2**).

2.2 Deposit modelling

Introduction

2.2.1 An extensive deposit model (incorporating data from *c*. 4000 boreholes) was produced as part of the geoarchaeological phase (Phase 3B) of the adjacent Olympic Parks works (Wessex Archaeology 2009a). Permission to use that data were sought by Wessex Archaeology and granted from the Olympic Delivery Authority; the data from the recent works from Pudding Mill Lane have therefore been reciprocally entered into the larger Olympic Park model in order to collectively produce a more detailed model of the Site area than would otherwise have been possible.

2.2.2 For the purposes of this assessment, a subset of the combined Olympic Park/ Crossrail dataset was extracted, corresponding to all data points within the broader 600m square Study Area as defined. All modelling was undertaken using Rockworks® 2006 (Revision 6.8.15) - an outline of the methodology used during deposit modelling is given below; further details regarding settings used and stratigraphy/ lithology types can be found in **Appendix 3**.

2.2.3 A common approach to geoarchaeological deposit modelling is to group individual sedimentary or lithostratigraphic units with similar characteristics within a particular borehole, and then to other similar groups of units within adjacent boreholes. The boreholes are examined by drawing intersecting transects across the study area. Linking deposits between boreholes produces a series of site-wide deposits (facies) which can be representative of certain environments – thus is can be possible to recreate a series of environments both laterally and through time (Burton *et al*. 2004).

2.2.4 However, the nature of the geotechnical data from Pudding Mill Lane and the Olympic Site lent itself to a more geomorphological approach. Rather than attempting to reconstruct detailed facies across the entire Site, wider stratigraphic units were mapped in order to show the buried topography (e.g. gravel islands, channel features *etc*) and thickness of overlying Holocene alluvial deposits. The more detailed and non-stratigraphic lithological data was then interrogated in Rockworks by plotting transects across this model to examine the sedimentary specifics of areas of interest.

Stratigraphy

2.2.5 The geotechnical data lends itself readily to division into four major stratigraphic categories:

- ***Made ground****;*

- ***Alluvium** - essentially equating to Holocene deposits (although in some areas of the Olympic Park site lower alluvium may be Late Glacial in date), and including peat;*

- ***River Gravels** (undifferentiated); and*

- ***Geology** (with subdivisions for different Formations; Lambeth Group, London Clay etc)*.

2.2.6 By assigning the lithostratigrahic units described within each geotechnical borehole into the appropriate stratigraphic unit, it was then possible to model that stratigraphy using Rockworks. This allows key data to be modelled on a site-wide basis; for example the surface of the River Terrace Gravels (which essentially equates to the pre-Holocene topographical template for the Site).

Lithology

2.2.7 As described in **Appendix 3**, the individually described contexts from all of the borehole logs were assigned to one of 24 lithological units (e.g. peat, sandy gravel, organic silt *etc*).

2.3 Sediment description

2.3.1 Once opened the cores were rapidly described geoarchaeologically according to Hodgson (1997), with characteristics such as colour, texture, inclusions and the nature of boundaries being noted (**Appendix 2**). The data from the cores were input into the site-wide Deposit Model. As per the WSI (Wessex Archaeology 2009c), no subsampling was undertaken at this stage.

2.4 Storage of cores

2.4.1 Following geoarchaeological description the cores were re-sealed and are currently being stored at the offices of Wessex Archaeology in Salisbury pending further analysis (if required).

3 Assessment Results

3.1 Deposit modelling

Introduction

3.1.1 The Site and surrounding area is relatively well covered by Olympic Park boreholes to the eastern side of the Site, but much less so to the west and north (**Figure 2**). In any deposit modelling exercise it is important to bear in mind that modelling can only demonstrate trends from one intervention to the next, and that therefore the accuracy (or otherwise) of modelling is entirely dependant on the relative spacing of data points. For this reason the modelling results, in particular in the north and west of the Study Area, should be viewed with caution.

3.1.2 As a general introductory comment regarding the thickness of made ground at the Site, this was generally shallower in the south-west part of the Site (*c.* 1-2m), and gradually thickening towards the north-east extent of the Site, to a maximum thickness of *c.* 3m (**Figure 3**).

Gravel topography

3.1.3 The gravel topography underlying the Site can effectively be considered to be the pre-Holocene template upon which the Holocene alluvial and other deposits were later deposited.

3.1.4 The gravel deposits in the Lea Valley were deposited in the Pleistocene by high-energy flashy rivers of glacial meltwater, forming sinuous intercutting braided channels with raised gravel area or islands between them (Gibbard 1994). With the onset of calmer climatic conditions of the Holocene these relict features remained, essentially forming the template for the Early Holocene (and later) landscape and channel activity.

3.1.5 The raised gravel islands (within the Site generally speaking those areas with gravel topography above 0.6m OD/ 100.06m ATD) provided drier areas suitable for settlement and other activity during prehistory, within a landscape which was becoming increasingly wetter and marshy as water levels rose along with relative sea level and reduced flow gradient. They can be considered to be of relatively high potential for prehistoric settlement and other dryland archaeological features. During the post-Roman period even these higher areas were marshy and subject to regular flooding.

3.1.6 Lower lying off-island areas (in later prehistory generally in areas where the gravel level was below 0.2m OD/ 100.02m ATD), including wetland areas and active channels, would most likely have been exploited for their resources throughout prehistory and into the historic period. Features such as wooden trackways of Neolithic and Bronze Age date could also be expected in these wetland areas, and indeed have been recorded in similar settings in the wider area (e.g. Crockett *et al*. 2002; Meddens and Sidell 1995).

3.1.7 The gravel topography underlying the area of the Site is plotted in **Figure 4**.

3.1.8 The low-lying area to the east of the Site (which drops down to -1.2m OD/ 98.8m ATD) was identified during work on the Olympic Park, and was interpreted as part of the course of the palaeo-Lea; the most likely course of the main River Lea during the Holocene and probably up until the Iron Age or Roman period (Wessex Archaeology 2009a; Fig. 5).

3.1.9 A raised gravel area (c.0.8-1.0m OD) can be clearly seen in the centre of the Site; this area and its surrounds (0.6-0.8m OD) are the most likely to hold archaeological settlement features - based on those found at the Olympic site these features would be very likely to be of Bronze or Iron Age date.

3.1.10 Across the Olympic Park site prehistoric settlement was particularly found to be concentrated at the edge of raised gravel areas adjacent to low-lying wetlands or channels (Wessex Archaeology 2009a) – this also seems to be true here, with Trench PDZ8 8.04/5.35 containing Bronze Age settlement features being located at the eastern edge of the higher gravel area only *c*. 50m from the palaeo-Lea.

3.1.11 The generally raised topography across the central bulk of the Site offers a moderate to high potential for the presence of prehistoric settlement features.

Organic and alluvial deposits

3.1.12 Peats (and organic alluvial deposits) were primarily concentrated to the east and west of this raised gravel area within the central portion of the Site, as could be expected

(**Figures 4, 5 and 6**). From results at the Olympic Park site we know that these peats are likely to have been formed within abandoned/ marginalised channels or oxbow lakes, and may be of prehistoric or historic date.

3.1.13 It is important to note that as basal water levels rose over time, wetland and marsh deposits were able to form at higher levels; thus absolute level OD or ATD is not a reliable indicator of whether marsh or wetland deposits might be encountered. However, organic alluvial sediments higher in the sequences are likely to be of historic (post-Roman and especially Saxon) date; similar deposits of this date were quite widespread on the Olympic Park site, and were found to represent a marshy wetland environment.

3.2 Sediments

3.2.1 Thirty seven sleeved cores in total were obtained from 14 archaeological boreholes (including PML59ARCH from which no cores were retrieved) – these were described and the results are presented below (**Appendix 2**; **Tables 2** - **14**).

Problems with retrieval

3.2.2 Retrieval was generally quite poor, which is not unusual when dealing with soft wet fine-grained alluvial sediments, particularly at depth, and not a reflection on the methodology.

3.2.3 Most of the boreholes are represented by a number of cores inadequate to assess the deposits present; however several sequences are present in sufficient proportions to be meaningful.

3.2.4 In one case, PML59ARCH, a combination of very gravely made ground and only a thin granular alluvial layer meant that no retrieval was possible.

Results

3.2.5 Five boreholes produced a reasonable depth of sampled deposits: WS203ARCH; WS207ARCH; WS208ARCH; WS212ARCH and WS218ARCH (**Tables 5**, **6**, **7**, **8** and **10** respectively). See **Figure 2** for borehole locations, and **Figure 7** for a schematic transect of the deposit sequence along the long axis of the Site.

3.2.6 In WS203ARCH, located ‘off-island’ to the south-west of the Site, the underlying gravel topography was recorded at 0m OD (100m ATD). Soft, sticky, waterlogged organic-rich deposits containing freshwater molluscs indicative of a well-vegetated probable channel-edge environment were present up to 1.74m OD (101.74m ATD). Above this, fine mineralogenic alluvial sediments with evidence of soil formation were indicative of a drier but periodically flooded environment, and then from 2.85m OD (102.85m ATD) to the top of the sequence at 3.24m OD (103.24m ATD) a probable return to a wetland or marshy environment was indicated.

3.2.7 Similarly WS208ARCH was located firmly off-island *c*. 20m north-north-west of WS203ARCH. The portions of the borehole containing the gravel surface itself were not recovered, but from adjacent boreholes it is thought to lie at *c*. 0m OD (100m ATD). The sediments recovered were extremely similar to WS203ARCH, with organic rich channel-edge deposits present up to 1.73m OD (101.73m ATD), and with more mineralogenic probable overbank alluvium dominating above this. The return of freshwater snails from 2.23 to 2.97m OD (102.23 – 102.97m ATD) is again indicative of a return to wetter (probably marshy) conditions.

3.2.8 In WS207ARCH, located towards the edge of the raised gravel area and *c*. 25m east of WS203ARCH, gravels were recorded at 0.85m OD (100.4m ATD). The upper portion had been reworked alluvially as indicated by the inclusion of thin horizontal laminae of humic sediments. Above the gravel a thin peat layer to 0.97m OD (100.97m ATD) was sealed by a slightly humic alluvium to 1.85m OD (101.85m ATD), indicating that peat growth was halted by an increased depth of sediment-carrying water.

3.2.9 WS212ARCH was located on the edge of an area of raised gravel topography, with gravels being recorded at 0.7m OD (100.6m ATD). Coarse sand with abundant freshwater molluscs represented active channel deposits at the base of the sequence to 0.95m OD (100.95m ATD). Above this, soft, sticky humic alluvium, with horizontal laminated variations toward the top (2.05m OD; 102.05m ATD), again represent shallow water conditions at a probable channel margin. Apart from a slight reduction in freshwater mollusca from 2.1 to 2.55m OD (103.1 to 103.55m ATD), the soft organic alluvia continue up to the top of the sampled sequence at 3.05m OD (103.05m). The sequence may be non-continuous with unrecognised erosive boundaries, although it is possible that the entire sequence represents a relatively late (post-Roman) channel which has been subsequently abandoned.

3.2.10 WS218ARCH was located on an area of raised gravel, with the top of gravels being recorded at *c*. 1.07m OD (101.07m ATD). Above this *c*. 0.5m of soft alluvium may represent either channel margin activity or marsh deposits – no inclusions were noted of either vegetation or molluscs, which makes interpretation problematic. Overbank alluvial deposits were recorded from *c*. 2m OD (102m ATD) upwards.

Summary

3.2.11 In areas of lower underlying gravel at the west of the Site (as in WS203ARCH, 208ARCH & 207ARCH) the lower sequence is dominated by organic alluvial deposits indicative of a channel edge environment; sediments laid down in the well-vegetated margins of meandering channel(s) of probable later prehistoric date.

3.2.12 Higher in these sequences conditions were only seasonally wet and mineralogenic alluvium dominates in the form of an accretional floodplain soil; later, as basal water levels rose, wetland conditions again dominate (up to *c*. 3m OD/ 103m ATD) as a marshy environment developed, most probably in the post-Roman /Saxon period (the latter is indicated by comparisons from the Olympic Park).

3.2.13 Over areas of raised gravel results were varied, but often include indications of a dryland soil overlying the gravel (such as is found in some trenches for the Olympic Park) and in some areas (e.g. WS218ARCH) marshy deposits directly overlay the gravel.

3.2.14 In general it can be said that humic alluvial deposits indicative of marshy environments found at relatively high levels - for example the humic marshy deposits towards the top of WS212ARCH which extend up to around 3m OD (103m ATD) - are very probably of post-Roman and perhaps Saxon date, while lower marsh/ wetland sediments will be of varied date and potentially earlier.

4 Potential

4.1 Research Aims and Objectives

4.1.1 With specific reference to the project research themes (derived from Nixon *et al* 2003, and identified in Crossrail 2005), the sediments present on Site have the potential to address the following research themes:

- *Understanding London's hydrology, river systems and tributaries and the relationship between rivers and floodplains;*

- *Understanding the relationship between landscape, river and settlement;*

- *Studying the correlation between sites associated with watercourses and meander bends, so as to understand the origin of settlements; and*

- *The development of models for understanding the significance of geomorphology, ecology, ecosystems and climate, hydrology, and vegetational and faunal development, on human lives.*

4.1.2 In addition the Site may have the potential to input to some extent to the following identified themes (*ibid*):

- *Characterising changing climatic conditions, and air and water quality and pollution, throughout the archaeological record, towards understanding its implications for how people behaved;*

- *Understanding what London's past environments meant to different groups and individuals.*

4.1.3 Although no material of suitable date has yet been identified from the wider Olympic Park site, if suitable deposits are encountered then there may be some small possibility of also addressing:

- *The Mesolithic/Neolithic transition: understanding the significance of horticultural experimentation at this time, and the transition from hunter-gatherers into farmers.*

4.2 Discussion

Introduction

4.2.1 The potential of the Site is essentially twofold: to contain archaeological features and artefacts; and to contain palaeoenvironmental sequences which could elucidate the past environment and man's role within it/ effect upon it. This potential is explored further below.

Archaeology

4.2.2 The known presence of Bronze Age settlement activity at the eastern edge of the raised gravel area (Trench PDZ8.04/5.35) - as well as in other similar palaeo-topographical locations nearby in the Olympic Park site - clearly demonstrates the potential of this area for prehistoric archaeological features. As **Figure 4** shows, this raised gravel zone - representing an area of drier ground within channelised and increasingly wet landscape – extends across much of the Site.

4.2.3 The central portion of the Site footprint (**Figure 8**) can be considered to be of good potential to contain prehistoric settlement archaeology, most probably in the form of cut features at around or just above the level of the gravel surface.

4.2.4 It should be emphasised that although this zone is of highest potential for settlement evidence, the wetland areas will most likely have been heavily exploited and have good potential to contain remnants of prehistoric features such as wooden trackways, which are well known from the local area (e.g. Silvertown, Crockett *et al*. 2002; also see Meddens & Sidell 1995).

4.2.5 Based on the lack of evidence for Romano-British and Saxon archaeology in the immediate area, it is considered that the potential for archaeological features of this date is low.

Palaeoenvironment

4.2.6 Although the zone of higher settlement potential identified above is likely to contain valuable palaeoenvironmental material and layers (possibly including buried land surfaces) associated with any archaeological remains present, in terms of palaeoenvironmental sequences it is the off-island areas which are of greater potential.

4.2.7 Although organic deposits (**Figure 6**) are present on the gravel high area, these are likely to be humic marsh sediments of Saxon date, significantly post-dating any possible archaeological remains present on the Site. However, the south-west zone of the Site contains thick organic and peat deposits which would have formed in abandoned channels and in the margins of watercourses. Intercutting channel features of a range of dates may be present, potentially contemporary with archaeological activity upon the areas of raised gravel.

4.2.8 Radiocarbon dating and palaeoenvironmental assessment of these sequences would allow our knowledge of the past environment and human exploitation of the local area to be greatly extended. Recommendations for this are made below.

5 Recommendations

5.1.1 Further intrusive mitigation will allow for extensive, informed and targeted sampling of the deposits on Site in order to allow full detailed assessment and analysis to take place.

5.1.2 In addition to a thorough sampling strategy relating to any archaeological features and deposits present, geoarchaeological and palaeoenvironmental sampling should include monolith and bulk sampling of a variety of exposed sections through representative sequences in various areas (especially those sequences containing organic sediments and/or peat which may be contemporary with any archaeology present). Provision should also be made for micromorphological sampling of any buried land surfaces which may be associated with archaeological activity.

5.1.3 Either the continual presence of, or regular monitoring by, geoarchaeological/ palaeoenvironmental specialists will be necessary in order to ensure that the sampling programme can be modified according to the needs of the Site, the sedimentary environments encountered and the types of material present.

5.1.4 Provision should be made for a considerable number of radiocarbon dates, in order to place the sequences into secure chronological (and archaeological) context, and to understand the changing palaeoenvironment through time.

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7 Appendices

7.1 Appendix 1: Geotechnical investigation location details

Geotechnic designation code	Easting (OS NGR)	Northing (OS NGR)	Height (m OD)	Depth drilled (m)
PML28	537631.600	183286.420	4.550	0.6
PML28A	537633.400	183288.020	4.580	0.7
PML29R	537664.860	183361.590	4.570	30.03
PML29RA	537661.570	183365.360	4.530	1.05
PML30ARCH	537752.440	183454.650	4.500	8
PML30R	537751.050	183453.650	4.440	32
PML30RTP	537750.360	183455.290	4.430	1.05
PML37R	537850.140	183543.990	4.720	33.92
PML50R	537878.120	183541.530	4.630	35.02
PML51R	537841.700	183516.030	4.650	35.05
PML52R	537812.430	183481.650	4.540	32
PML55	537803.040	183439.620	4.090	9.5
PML55ARCH	537804.030	183440.760	4.110	4
PML56	537768.520	183358.240	4.030	8.5
PML57	537713.170	183343.020	4.530	10
PML58	537699.430	183276.020	4.370	8.5
PML59ARCH (no retrieval)	537805.940	183487.850	4.530	8
PML60ARCH	537683.700	183405.730	4.710	9.5
PML61R	537751.830	183341.600	4.030	45
PML62	537639.760	183320.800	4.900	35
PML63	537872.260	183548.490	4.750	9
TP458	537799.110	183427.120	4.030	0.5
TP458A	537798.630	183427.790	4.040	0.8
TP458B	537798.030	183428.440	3.970	1.2
WS201	537689.580	183255.990	4.630	8.5
WS201A	537677.730	183232.910	4.630	0.75
WS201B	537678.060	183234.050	4.620	0.36
WS201C	537677.190	183235.040	4.620	1.4
WS201D	537685.910	183232.760	4.630	0.01
WS201E	537690.600	183237.370	4.650	0.35
WS201F	537694.780	183245.330	4.660	0.4
WS201G	537695.990	183248.480	4.660	1.25
WS202	537669.950	183269.920	4.670	3
WS202A	537668.790	183267.680	4.660	0.25
WS203	537611.940	183299.030	4.760	4
WS203ARCH	537611.710	183308.100	4.740	6

Geotechnic designation code	Easting (OS NGR)	Northing (OS NGR)	Height (m OD)	Depth drilled (m)
WS204	537733.560	183306.530	3.860	3
WS205	537702.570	183302.190	4.120	3
WS206	537671.800	183300.600	4.560	3
WS206A	537673.990	183301.590	4.540	0.8
WS207	537643.400	183302.920	4.860	4
WS207ARCH	537642.520	183302.190	4.850	8.5
WS208	537602.300	183329.520	4.780	5.8
WS208ARCH	537600.700	183328.410	4.770	8.5
WS212	537633.980	183360.340	4.600	1
WS212ARCH	537635.140	183355.120	4.690	5
WS212ARCHA	537635.230	183361.320	4.550	1
WS214	537757.300	183381.940	4.510	3
WS214A	537756.310	183381.150	4.510	1.2
WS215	537739.340	183382.960	4.520	3
WS216	537705.010	183375.630	4.310	3.6
WS216ARCH	537704.000	183376.590	4.270	8.5
WS217	537659.310	183370.560	4.550	3
WS218	537763.670	183414.880	4.520	4
WS218ARCH	537762.100	183415.050	4.520	4.7
WS219	537819.160	183451.700	4.080	3
WS220	537788.220	183464.560	4.470	3
WS220ARCH	537787.380	183465.810	4.490	5
WS221	537831.760	183473.240	4.420	3
WS221ARCH	537829.670	183473.750	4.440	4.2
WS222	537872.990	183530.580	4.570	6
WS222ARCH	537871.470	183531.820	4.610	9
WS223	537845.980	183499.790	4.600	5
WS223ARCH	537845.030	183502.050	4.700	8.5
WS224	537819.830	183513.930	4.910	4

7.2 Appendix 2: Sediment descriptions

Key: FFR = fine fleshy rootlets; RPR = recognisable plant remains; HPR = humified plant remains; note that not all sequences are continuous, and that ***depth from top*** *will indicate where gaps in recovery have occurred.*

Table 2: PML30ARCH

PML30R	**OS NGR:** 537751.050 183453.650 4.44m OD (104.44m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
2.50 – 2.78	10YR 2/1 and 10YR 3/4 dark yellowish brown sandy gravel contaminated with diesel. Clear boundary.	Made ground
2.78 – 2.95	10YR 3/1 very dark grey silty clay loam with gravel inclusions, probably intrusive. Contaminated with diesel.	Alluvium

Table 3: PML55ARCH

PML55ARCH	**OS NGR:** 537804.030 183440.760 4.11m OD (104.11m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
2.80 – 2.95	10YR 2/1 black sandy clay loam. Soft, crumbly and gritty. Fairly humic. Rare small stones <5mm and FFR's throughout.	Organic alluvium

Table 4: PML60ARCH

PML60	**OS NGR:** 537683.700 183405.730 4.71m OD (104.71m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
2.50 – 2.95	10YR 3/1 very dark grey silty clay loam. Soft, silky and compact. Some visible RPR's. Becoming slightly darker in colour and stickier towards the bottom.	?organic alluvium
9.00 – 9.45	10YR 3/1 very dark grey stiff sticky clay	London Clay (.Solid geology.

Table 5: WS203ARCH

WS203ARCH	**OS NGR:** 537611.710 183308.100 4.74m OD (104.74m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
1.50 – 1.89	10YR 3/1 very dark grey silty clay loam. Soft and sticky occasional patches of 10YR 3/2 very dark greyish brown. Horizontal RPR's. Rare freshwater molluscs. Clear boundary.	Alluvium.
1.89 – 1.95	10YR 3/1 very dark grey silty clay loam mixed with sand and gravel. ?intrusive	Alluvium.
2.16 – 2.33	10YR 3/1 very dark grey silty clay loam with patches of 10YR 3/3 dark brown silty clay loam. <10mm layer of sandy gravel at 2.21. Clear boundary.	?overbank alluvium
2.33 – 2.45	10YR 3/2 very dark greyish brown silty clay loam. Compact and crumbly with sandy inclusions. 2% small rounded stones <25mm. Charcoal flecks and RPR's. 0.1% macropores.	?stabilisation
2.65 – 2.90	10YR 3/1 very dark grey silty clay loam which, when broken open, appears as 10YR 3/3 dark brown silty clay loam. Soft and crumbly. Rare HPR's. 1piece of CBM/brick at 2.69 – 2.73 ?intrusive.	Alluvium with oxidised areas.
3.00 – 3.29	10YR 3/1 very dark grey silty clay loam. Soft and sticky. Horizontal RPR's and some freshwater molluscs. Clear boundary.	Alluvium
3.29 – 3.45	10YR 3/1 very dark grey silty clay loam. Darker than above but not quite black. Soft and slightly fibrous. Humic but not peat. Common RPR's and freshwater molluscs.	Organic alluvium
3.50 – 3.65	2.5Y 3/1 dark grey silty clay loam with patches of 2.5Y 2.5/1 black. Soft and sticky. Some RPR's and freshwater molluscs. Clear boundary.	Organic alluvium
3.65 – 3.95	10YR 3/1 very dark grey silty clay loam interspersed with laminations of 10YR 2/1 black and 10YR 3/3 dark brown silty clay loam throughout. Laminae <10mm wide and <10mm apart. Clearer between 3.65 and 3.75. Common freshwater molluscs equally distributed between laminations. Some RPR's.	Organic alluvium ?with layers of inwash.
4.00 – 4.30	10YR 3/1 very dark grey silty clay loam with patches of 10YR 2/1 black silty clay loam. RPR's and common freshwater molluscs, ?sandstone inclusion at 4.10 – 4.18 ?intrusive. Sharp boundary.	Organic alluvium
4.30 – 4.45	10YR 2/1 black humic peat. Very fine and quite silty. Soft but less sticky than above. Slightly fibrous with RPR's.	Peat
4.50 – 4.74	10YR 2/1 black humic silty clay loam. Soft and sticky. RPR's throughout. Clear boundary.	Organic alluvium
4.74 – 4.95	10YR 3/4 dark yellowish brown and 10YR 2/1 black sandy gravel. Smelly due to rotted organics.	Sandy gravel with organics

Table 6: WS207ARCH

WS207ARCH	**OS NGR:** 537642.520 183302.190 4.85m OD (104.85m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
3.00 – 3.33	10YR 3/1 very dark grey silty clay loam with patches of 10YR 3/3 dark brown slightly humic silty clay loam. Some RPR's and occasional subrounded gravel <15mm. 2 large inclusions of possible sewer pipe at 3.17 – 3.29 ?intrusive. Clear boundary.	Organic alluvium.
3.33 – 3.45	10YR 2/1 black fine peat. Fibrous, predominantly made up of plant material. RPR's and FFR's observed. Thin (<1mm) lamination of 10YR 3/3 dark brown sand at 3.40 ?intrusive. Rare freshwater molluscs.	Peat.
4.00 – 4.45	10YR 3/3 dark brown sandy gravel with 10YR 3/1 very dark grey silty clay. Loosely compact and gritty. Horizontal laminations <2mm of 10YR 3/1 very dark grey, 10YR 2/1 black and 2.4Y 4/4 olive brown fine organics throughout. Freshwater molluscs present within laminated areas. RPR's and wood at 4.12 – 4.18. Large subrounded chalk inclusion at 4.40 – 4.45.	Sandy gravel with layers of organic alluvium.
8.00 – 8.45	10YR 3/1 very dark grey London Clay. Compact, soft and pliable. Area of sandy gravel at 8.10 – 8.20 concentrated around the outside so probably intrusive.	London Clay (natural geology)

Table 7: WS208ARCH

WS208ARCH	**OS NGR:** 537600.700 183328.410 4.77m OD (104.77m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
1.80 – 2.54	10YR 3/1 very dark grey silty clay loam. Soft and silky with some HPR's and snails throughout. Clear boundary.	Alluvium
2.54 – 2.75	10YR 3/2 very dark greyish brown silty clay loam. Soft and silky, HPR's, but no snails.	Alluvium
2.80 – 3.04	10YR 3/1 very dark grey silty clay loam. Very similar to above but slightly more brown in colour. Clear boundary.	Alluvium
3.04 – 3.25	10YR 3/2 very dark greyish brown silty clay loam. More humic than above. Fibrous with HPR's.	Organic alluvium
3.30 – 3.46	Laminated lenses (<1cm) of 10YR 3/2 very dark greyish brown coarse silt/ fine sand and 10YR 3/1 very dark grey silty clay loam. Clear boundary.	Organic alluvium ?with higher energy alluvial events
3.46 – 3.50	10YR 3/2 very dark greyish brown silty clay loam. Soft and silky. No inclusions. Clear boundary.	Alluvium
3.50 – 3.57	10YR 3/2 very dark greyish brown silty clay loam. More humic and fibrous than above. Horizontal HPR's and common snails. Clear boundary.	Organic alluvium
3.57 – 3.75	10YR 3/2 very dark greyish brown silty clay loam soft and slightly more fibrous than above. More HPR's ?roots. Some snails.	Organic alluvium
7.50 – 7.57	2.5Y 3/2 very dark greyish brown sandy gravel. Clear boundary	Sandy gravel
7.57 – 7.95	10YR 3/1 very dark grey London Clay. Compact, stiff and pliable. No inclusions.	London Clay – natural geology

Table 8: WS212ARCH

WS212ARCH A	**OS NGR:** 537635.14 183355.12 4.69m OD (104.69m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
1.50 – 1.95	10YR 2/1 black and 10YR 3/2 dark greyish brown silty clay loam. Very soft, sticky and quite humic. RPR's visible. Freshwater molluscs throughout but with a more concentrated layer at 1.80 – 1.89.	Organic alluvium.
2.00 – 2.45	10YR 2/1 black and 10YR 3/1 very dark grey silty clay loam with some patches of 10YR 3/2 very dark greyish brown. Soft and silky, more compact than above. Some visible FFR's and sparse freshwater molluscs. Gravel inclusions at 2.00 – 2.04 ?intrusive.	Organic alluvium
2.50 – 3.20	10YR 3/1 very dark grey silty clay loam with layers of 2/1 black and 2/2 very dark brown. Quite compact but silky. Laminations <2mm of 2/1 and 2/2 very visible at 2.63 – 2.80 with a concentration of freshwater molluscs. Horizontal RPR's and FFR's throughout. Clear boundary.	Organic alluvium with inwashes.
3.20 – 3.45	10YR 3/3 dark brown with 10YR 3/1 very dark grey silty clay loam. Fairly compact and crumbly. Less sticky than above with more RPR's and common freshwater molluscs.	Organic alluvium.
3.50 – 3.60	10YR 3/1 very dark grey silty clay loam. Very soft and sticky with inclusions of small stones <20mm. RPR's and freshwater molluscs visible. Clear boundary.	Alluvium
3.60 – 3.85	10YR 3/2 very dark greyish brown and 10YR 2/1 black sand. Coarse and ?humic. Abundant freshwater molluscs throughout. No visible RPR's. Clear boundary.	Sand with organics and freshwater molluscs
3.85 – 3.95	10YR 2/1 black sandy gravel.	Sandy gravel

Table 9: WS216ARCH

WS216ARCH	**OS NGR:** 537704.000 183376.590 4.27m OD (104.27m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
3.30 – 3.45	10YR 3/3 dark brown sandy gravel with 10YR 3/1 very dark grey silty clay loam. Occasional RPR's	Alluvium
8.00 – 8.45	10YR 3/1 very dark grey London Clay with 2.5Y 4/3 olive brown sand at 8.04 – 8.06 and 8.14 – 8.18.	London Clay (natural geology)

Table 10: WS218ARCH

WS218ARCH	OS NGR: 537762.100 183415.050 4.52m OD (104.52m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
2.00 – 2.18	10YR 2/1 black sandy gravel. Clear boundary.	Made ground
2.18 – 2.40	2.5Y 2.5/1 black sandy clay loam. Crumbly with sandy inclusions and small rounded stones <1cm. Becoming slightly paler in colour towards the bottom. Clear boundary.	Post medieval soil.
2.40 – 2.45	10YR 3/1 very dark grey silty clay loam. Soft, silky and sticky. Slightly humic.	Overbank alluvium
2.50 – 2.63	10YR 3/1 very dark grey sandy gravel. Clear boundary	Sandy gravel
2.63 – 2.85	10YR 3/1 very dark grey silty clay loam. Very soft and sticky. No inclusions. Clear boundary.	?overbank alluvium
2.85 – 2.95	10YR 3/2 very dark greyish brown silty clay loam. Soft and sticky and slightly humic. More brown than above.	Stabilisation horizon.
3.00 – 3.45	2.5Y 3/1 very dark grey silty clay loam. Soft and very sticky. Common sounded small stones <2cm with sandy inclusions. Becoming more gravely towards the bottom with larger stones <3.5cm.	Alluvium

Table 11: WS220ARCH

WS220ARCH	OS NGR: 537787.380 183465.810 4.49m OD (104.49m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
2.80 – 3.18	10YR 3/1 very dark grey sandy clay loam with a layer of made ground at 2.80 – 2.84. Soft, sticky and gritty becoming paler in colour towards the bottom. RPR's throughout.	Alluvium beneath made ground
3.18 – 3.75	2.5 3/2 very dark greyish brown sandy clay loam with 2.5 4/3 olive brown sandy gravel at the bottom. Fining upwards.	Slightly organic alluvium overlying gravel
Comment:	Gap between 3.25 and 3.50	

Table 12: WS221ARCH

WS221ARCH	OS NGR: 537829.670 183473.750 4.44m OD (104.44m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
2.50 – 2.95	10YR 3/1 very dark grey silty clay loam with patches of 10YR 3/3 dark brown and 3/4 dark yellowish brown. Soft and silky. Stone free. No visible organics.	Alluvium

Table 13: WS222ARCH

WS222ARCH	**OS NGR:** 537871.470 183531.820 4.61m OD (104.61m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
3.00 – 3.45	10YR 2/1 black silty clay loam mottled with 10YR 3/3 dark brown with a layer of made ground at the top. Highly contaminated with diesel.	Alluvium
3.75 – 3.95	10YR 2/2 very dark brown sand. Highly contaminated with diesel.	sand
8.00 – 8.45	10YR 3/1 very dark grey stiff sticky clay with a layer of gravel at the top. Highly contaminated with diesel.	London Clay

Table 14: WS223ARCH

WS223ARCH	**OS NGR:** 537845.030 183502.050 4.70m OD (104.70m ATD)	
Depth from top (m)	**Sediment description**	**Interpretation**
3.00 – 3.45	10YR 2/2 very dark brown and 10YR2/1 black sandy clay gravel.	?made ground

7.3 Appendix 3: Deposit modelling methodology

Introduction

7.3.1 Rockworks® 2006 (Revision 6.8.15) was used for all modelling. Data was input into the model via Excel tables for each separate Site (in this case Olympic Park and Pudding Mill Lane) containing data including location, lithology and stratigraphy for each borehole. The software was then used to output georeferenced thickness and surface plots of the relevant stratigraphy, along with lithological transects.

Settings used in Rockworks

7.3.2 Inverse Distance Weighting was used for all modelling, with a weighting exponent of 2.0 and sector based searching set to 45º (8 sectors). Decluster points (250) and Smooth Grid (1/1) were selected.

Area modelled

7.3.3 The modelling of the Pudding Mill Lane area itself utilised the data from 324 boreholes within a grid square defined by NGR 537538 183190 (south-west) and 538150 183778 (north-east).

Stratigraphy

7.3.4 The following stratigraphic units were defined and applied (where possible) to each borehole log:

- *MADE GROUND – various granular and cohesive materials including ash, clinker, brick and concrete;*
- *ALLUVIUM – soft to firm locally sandy or gravelly CLAY/ SILT, including organic rich deposits;*
- *RIVER TERRACE DEPOSITS – SAND and GRAVEL in varying proportions;*
- *LAMBETH BEDS – This incorporates the upper geological units, predominantly:*
    - ➔ *WOOLWICH & READING BEDS (soft to firm locally sandy or gravelly CLAY);*
    - ➔ *WOOLWICH & READING BEDS – Lower Mottled Beds (compacted/ locally cemented mottled CLAYS and SILTS and fine SANDS with occasional shells and burrows from above and rare brown and black rounded flint gravel, over mottled clay-bound rounded flint GRAVEL or gravelly CLAY); and*
    - ➔ *UPNOR FORMATION (variable deposits, typically clay-bound rounded flint GRAVEL or gravelly CLAY over bioturbated stiff and friable mid to dark grey slightly sandy and sandy CLAY with slightly clayey sand over gravelly CLAY or clay-bound GRAVEL over clayey SAND or sandy CLAY).*
- *THANET SAND – very dense slightly silty mainly fine SAND. At base is the flint gravel BULHEAD BEDS; and*
- *CHALK – deepest stratigraphic unit encountered (deepest geotechnical borehole reached -90m OD).*

7.3.5 Originally it was hoped to also separate out the LONDON CLAY (including HARWICH FORMATION) as a geological unit, but it was only found to have been specifically recorded in 23 of the ODA geotechnical boreholes and 13 from the Stratford City boreholes. Although it is known that LONDON CLAY is often very limited in the Lea Valley due to glacial scour, a number of boreholes' upper WOOLWICH & READING BEDS descriptions could be interpreted as LONDON CLAY (firm grey CLAY), but due to uncertainties over the consistent identification and recording of LONDON CLAY as such, it has been incorporated into the LAMBETH BEDS Group.

Lithology

7.3.6 Twenty four lithological units were defined (**Table 15**). These are comparable with lithology units defined in the Lea Valley Mapping Project (Burton *et al*. 2004), and also conform closely to the standard sedimentary descriptions provided during geotechnical investigations. Although generally clearly identified and defined within the various geotechnical records, a series of protocols was defined to deal with potential ambiguities in lithological recording in a consistent manner (**Table 16**)

Table 15: Lithology units used within the Deposit Model

Classification	Basic Soil Type	Description	Code	Symbol
Coarse Soils	GRAVEL	GRAVEL	GR	
		Sandy GRAVEL	SD/ GR	
		Silty GRAVEL	SL/ GR	
		Clayey GRAVEL	CL/ GR	
	SAND	SAND	SD	
		Gravelly SAND	GR/ SD	
		Silty SAND	SL/ SD	
		Clayey Sand	CL/ SD	
Fine Soils	SILT	SILT	SL	
		Gravelly SILT	GR/ SL	
		Sandy SILT	SD/ SL	
	CLAY/ SILT	Clayey SILT/ Silty CLAY	CL/ SL	
	CLAY	CLAY	CL	
		Gravelly CLAY	GR/ CL	
		Sandy CLAY	SD/ CL	
Organic Soils	Organic Clay, Silt, Sand or Gravel	Organic Gravel	ORG-GR	
		Organic Sand	ORG-SD	
		Organic Silt	ORG-SL	
		Organic Clay	ORG-CL	
	Peat	Organic	ORG	
Others	WATER	WATER	WTR	
	MADE GROUND	MADE GROUND	MGR	
	VOID	VOID	VOID	
	SOLID GEOLOGY	SOLID GEOLOGY	SOLID GEOLOGY	

7.3.7 The colour of the symbol used in the scheme therefore represents the main unit, with the symbol representing the sub-component, or if dominated by a single component, that symbol. This means that for the basic soil types there are five different colours, each represented by five different symbols for the components.

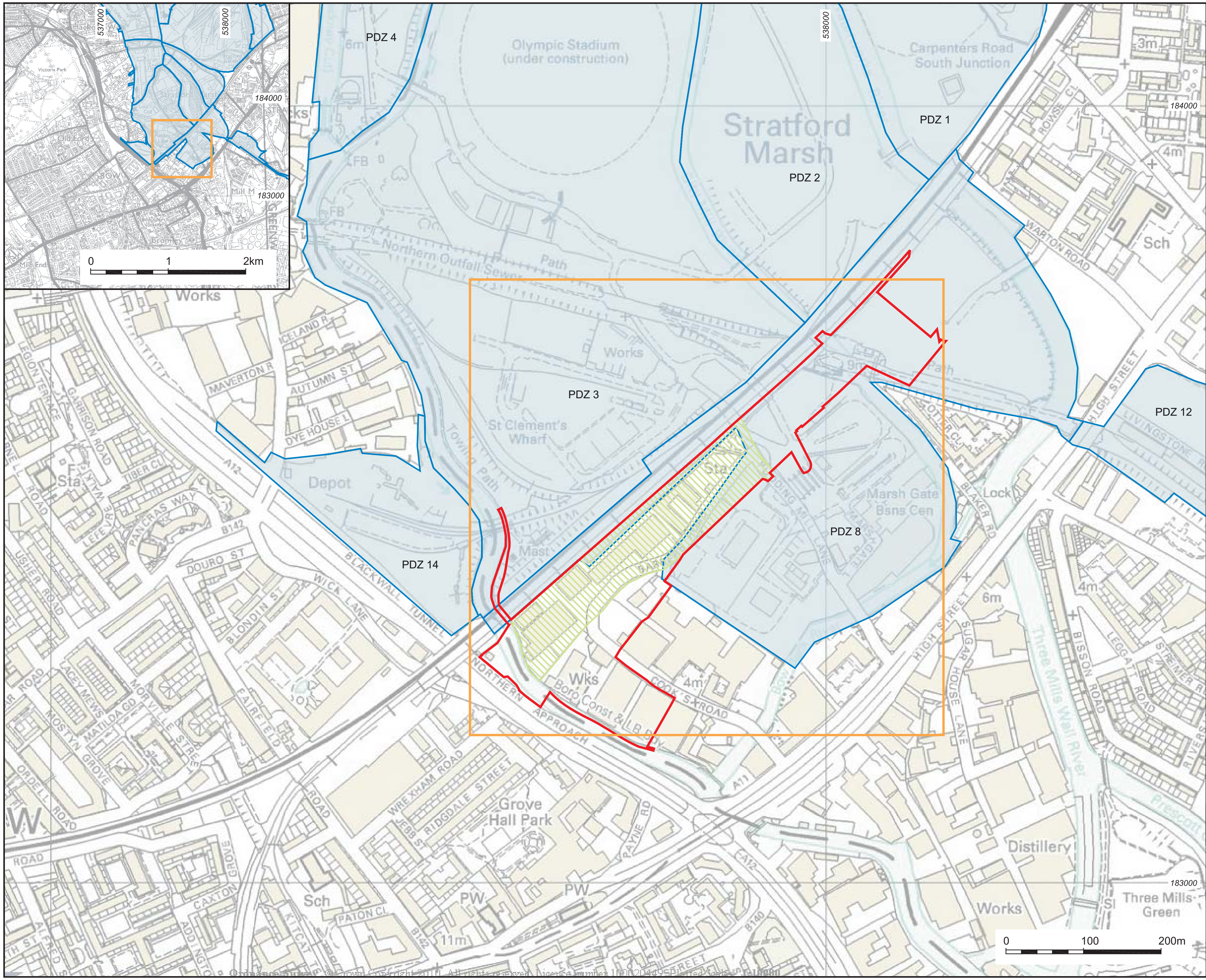
7.3.8 The four remaining “Others” units are used to identify the following additional units:

- *WATER represents surface water (up to 2.40m in some interventions);*
- *MADE GROUND is the same as stated above in the stratigraphy section;*
- *VOID represents no recovery in the core, so the unit can only be inferred by that either side of it; and*
- *SOLID GEOLOGY represents anything beneath the RIVER TERRACE DEPOSITS (LAMBETH BEDS and deeper)*.

7.3.9 The geological units are deliberately omitted from the lithology dataset as it allows the focus to be upon the Quaternary deposits and results in less vertical extension for each borehole log (the maximum borehole length (SR4362) is 90.5m BGL), whereas the base of the River Terrace Deposits only reaches a maximum depth of 23.8m BGL (MBHCZ5B-130). Although the geology lithology is not utilised within the dataset processed through Rockworks, it is retained within the datafile, allowing import easily into the deposit model should the geological lithology also wish to be viewed and interrogated.

Table 16: Protocols for interpretation of lithology units

Structure and format	**Geotechnical Report Example**	**Interpretation**
Use of capitals	“Soft brown mottled grey gravelly CLAY. Gravel is subrounded to rounded fine to medium flint. (ALLUVIUM)”	This level would therefore be identified as a CLAY (CL).
Organic reference	“Soft to firm grey black slightly silty organic CLAY (ALLUVIUM)”	This level would therefore be identified as an Organic Clay (ORG-CL).
Multiple components	“Medium dense brown SAND and GRAVEL. Sand is fine to coarse. Gravel is subrounded to rounded fine to medium flint (RIVER TERRACE DEPOSITS)”	This level would be identified as Sandy Gravel (SD/ GR). The scheme adopted here can also result in two main components when the phrase “very” is used in the description (see below).
Expressions of relative abundance	“Very stiff, orange, brown, fine to medium, sandy, very gravelly CLAY. Gravels of subangular to rounded, fine to coarse flint (RIVER TERRACE DEPOSITS)”	This would therefore be described as a gravely CLAY (GR/ CL). Where descriptions of the minor component are given as “some”, “occasionally” or has no emphasis and is not capitalised then the minor component is ignored.



Wessex Archaeology

Study area

Site outline

Archaeological evaluation area (XPM 09)

Olympic Park planning delivery zones (PDZs)

Crossrail

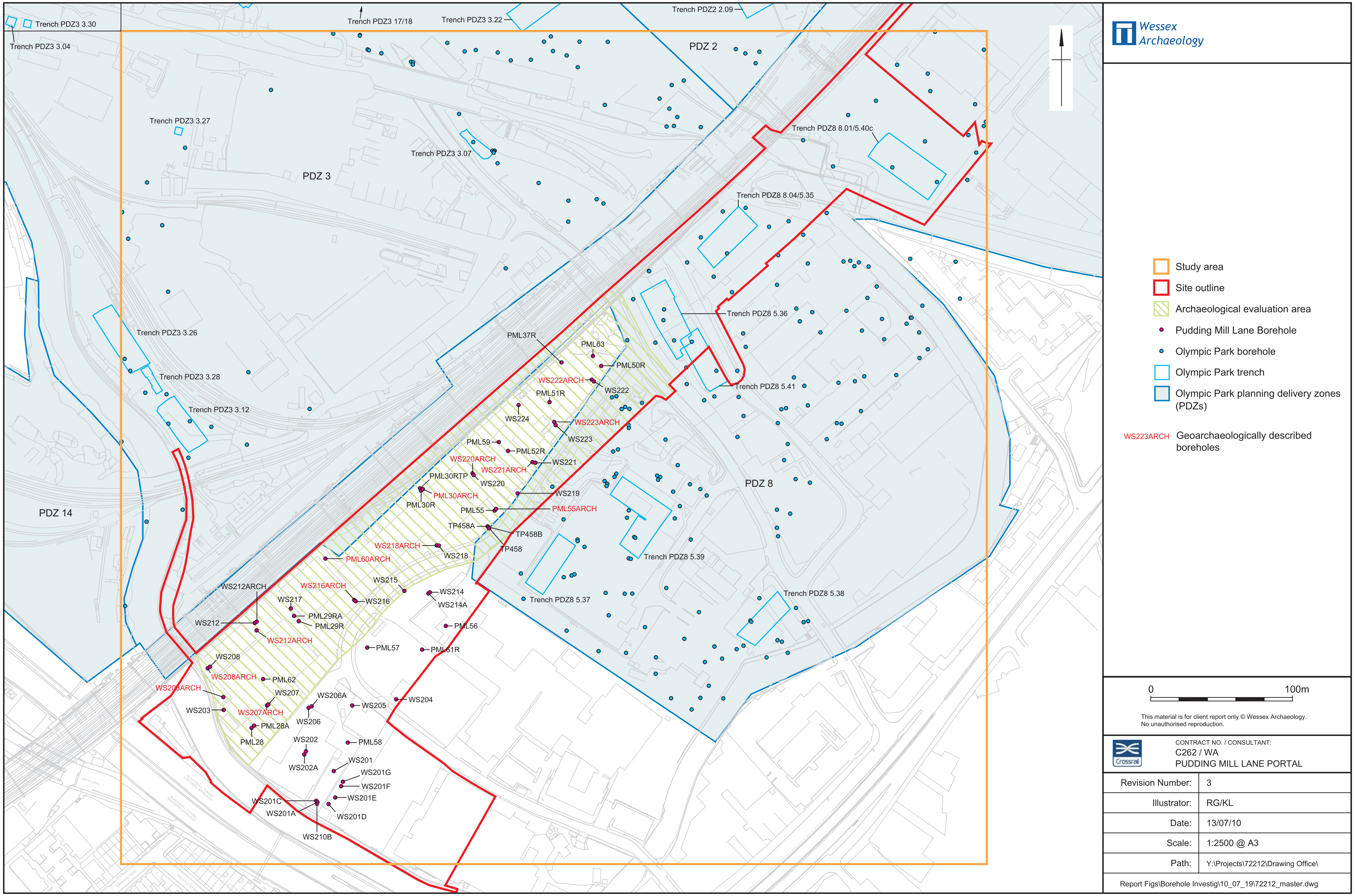
CONTRACT NO. / CONSULTANT:
C262 / WA
PUDDING MILL LANE PORTAL

Revision Number:	3
Illustrator:	RG/KL
Date:	01/07/10
Scale:	1:50000 & 1:5000 @ A3
Path:	Y:\Projects\72212\Drawing Office\

Report Figs\Borehole Investig\10_07_19\72212_master.dwg

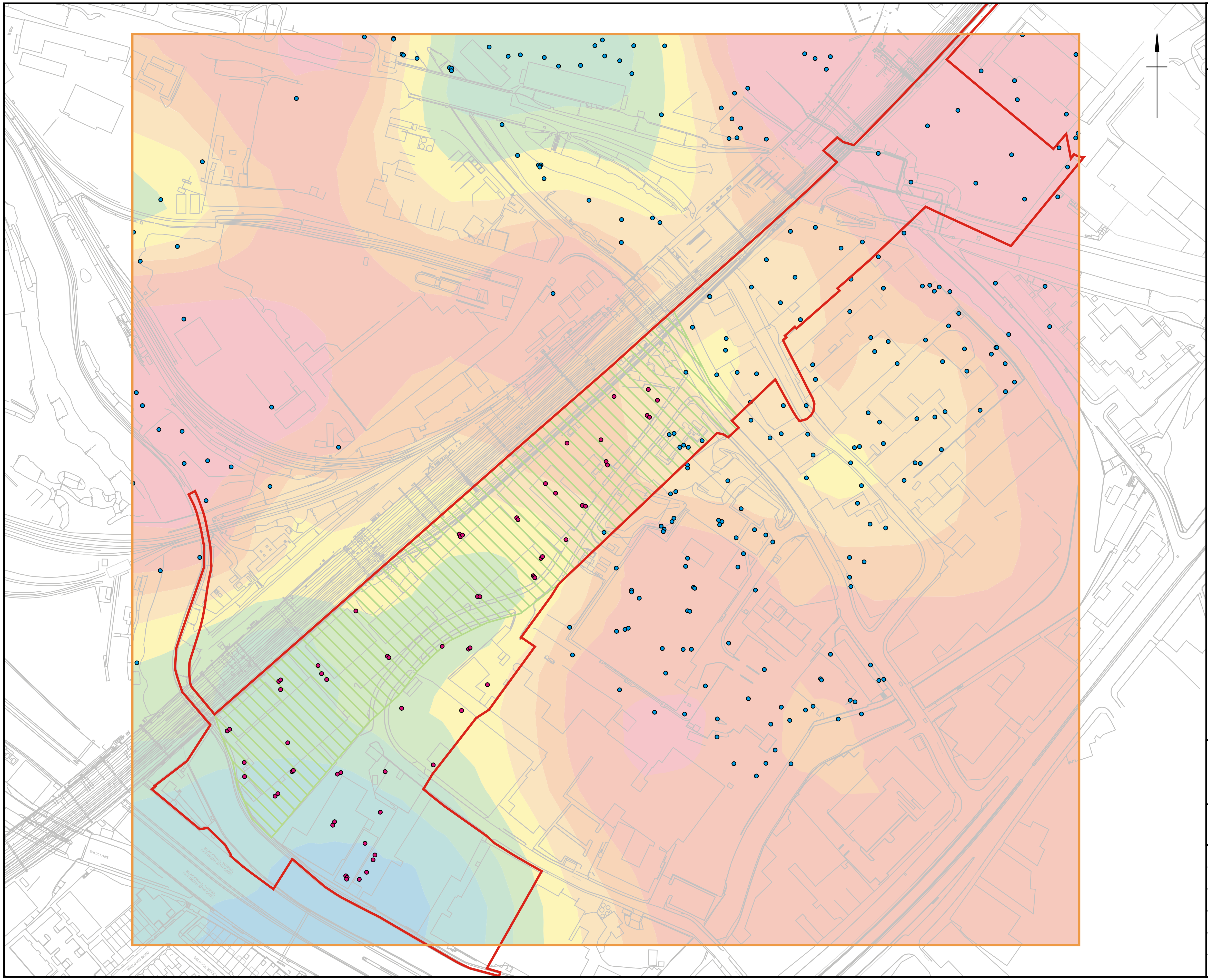
Site location plan

Figure 1



Borehole location plan, showing Pudding Mill Lane borehole locations with coverage of Olympic Park boreholes and evaluation trenches

Figure 2



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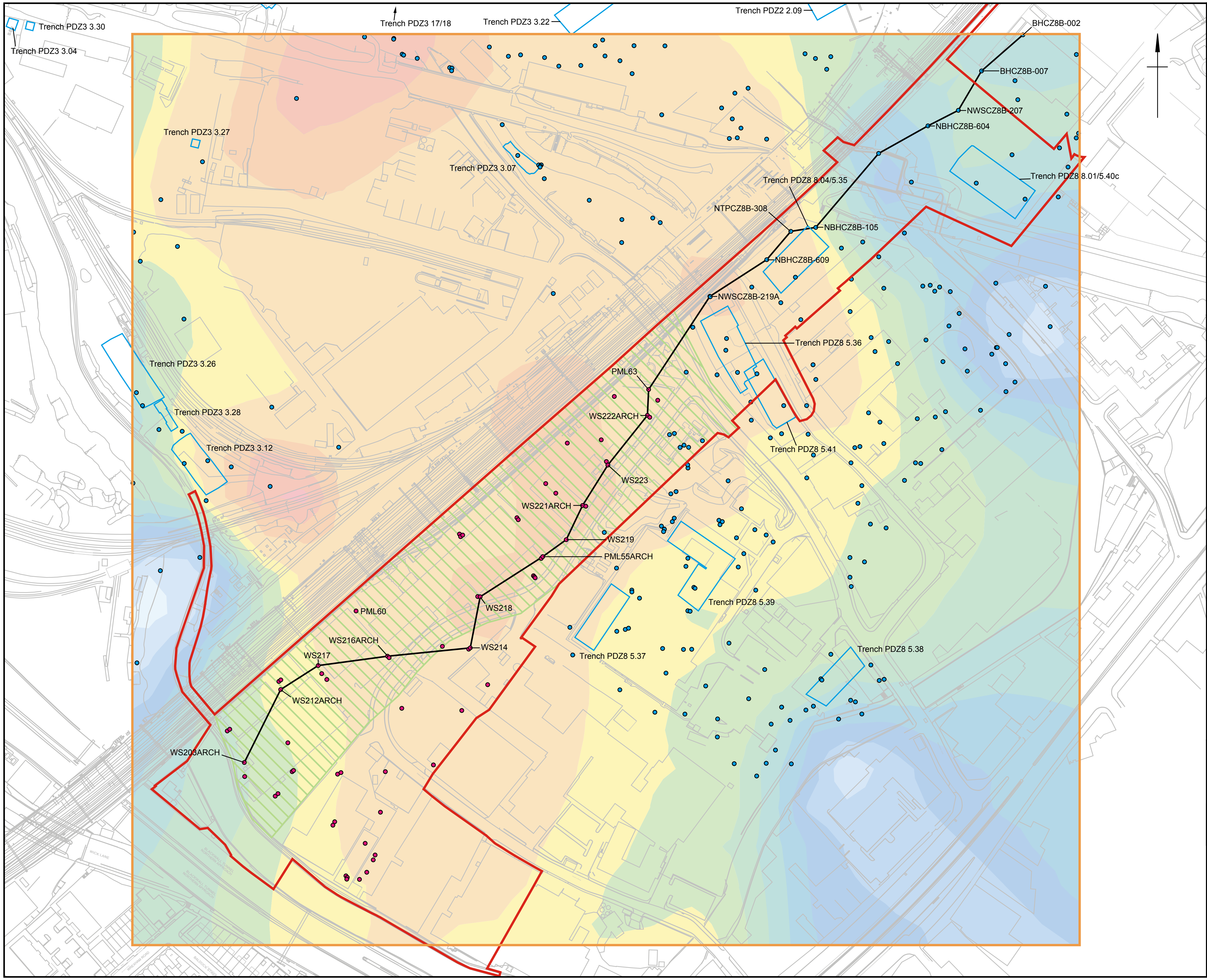
Thickness of made ground deposits

Figure 3



Crossrail

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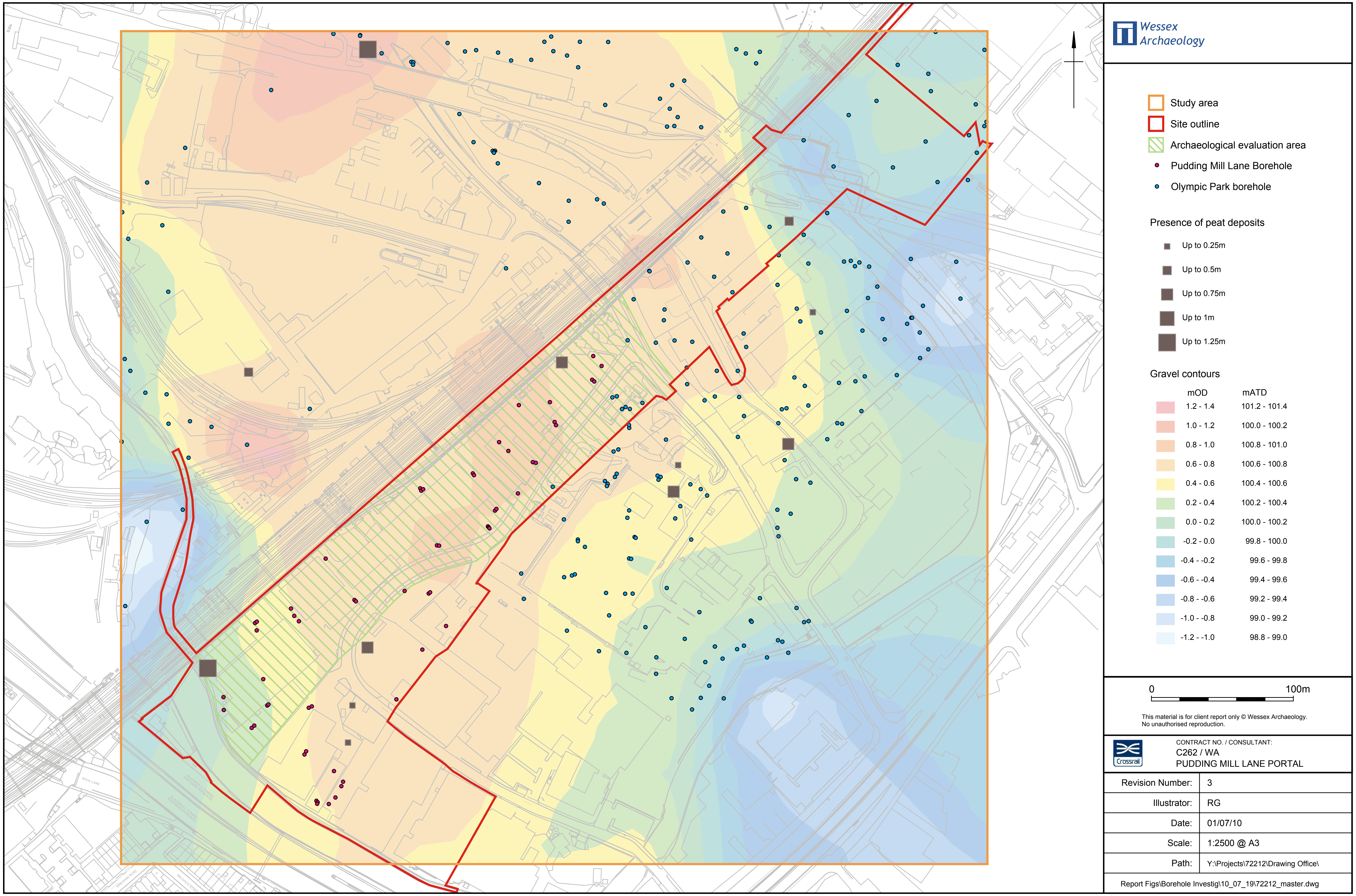
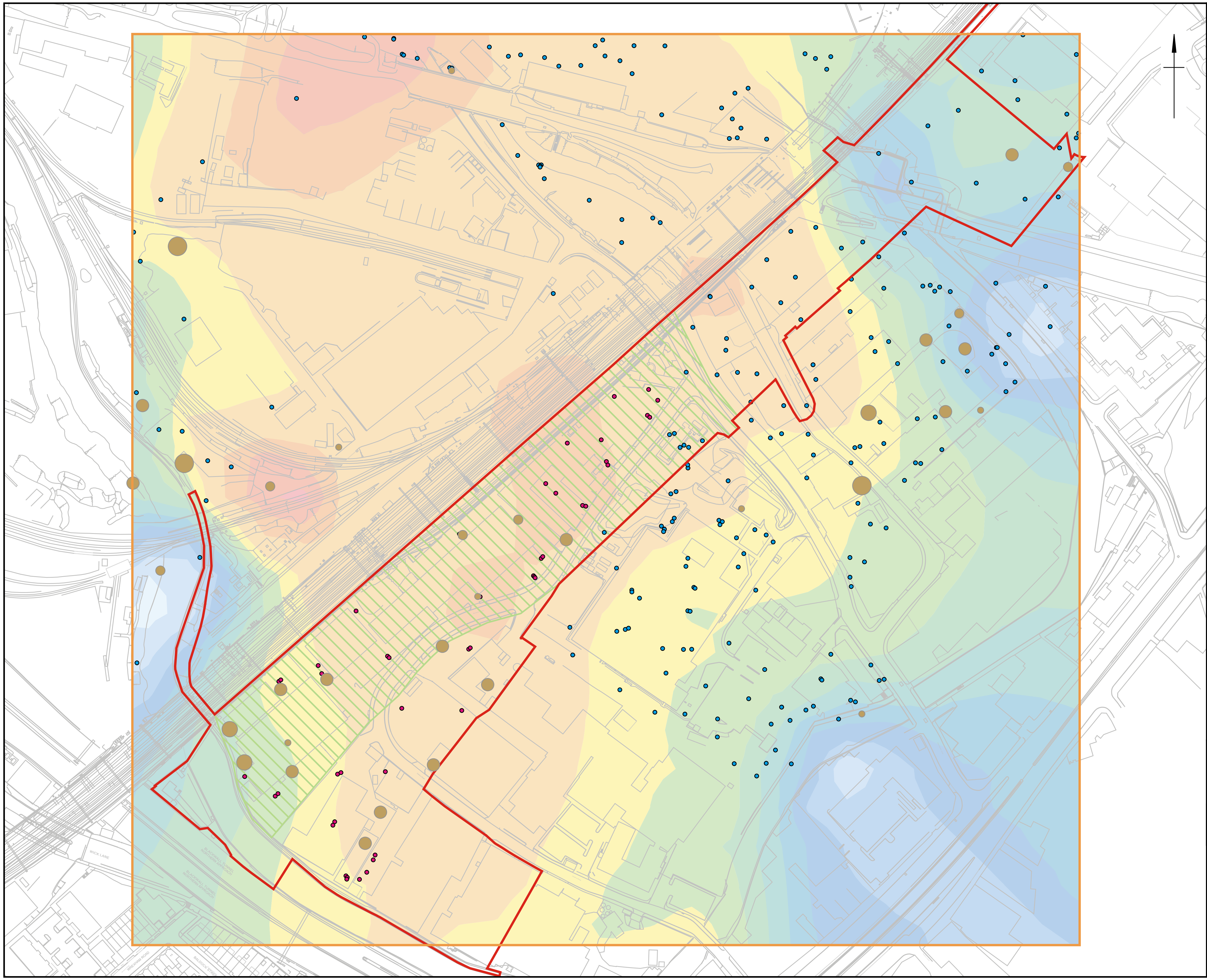
Underlying gravel topography with transect location

Figure 4



Distribution of peat deposits overlain on gravel topography

Figure 5



Wessex Archaeology

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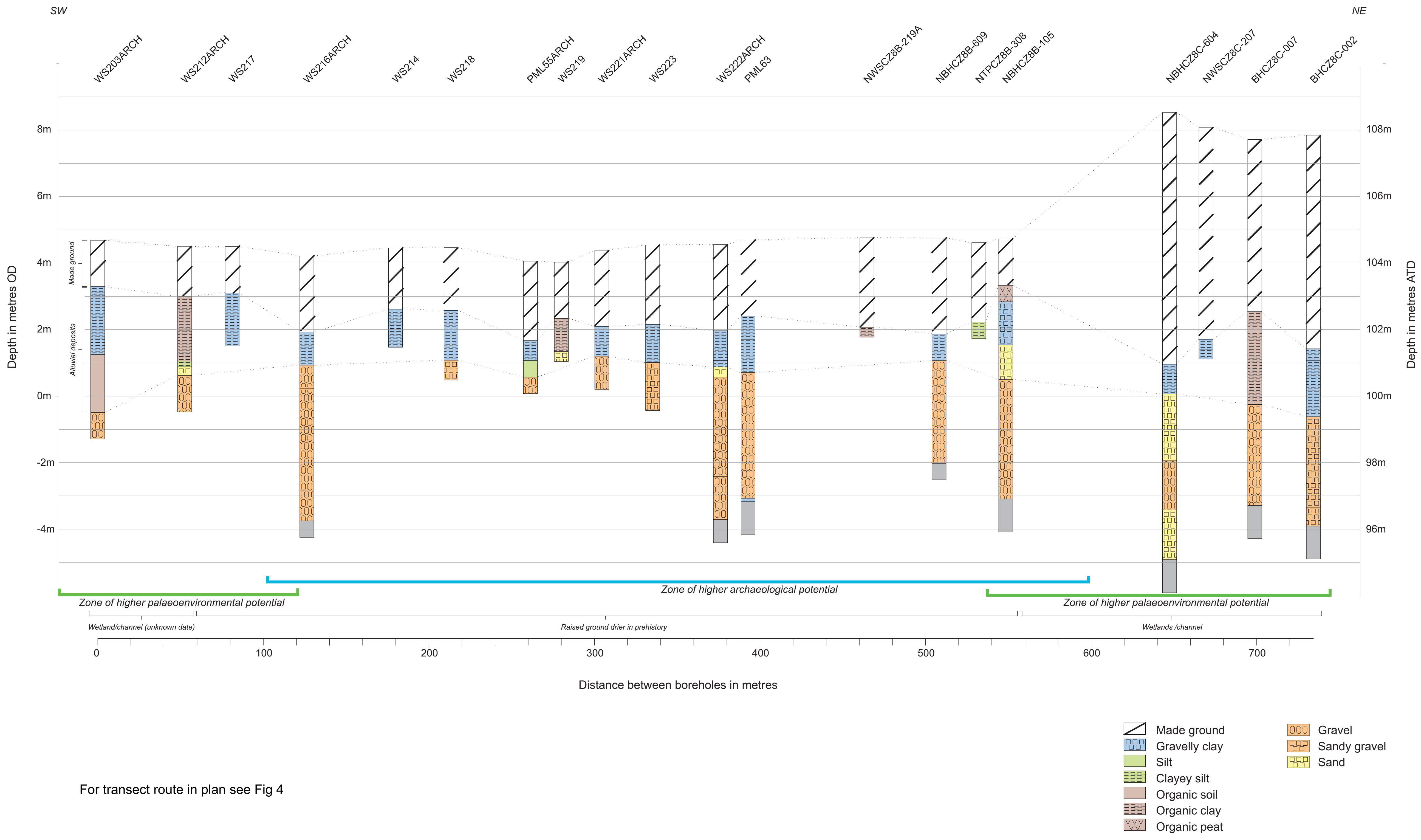
Distribution of organic clay and silt deposits overlain on gravel topography

Figure 6



For transect route in plan see Fig 4

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Path:	Y:\Projects\72212\...\...\Report Figs\Borehole_Investig\10_07_19\Transect.ai		

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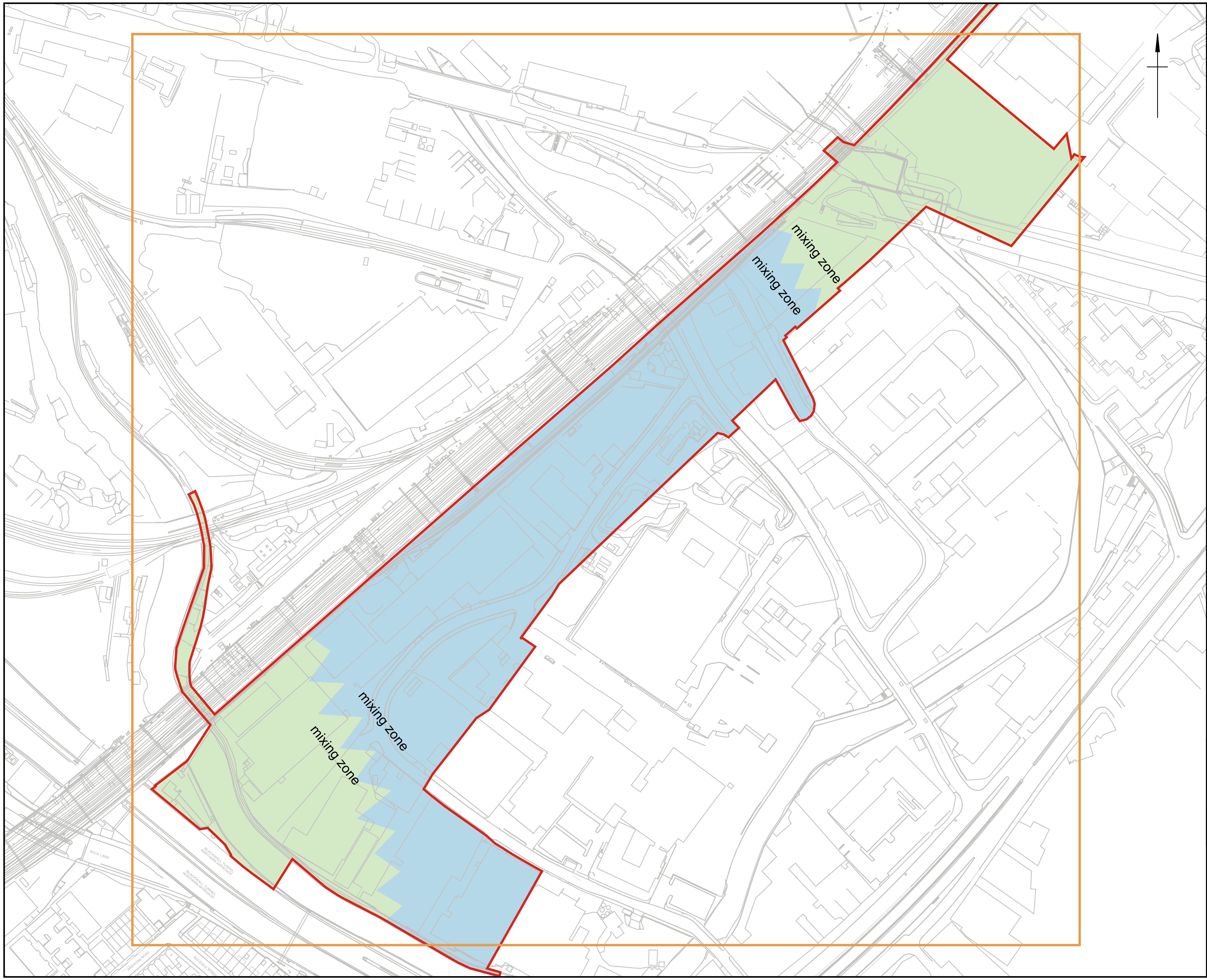
Schematic transect showing sediment types longitudinally along the site

Figure 7



Wessex Archaeology

Study area

Site outline

Zone of higher archaeological potential

Zone of higher palaeoenvironmental potential

0 100m

Crossrail

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Revision Number:	3
Illustrator:	KL
Date:	01/07/10
Scale:	1:2500 @ A3
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Report Figs\Borehole Investig\10_07_19\72212_master.dwg

Zones of archaeological and palaeoenvironmental potential

Figure 8