Silvertown Tunnel London Boroughs of Newham and Greenwich

Geoarchaeological Watching Brief and Deposit Model Report

November 2020

Client: Fugro

Issue No: V01
OA Reference No: SVTWB
NGR: TQ 39720 80100

oxfordarchaeology
southsouthsouth

Client Name:	Fugro
Document Title:	Silvertown Tunnel
Document Type:	Geoarchaeological Watching Brief and Deposit Model Report
Grid Reference:	TQ 39720 80100 (Centre)
Planning Reference:	
Site Code:	SVT20
Invoice Code:	SVTWB
Receiving Body:	
Accession No.:	
OA Document File Location:	oau\Geoarchaeological Services\GEOARCH REPORTS\GTR LONDON\SILVERTOWN TUNNEL\REPORT
OA Graphics File Location:	oau\GeoarchaeologicalServices\GEOARCHREPORTS\ GTR LONDON\SILVERTOWN TUNNEL\REPORT
Issue No:	V01
Date:	November 2020
Prepared by:	Jason Stewart (Geoarchaeologist)
Checked by:	Elizabeth Stafford (Head of Geoarchaeology)
Edited by:	Chris Hayden (PX Project Manager)
Approved for Issue by:	Leo Webley (Head of PX)
Signature:	………………………………………………..

OA South
Janus House
Osney Mead
Oxford
OX2 0ES

t. +44 (0)1865 263 800

OA East
15 Trafalgar Way
Bar Hill
Cambridge
CB23 8SG

t. +44 (0)1223 850 500

OA North
Mill 3
Moor Lane Mills
Moor Lane
Lancaster
LA1 1QD
t. +44 (0)1524 880 250

e. info@oxfordarch.co.uk
w. oxfordarchaeology.com
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Silvertown Tunnel, London Boroughs of Newham and Greenwich

Geoarchaeological Watching Brief and Deposit Model Report

Written by Elizabeth Stafford and Jason Stewart

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1 INTRODUCTION

1.1 Scope of work

1.1.1 In March 2020, Oxford Archaeology (OA) was commissioned by Fugro to undertake a watching brief on geotechnical groundworks and deposit modelling associated with the proposed new Silvertown Tunnel in the London boroughs of Greenwich and Newham (centred on NGR TQ 39720 80100).

1.1.2 The primary aim of the investigation was to provide additional baseline data on the nature of the sub-surface sediment sequences and their geoarchaeological and palaeoenvironmental potential, and to identify any horizons within these deposits with the potential to preserve evidence of human occupation. This work builds on the previous deposit model developed for the scheme (Quest 2015).

1.1.3 The scheme involves construction of a twin-bored road tunnel providing a new connection between the A102 Blackwall Tunnel Approach on the Greenwich Peninsula (Royal Borough of Greenwich) and the Tidal Basin roundabout junction on the A1020 Lower Lea Crossing/Silvertown Way (London Borough of Newham). The tunnel is approximately 1.4km in length.

1.1.4 The specification for the geoarchaeological work was outlined in a Technical Note provided by the scheme designers (Arup 2020a). This included a requirement for geoarchaeological site attendance to monitor 12 boreholes and 6 trial pits, identifying peat deposits where possible, taking and analysing samples, and updating the existing Geoarchaeological Deposit Model. This complies with agreements established between Transport for London (TfL) and Historic England as part of a statement of common ground (agreed 29/09/2016).

1.2 Location, topography and geology

1.2.1 The site straddles both banks of the River Thames. To the northeast it is located in Silvertown, Newham, immediately east of the confluence of the River Lea and the Thames. The western boundary of the site lies within 100m of the present-day channel of the Lea, which in this stretch is known as Bow Creek. On the opposite bank to the southwest the site is located on the Greenwich Peninsula (Fig. 1).

1.2.2 Both areas of investigation lie on the (now reclaimed) Thames floodplain. The earliest map to show the area in any detail is Rocque's map of 1762, which shows the land either side of the River Thames as agricultural fields and marshland. Historic Ordnance Survey mapping dating to between 1893 and 1896, shows that the area on the Greenwich side remained largely open toward the end of the 19th century, with some industrial development, whilst the northern bank in Silvertown was occupied by open ground, industrial development, docks and rail infrastructure. The Royal Victoria Dock, built on the Plaistow Marshes, was opened in 1855 and is located approximately 100m to the east of the site. The dock was connected directly to the Thames through a (now infilled) lock and tidal basin, the location of which falls within the current scheme beneath the A1020 Silvertown Way.

1.2.3 Mapping by the British Geological Survey (BGS) indicates that, beneath depths of modern made ground, the superficial geology across the scheme comprises river alluvium of fine-grained clays, silts and sands, with intercalated peats deposits. Most of these deposits are likely to have been laid down during the Holocene (< *c* 12,000 years BP). Beneath the Alluvium lies Pleistocene fluvial sand and gravel of Late Devensian age (the Shepperton and Lea Valley Gravel, c 16,000 – 11,500 years BP). The bedrock beneath both areas comprises Palaeocene London Clay.

1.3 Geoarchaeological background

Regional

1.3.1 In order to understand fully the character and distribution of likely archaeological sites in the Lower Thames Estuary area and the reasons behind major changes in settlement patterns in the past, it is necessary to understand the changing nature of the estuary. The following section is a broad summary based on a number of key recent publications from the Lower Thames area (eg Bates and Stafford 2013; Stafford *et al.* 2012; Sidell *et al.* 2000).

1.3.2 The Lower Thames extends from Blackfriars in the West to the Shorne Marshes in the East and forms the inner part of the Thames Estuary. The estuary of the Thames is classified as a tide dominated estuary (*sensu* Dalrymple *et al.* 1992) with major sand bars within the outer estuary area (the marine dominated zone) and an inner mixed energy zone with tidal meanders. The floodplain associated with the mixed energy zone of tidal meanders is widest between the north bank Roding (Barking Creek) and Ingrebourne (Rainham Creek) tributaries where a maximum distance of some 4.5km is attained. Today the Thames Estuary extends 100 miles (*c* 161km) from the tidal limit at Teddington to the estuary mouth at Sunk Head where it is 49 miles (*c* 79km) across between Margate and Orford Ness.

1.3.3 The Pleistocene deposits of the Lower Thames have been extensively studied (eg Gibbard 1994; Bridgland 1994). Deposition began in the late Anglian stage (*c* 450,000 years ago) and continued intermittently throughout the Pleistocene. Sediments, deposited in cold climate braided stream systems, exist as wedges of sand and gravel on the valley sides, which were subsequently eroded by fluvial incision during periods of lowered sea-level to create a sequence of gravel terraces. The most recent episodes of gravel deposition formed the Shepperton Gravel beneath the current floodplain.

1.3.4 The composite surface of the Pleistocene deposits and bedrock geology form the 'template' onto which alluvial and estuarine sedimentation occurred during the Holocene (Bates and Whittaker 2004; Bates and Stafford 2013), that is, during the last 12,000 years. The landscape during this period saw a number of changes, largely attributed to a rise in sea-level (eustatic sea level change) caused by the continued shrinking of the northern ice caps and subsidence (isostatic subsidence) in south-east England. The Holocene sediments form a wedge, thickening downstream, from less than 2m at Tower Bridge to a maximum thickness of 35m east of the study area at Canvey Island (Marsland 1986). Within the inner estuary Holocene sediments consist of complex sequences of minerogenic and organic clay, silts, sands and peats, deposited in a variety of environments representing variously alder carr, fen, reedswamp, intertidal saltmarsh and mudflats.

1.3.5 The traditionally adopted stratigraphic sequence for the Lower Thames is based on work undertaken by Devoy (1977; 1979; 1980; 1982). Borehole stratigraphies were integrated with biostratigraphic studies to infer successive phases of marine transgression (Thames I-V) represented by clay/silt units and regressions (Tilbury I-IV) represented by peat units. Devoy constructed two age-altitude curves of relative sea level movement, one for Tilbury (outer estuary) and one for Crossness, Dartford and Broadness (inner estuary). The model suggested that through the course of the Holocene, sea-level may have risen by as much as 25m, with subsidence in the south-east of 2-3m.

1.3.6 The 'Thames-Tilbury' model is regarded as the seminal work in this area and in the past has been widely applied by researchers outside the original study area in the absence of more locally based models. However, several studies have highlighted problems with applying the model outside of its original study area, such as the need for two age/altitude curves, suggesting it cannot always be easily applied to the whole of the Thames Estuary, both in terms of lithology and age/altitude analysis (Haggart 1995; Sidell *et al.* 2000, 16). This reflects the complex nature of the floodplain environment during this period, consisting of peat forming communities, migrating channels and sand eyots (*ibid*.). Bates and Whittaker (2004) point out that Devoy's work has resulted in a view of sediment accumulation being controlled within the area by a combination of factors dominated by sea-level change and isostatic subsidence, taking little account of palaeogeography, sedimentary basin size and local to regional sedimentation patterns.

1.3.7 More recent work has simplified the Devoy model into a broader tripartite sequence for the Holocene, similar to other models in Southern England (Long 1995; Long *et al.* 2000). This suggests rapid sea-level rise occurred in the early Holocene with marine inundation and estuary expansion, followed by a phase of estuary contraction and peat formation during the mid Holocene (*c* 5000-2500 cal BC) as a consequence of a reduction in the rate of sea-level rise. A further phase of marine inundation and estuary contraction occurred during the later Holocene, which would continue to the present day without the historical intervention of river walls, embankments and other flood defences.

1.3.8 Other studies focus on individual sites or tributary valley sequences such as the Lea (Corcoran *et al.* 2011; Powell 2012) and Ebbsfleet (Andrews *et al.* 2012; Bates and Stafford 2013; Wenban-Smith *et al.* 2020) which begin to address the local factors responsible for sequence accumulation. These latter studies focus on detecting contrasting zones, where the archaeological significance depends upon the position of the wetland-dryland interface, or identifying areas between channels, peatlands and siltlands. Such areas are considered likely to be the foci of human activity and a key to identifying areas of high archaeological potential.

Local and site specific

1.3.9 The following is a summary of previous geoarchaeological investigations carried out in in the locality of the scheme (Quest 2015, fig. 1). The northern area of investigation, in the Lower Lea Valley at Silvertown was investigated as part of the Lea Valley Mapping Project (Corcoran *et al.* 2011). The area falls within Landscape Zone LZ1.1b.

Here the buried surface of the Late Devensian Lea Valley Gravel occurs between -3 and -5m OD. The overlying Holocene alluvium, reaching thicknesses of *c* 4m, is generally minerogenic in nature, comprising clays silts and sands. Intercalated peat deposits are generally only preserved intermittently when compared to other localities. This is largely due to the dynamic fluvial history of the River Lea, comprising shifting and meandering channel systems, effectively eroding and scouring the floodplain surface.

1.3.10 As a consequence of past channel activity, this area, at the confluence of the Lea and Thames channels, is generally considered to have lower potential for the preservation of significant archaeological remains or palaeoenvironmental sequences than other areas of the floodplain. However, it is still possible for localised organic sequences that have survived later erosion to be preserved. At Victoria Dock Road, for example, immediately to the north, peat deposits were radiocarbon dated to the Late Neolithic to Early Bronze Age (Barnett *et al.* 2010). At Fords Park Road, *c* 0.6km to the northeast, evidence of Mesolithic and Bronze age occupation was recorded on a relict floodplain island or sandy eyot (Nicholls *et al.* 2013).

1.3.11 Several previous geoarchaeological investigations have been carried out across the Greenwich Peninsula, for example at plots MO115, MO117 (Young and Batchelor 2013a; 2013b), the Millennium Festival Site (BWP97; Bowsher and Corcoran nd), the Cable Car South Station (CAB11; Batchelor *et al*. 2012), Greenwich Millennium Village (Miller and Halsey 2011) and at the Victoria Deep Water Terminal and across Greenwich Peninsula as a whole (TUA02; Corcoran, 2002). The sediment sequences generally comprise Shepperton Gravel, overlain by Holocene alluvium and modern made ground. Here, in contrast to the Lower Lea, peat deposits are much more widely distributed, reflecting a more stable, accretionary marshland environment. A major peat bed represents the period of mid Holocene estuary contraction, commonly dated to between *c* 4000 and 1000 cal BC (ie the late Mesolithic to the late Bronze Age).

Silvertown Tunnel Deposit Model

1.3.12 A desk-based deposit model was developed in 2015 and submitted as supporting information with the Cultural Heritage Assessment for the Environmental Statement (TfL 2016, Appendix 8B and Chapter 8 respectively).

1.3.13 The deposit model comprised *c* 500 data points deriving from historical geotechnical investigations, the BGS borehole archive, and previous purposive geoarchaeological fieldwork (Figs 2 and 3). The data was analysed in geological modelling software Rockworks16, and lithological data correlated into six broad stratigraphic units: (1) Shepperton and Lea Valley Gravel; (2) Sand; (3) Lower Alluvium; (4) Peat; (5) Upper Alluvium and (6) Made Ground. The report was accompanied by a range of cross-sections (Transects A-D), elevation and thickness plots for key surfaces and stratigraphic units.

1.3.14 In summary the desk-based deposit model concluded that in Silvertown, the results were generally consistent with the work of the Lea Valley Mapping Project (Corcoran *et al*. 2011). The surface of the late Devensian Lea Valley Gravel (Unit 1) generally lay at elevations of -2m to -4m in the north, dropping to below -4m OD towards the river. However, the modelling of the surface did appear to identify a linear depression, potentially a large palaeochannel, skirting the northern and eastern edge of the site (see Fig. 3). The palaeochannel may cross the area in the vicinity of Bell Lane, but the deposit model noted the general paucity of sub-surface data in this area.

1.3.15 The Holocene sediment sequences were for the most part minerogenic. A basal sand (Unit 2), up to 0.9m thick, directly overlying the gravel, was noted in two boreholes towards the northwest of this area and was interpreted as being deposited under low to moderate energy fluvial conditions, perhaps within former channels, possibly during the late Glacial or early Holocene periods. A lower alluvium (Unit 3) was also intermittently present, often presenting as a sandy silt, and was interpreted as having accumulated during the early to middle Holocene (Mesolithic) within a fluvial or estuarine environment. It is generally less than 2.0m in thickness, but there are isolated areas where greater thicknesses are present. Unit 3 is present more frequently in the north, but also adjacent to the Thames near Bell Lane.

1.3.16 The distribution of peat deposits (Unit 4) at Silvertown appeared limited to three boreholes within the site boundary, up to 1.5m in thickness, the top of which occurred at *c* -2m to -3.5m OD. Notably, the model of peat thickness indicated that the greatest thicknesses of peat occurred more frequently within the linear depression identified in the gravel surface. Adjacent to the Thames in this same area, boreholes drilled for the London Cable Car Route sampled substantial peat deposits which were radiocarbon dated to the early Mesolithic to late Bronze Age periods (see Fig. 3, NTBH03, also Quest 2011). The accumulation of peat represents a transition to semi-terrestrial conditions (alder carr), supporting the growth of wetland vegetation and forming a land surface which might have been utilised by prehistoric people

1.3.17 A minerogenic silty clay alluvium (Unit 5) forms the upper part of the Holocene sedimentary stack, probably representing deposition from standing or slow-moving floodwater. The surface of the alluvium across the area of investigation is generally recorded at between 1.0 and 0.0m OD. Occasionally a thin horizon of peat is recorded within the alluvium, at elevations between *c* -0.5 and 0.3m OD, indicative of a second, later transition to semi-terrestrial conditions. The total thickness of the Holocene sedimentary stack (Units 2-5) at Silvertown was estimated at 3-8m, sealed by a thick layer of modern made ground.

1.3.18 On the Greenwich Peninsula the modelling suggested a more consistent sequence across the area with the surface of the Shepperton Gravel (Unit 1) averaging -1.5 and -3m OD. The highest points on the gravel surface were recorded towards the centre of this area at *c* -1.0 to -1.5m OD; elsewhere, the surface is recorded consistently between -2 and -3m OD, except where it falls towards the Thames (Fig. 3). The basal sand (Unit 2) and alluvium (Unit 3) occurred sporadically, the latter most frequently in the south. A major peat horizon (Unit 4) up to 2m thick was recorded in most boreholes, the top of which was recorded between 0.0m and -3.0m OD. As with Silvertown, the upper part of the Holocene sequence at Greenwich is largely formed of minerogenic alluvium (Unit 5) sealed by variable thicknesses of modern made ground.

1.4 Archaeological and historical background

1.4.1 A summary of the archaeological and historical background to the site was presented in the overarching WSI (Arup 2020b). The following provides a summary.

Prehistoric

1.4.2 No direct occupation evidence of human activity has been found within the study area, but artefacts from the Palaeolithic onwards have been found in the general area.

1.4.3 Boreholes undertaken in advance of works associated with the adjacent Emirates Air Line Cable Car, produced sequences of peat and alluvial clay from the Mesolithic to Bronze Age periods.

1.4.4 The geoarchaeological deposit modelling for the site (Quest 2015) indicates the potential for peat and relict land surfaces at the locations of the tunnel portals and the cut-and-cover areas of the tunnels. These are believed to probably date to the prehistoric period, with a potential for archaeological and palaeoenvironmental evidence. Such deposits also have the potential to preserve organic remains, including artefacts and ecofacts. They may also contain or seal former land surfaces, particularly on the former high points on gravel ridges.

Roman

1.4.5 The are no records of evidence from the Romano-British period from within the site or wider study area. The area is suggested to have been characterised by a landscape of marshy meadowlands during this period, so any archaeological evidence is likely to be associated with riverside activity and transport.

Medieval

1.4.6 No evidence from the early medieval period has been recorded within the study area, with it typically being rare within the Greater London region.

1.4.7 The medieval manor of Covelees dates to *c* 1248 and was located approximately 500m to the northwest of the site. Flood defences are also recorded in the area from the 12th century and a putative causeway in the area is speculated as possibly dating to this period.

Post-medieval

1.4.8 The site and its setting is shown on Rocque's 1762 map as being located within agricultural fields on either side of the River Thames.

1.4.9 Evidence associated with the post-medieval whaling industry has been recorded within the area. A partial whale skeleton was recovered during dredging work in the Thames approximately 250m from the site. The Grade II listed Enderby House was constructed for the whaling firm of Samuel Enderby. By the early 19th century the area was starting to undergo development and was changing from an area of agricultural fields to being part of London's urban periphery. This is reflected in the surviving built heritage of the area, including the Grade II listed entrance to the Blackwall Tunnel.

1.4.10 The development of the local docks and associated infrastructure in 19th century is also reflected in the known heritage assets. This development continued into the mid-

20th century. Early to mid 20th-century development in the area included the construction of a group of 14 Grade II listed Stothert and Pitt cranes, and Grade II listed grain silos from 1920. Further, later, non-designated, grain silos also were constructed to the south of the site. Other designated assets from this period are the Chapel of St George and St Helena and the Silvertown War memorial, both Grade II listed.

2 AIMS AND METHODOLOGY

2.1 Aims

2.1.1 The primary aim of the watching brief was to supplement the geotechnical logs with archaeologically relevant detail to provide additional baseline data for assessing the archaeological and palaeoenvironmental potential of sub-surface deposits that may be impacted by construction. Specifically:

i. To characterise the sequence of sediments and patterns of accumulation along the route, including the depth and lateral extent of major stratigraphic units.
ii. To identify significant variations in the deposit sequence indicative of localised features, such as palaeochannels, topographic highs or buried 'islands'.
iii. To identify the location and extent of any waterlogged organic deposits and/or buried soils or land-surfaces and address the potential for the preservation of archaeological and palaeoenvironmental remains and their likely locations.
iv. To clarify the relationships between sediment sequences and other deposit types, including periods of 'soil' or peat growth, and the effects of relatively recent human disturbance, including the location, extent and date of 'made ground'.
v. To discuss the sequence of sediments within the wider landscape context of known quaternary geology and geomorphology, referencing previous geoarchaeological and palaeoenvironmental work carried out in the vicinity.

2.2 Methodology

2.2.1 The geotechnical ground investigation comprised excavation of trial pits and cable percussion boreholes. A summary of interventions is given in Table 1 and the layout is illustrated in Figures 1 and 2. Three trial pits and one borehole at Greenwich originally designated for monitoring were descoped from the geotechnical works (BH-G-09, TP-G-01 and TP-G-02). An additional borehole was recorded at Silvertown (BH-S-19) during standing time.

Table 1: Summary of monitored geotechnical interventions

Bore	Easting	Northing	Elevation (m OD)	Total depth (m)
BH-G-06	539146.53	179397.77	2.30	54.00
BH-G-07	539121.59	179424.67	2.80	55.00
BH-G-08	539115.52	179463.68	2.34	32.70
BH-G-10A	539137.95	179492.24	2.55	15.00
BH-G-11	539186.54	179469.76	3.26	41.44
BH-S-13	539933.50	180332.75	2.82	45.00
BH-S-14	539917.00	180425.26	5.38	14.30
BH-S-15	539954.77	180443.14	5.13	7.50
BH-S-16	539889.79	180518.40	3.65	36.70
BH-S-18	539893.35	180536.09	3.57	41.00
BH-S-19	539871.96	180583.22	3.37	41.00
TP-S-03	539907.42	180240.40	5.12	3.10

TP-S-04	539923.21	180323.99	2.83	1.70
TP-S-06	539956.35	180378.42	2.62	2.70

2.2.2 The drilling of the cable percussion boreholes was initially intended to be monitored directly onsite. However, the fieldwork in March 2020 coincided with the implementation of COVID 19 Health and Safety restrictions. After an initial cessation, work resumed under a revised safe system of work. Consequently, the majority of the boreholes were recorded from bulk samples collected at the geotechnical contractor's store. No intact core samples were available for examination. U100 cores were generally sealed and sent offsite immediately for lab testing. The excavation of all trial pits was, however, monitored onsite.

2.2.3 Bulk samples from deposits with the potential for heavy contamination (eg asbestos, hydrocarbons) as indicated from the drilling logs, particularly made ground deposits and the very upper levels of the alluvium, were stored separately, and were not examined by the attending geoarchaeologist. A small number of sub-samples were recovered on an opportunistic basis from peat deposits, but the broad nature of the bulk sample recovery and potential mixing of deposits from different levels limits their usefulness for detailed palaeoenvironmental or dating work.

2.2.4 The sediment was logged on standard proforma sheets in accordance with Jones *et al*. (1999) and Historic England guidelines for geoarchaeology (2015). The logs include a description of colour, compaction, texture, sorting structure and inclusions. It was not possible to log the contact between sediment due to the disaggregated nature of the samples. These descriptions were integrated with the geotechnical logs allowing quality assurance of the descriptions and interpretations. The data was then entered into borehole modelling software (Rockworks17) for the correlation of stratigraphic units and production of cross-sections.

2.2.5 The interpreted digital stratigraphic data from the original deposit model (Quest 2015) was unavailable at the time of writing. Taking into account the relatively small number of interventions covered by the watching brief, it was not considered an efficient use of resources to reinput the full dataset (500 datapoints) into Rockworks in order to update the full model at this stage. Consequently, a selection of datapoints (the original logs being held in the BGS archive) from Transects A-D (Quest 2015, figs 10-13) have been included in two new cross sections for comparative purposes (Figs 4 and 5). The full dataset derived from the watching brief is included in the appendices.

3 Results

3.1 Introduction and presentation of results

3.1.1 The results of the watching brief are presented below and include a stratigraphic summary of the boreholes and trial pits. The detailed lithological and stratigraphic data comprising the deposit model is tabulated in Appendices A and B.

3.1.2 The broad stratigraphic sequence observed during the ground works was similar to that presented in the original deposit model. However, due to uncertainty surrounding the correlation of minerogenic units within the Holocene sediment stack, particularly Units 2, 3 and 5 in the complex sequences at Silvertown in the absence of the key stratigraphic marker, namely the peat (Unit 4), these deposits have been grouped together as Holocene alluvium in Appendix A. The lithological variation and the position of the peat beds is illustrated in the cross-sections in Figs 4 and 5 and the relative depths included in Appendix B.

3.2 Silvertown

3.2.1 The lithological profiles and stratigraphic correlations for the interventions recorded at Silvertown are presented in Figure 4, along with a select number of additional data points that appeared in the original Transect C (Quest 2015, fig. 12).

3.2.2 The top of the late Pleistocene fluvial gravels (Lea Valley Gravel) varies between -3.13m OD in the north (BH-S-19), dropping to *c* -5.18m OD in the south (BH-S-13). approaching the margins of the current Thames. The elevations are consistent with those from the previous deposit model. The lower elevation in BH-S-13 may well denote the continuation of the palaeochannel identified in that model (see Fig. 3). A slight depression to -4.35m OD is also noted in the elevation of the surface of the gravel in borehole BH-S-16 and BH-S-18. At both locations the gravel is overlain by intercalated beds of gravelly clay, gravelly sand, sand and silty sand below *c* -2m OD that may be equivalents of the basal sand and lower alluvium of the original deposit model (Units 2 and 3). In BH-S-18 unworked waterlogged wood fragments were recorded at 7.5-7.9m BGL.

3.2.3 A thin 0.1m thick lens of dark brown organic silt was also present towards the base of BH-S-13 at 7.8-7.9m BGL (*c* -5m OD). Lithologically, the sequence at the base of this borehole is similar to that recorded in borehole NTBH03 during the investigations for the London Cable Car Route (Figs. 3 and 4), *c* 70m to the southwest. The organic silt lens maybe be a remnant or lateral equivalent of a major lower peat bed, the base of which was radiocarbon dated to the early Holocene at 8790-8560 cal BC.

3.2.4 Further up-profile in BH-S-13, 0.95m of peat was noted between 3.80m and 4.75m BGL (-1.93m and -0.98m OD). This peat was described as dark brown, silty in its lower part, and contained frequent wood fragments. The surface elevation is slightly anomalous being *c* 1m higher than that recorded in the previous deposit model for Unit 4 at Silvertown (-2.0 to -3.5m OD). It is also higher than the adjacent borehole NTBH03, the top of which was radiocarbon dated to 1080-920 cal BC (late Bronze Age). The anomaly could be due to an error in the drilling depths, or alternatively the peat in BH-S-13 could be genuinely younger, representing a diachronous surface.

3.2.5 The majority of the remainder of the sedimentary stack comprised a substantial thickness of inorganic silty clay alluvium (Unit 5) which reached up to 4.5m in thickness in borehole BH-S-19. The site has been heavily affected by industrial land use with excavation for a lock as part of the Royal Victoria Dock construction exposed in BH-S-15 and BH-S-14. In addition to this, a mix of ground raising and demolition of bombed industrial structures has resulted in *c* 2-4m of made ground overlying the alluvial sequence.

3.3 Greenwich

3.3.1 The lithological profiles and stratigraphic correlations for the interventions recorded at Greenwich are presented in Figure 5, along with a select number of additional data points that appeared in the original Transect A (Quest 2015, fig. 10).

3.3.2 The top of the late Pleistocene gravel surface (Shepperton Gravel) is recorded consistently between -2.2 and -2.8m OD, with modern truncation down to gravel in BH-G-06.

3.3.3 Directly overlying the gravel lay a body of silty and gravelly sand between 0.7m and 1m thick, possibly an equivalent of the basal late Glacial to early Holocene sand (Unit 2) defined in the original deposit model. The surface of these deposits occurred at c -1.5m OD. The gravel content was generally low but varied. It is possible that the sediments are more extensive across the area than was recorded in older BGS boreholes in which the facies may have been incorporated into the underlying gravel body.

3.3.4 The sand deposits are sealed by a continuous blanket of peat, often containing frequent wood fragments indicating alder carr environments. The thickness of the peat varies between 0.45m and 1.1m and the surface occurs at *c* -0.65 to -0.9m OD.

3.3.5 The overlying alluvial layer (Unit 5) has an irregular thickness between 0.5m and 2.3m, with the top elevation at *c* 0.0m and 2.0m OD due to modern truncation. The overlying made ground averages 2-3m in thickness, although in borehole BH-G-06 it exceeds 5m and extends down to the surface of the fluvial gravel (Unit 1).

3.4 Finds summary

3.4.1 No finds were recovered from the natural alluvial and peat sequences. A selection of material was retained from the made ground but on further examination all of it was found to be clearly modern debris, mostly comprising stock bricks which will not be archived.

3.5 Sample summary

3.5.1 A small number of sub-samples were recovered on an opportunistic basis from peat deposits, but the broad nature of the bulk sample recovery and potential mixing of deposits from different levels limits their usefulness for detailed palaeoenvironmental work or radiocarbon. The sub-samples have been retained in the interim should further work be required. Samples taken from intact purposive cores or monoliths would be better suited for assessment purposes. In terms of range-finding radiocarbon dates, it is considered there is sufficient data from previous investigations in the locality to estimate broad date ranges for the main peat bodies. Table 2 provides a summary of the sub-samples collected during this phase of work.

Table 2: Summary of sub-samples collected

	Depth top (m BGL)	Depth Base (m BGL)	Description
BH-S-13	4.0	4.5	Moderately firm dark brown peaty organic silt with occasional wood fragments
BH-S-13	7.0		Grey slightly sandy clayey silt with rare - occasional pockets (<5mm x 15mm x 20mm) of dark brown organic material. Sand is predominantly fine. Wood sampled from cutting shoe, 100mm long
BH-S-13	7.8	7.9	Dark brown to black peaty organic silt with few plant inclusions
BH-G-10A	3.0	3.8	Black well-formed peat, <5% 20m long reed fragments, slightly silty
BH-G-07	4.0	4.5	Mid reddish brown laminated peat with reed fragments
BH-G-08	3.0	3.5	Dark greyish brown to black well-formed peat, rare less than 2mm rootlets
BH-G-11	4.1	4.5	Soft black slightly clayey wood peat, <50mm fragments of wood. Clay is yellowish brown

4 DISCUSSION

4.1 Reliability of field investigation

4.1.1 Although it was originally intended to monitor the boreholes onsite, due to COVID 19 restrictions in March 2020, monitoring was restricted to recording of bulk samples (as well as cutting shoe samples). It is not considered this impacted significantly on the amount of information gathered. The nature of cable percussion drilling means visibility is generally poor as opposed to recording purposive intact and continuous core sequences. There is also often some error in the precise depths of changes in lithologies in the order of +/- 0.5m. The absence of intact cores also means it is not possible to observe the nature of the boundaries between different contexts or bedding structures in the sediment bodies.

4.1.2 The digitally interpreted stratigraphic data from the original deposit model (Quest 2015) was unavailable at the time of writing and it was, therefore, not possible to add this new borehole data to the original model. However, taking into account the relatively small number of interventions covered by the watching brief, it is considered that this qualitative assessment has been sufficient to compare and contrast the results with the original dataset by producing cross-sections that incorporated a selection of the original BGS datapoints (Figs 4 and 5), as well as reviewing the results in light of the elevation plot of the surface of the Shepperton/Lea Valley Gravel (Fig. 3)

4.1.3 Some samples from alluvial deposits near the top of the sequence were not examined by OA as they were kept separate due to contamination issues. However, the information has been combined with the supplied Fugro logs which has enabled a broad understanding of the nature of the sediment sequences to be obtained.

4.2 Discussion and potential

4.2.1 Overall, the results of the watching brief in combination with the previous deposit modelling (Quest 2015) has served well in broadly characterising the sub-surface stratigraphic architecture of the Holocene sequences that may be impacted by construction. However, it is clear there is much greater local complexity to the sequences, particularly at Silvertown associated with marginal channel locations and cycles of erosion, redeposition and stability associated with the shifting footprint of the River Lea at the Thames confluence. This complexity is set against the backdrop of changes within the wider estuary related to fluctuations in the rate of sea-level rise during the Holocene. These changes incorporate episodes of marine incursion typified by deposition of silt, clay and sand with the development of mudflat, tidal creeks and saltmarsh environments. A long period of estuary contraction due to a reduction in the rate of sea-level rise during the mid Holocene is typified by the widespread growth of alder carr peats, but also reedswamp depending on local hydrology and topography.

4.2.2 The results of the watching brief are generally consistent with the previous deposit modelling and have provided additional information in some areas where the original model was lacking data, particularly in the Silvertown area (Fig. 3).

4.2.3 In summary, the base of the sequence is formed by late Devensian fluvial gravels (Unit 1). On the Greenwich Peninsula this equates to the Shepperton Gravel of the Thames system, and at Silvertown the Lea Valley Gravel which is of equivalent age (*c* 16,000-11,500 years BP). This gravel was laid down in fast flowing cold climate braided stream systems at the end of the last glacial period. Following climatic amelioration and a reduction in seasonal discharge, the River Thames and its tributaries probably experienced a shift from braided stream to anastomosing form, and as a result in-channel deposition of sand and silt occurred (Unit 2).

4.2.4 The shape of the surface of the gravel (and to some extent the surface of the sand where these deposits represent relict late Glacial channels) essentially defined the topography of the early Holocene landscape. Bates (1998) refers to this as the 'topographic template' and suggests that variations in the template largely dictated patterns of subsequent landscape evolution as the wetlands developed during the prehistoric period. The surface of the gravels is considered a key archaeological horizon: a dry land surface on which early Mesolithic activity may have occurred prior to the expansion of the wetland front as a consequence of later relative sea-level rise.

4.2.5 The levels for the gravel surface seen in the watching brief are broadly consistent with the pattern identified in the previous deposit modelling. In the boreholes at Silvertown this occurs at -3.13m OD in the north (BH-S-19), dropping to *c* -5.18m OD in the south (BH-S-13). The lower elevation in BH-S-13 may denote the continuation of the palaeochannel identified in that model (see Fig. 3). At Greenwich the gravel surface is recorded consistently between -2.2 and -2.8m OD. Based on a previous radiocarbon dated model for the region (Bates and Stafford 2013, fig 96), it is predicted that that wetland environments had developed in low-lying areas below -2m OD by the early Neolithic.

4.2.6 At the base of the Holocene sedimentary stack the gravel is intermittently overlain by intercalated beds of gravelly clay, gravelly sand, sand and silty sand, below *c* -2m OD at Silvertown and below -1.5m OD at Greenwich. These deposits may be equivalents of the basal sand and lower alluvium of the original deposit model (Units 2 and 3), interpreted as in-channel sediments and later perhaps representing early estuarine inundation.

4.2.7 Significant thicknesses of peat appear to be largely absent at the Silvertown site, probably due to the dynamic fluvial environment of the Lower Lea Valley. The south-eastern area in the vicinity of BH-S-13 is, however, an exception which may occupy the margins of the large palaeochannel noted on Fig. 3. Similar, albeit better preserved peat sequences were recorded during the construction of the London Cable Car Route (NTBH03, Batchelor *et al.* 2012). The base of a lower peat was radiocarbon dated to the early Mesolithic and the top of an upper peat (Unit 4) to the late Bronze Age. Peat appeared more ubiquitous at the Greenwich site during the watching brief, forming a continuous blanket across the surface of the underlying sands and gravel.

4.2.8 The peat is considered to have high potential for the preservation of palaeoenvironmental remains to allow reconstruction of past vegetation patterns through the study of pollen, plant remains and insects. There is also some potential for the preservation of waterlogged wood and perhaps Neolithic and Bronze Age timber structures such as trackways and platforms leading from areas of higher ground or floodplain islands into the wetland or at the margins of palaeochannels (see Stafford *et al* 2012, fig 10.3). Neolithic trackways have been recorded associated with peat deposits at Fort Street, Silvertown (Crockett *et al.* 2010) and at Belmarsh (Hart 2010), whereas several Bronze Age examples have been discovered on both sides of the river in this part of the Inner Estuary, most notably in the Barking Creek area (River Roding). The peat generally formed in a low energy depositional environment and as such any associated archaeological remains are likely to be preserved relatively *in situ*.

4.2.9 The upper part of the sedimentary sequence (Unit 5) is formed largely of thick deposits of minerogenic silts and clays, probably deposited in a variety of later prehistoric and historic period estuarine environments of saltmarsh and mudflats, interspersed with tidal creeks during period of late Holocene estuarine expansion. These deposits have some potential for reconstructing the palaeohydrology of the area through the study of ostracods, foraminifera and diatoms, although this is dependent on providing a robust chronological framework and such deposits are often difficult to date through radiocarbon dating. As such any localised organic deposition or horizons detected within these deposits can provide important stratigraphic markers. Organic horizons within the upper alluvium were noted occasionally in the original deposit model, and in this study occurred towards the top of BH-S-13 at Silvertown. In terms of evidence for human occupation, the type of activity to be encountered is likely to be ephemeral and related to seasonal exploitation of marshland resources. Activity may be found *in situ*, although some reworking is to be expected in the vicinity channels.

4.2.10 Extensive made ground deposits were recorded, especially at Silvertown where there was significant truncation due to dock construction. At Greenwich there was also truncation down to gravels in some areas (eg BH-S-06). Overall, however, truncation largely appears to have impacted the upper levels of the alluvium with much of the underlying sequences remaining intact. In certain respects, the made ground offers some protection on those parts of the scheme where construction impact is shallow, beyond the deeper excavations planned for the portals and the cut and cover tunnels.

APPENDIX A INTERPRETED STRATIGRAPHIC DATASET

Borehole	Easting	Northing	GL	Top: Made Ground	Base: Made Ground	Top: All.	Base: All.	Top: Gravel	Base: Gravel	Top: Bedrock
Unit				6	6	2-4	2-4	1	1	-
BH-G-06	539146.5	179397.8	2.3	2.3	-2.8			-2.8	-7.8	-7.8
BH-G-07	539121.6	179424.7	2.8	2.8	0.6	0.6	-2.5	-2.5	-7.8	-7.8
BH-G-08	539115.5	179463.7	2.34	2.34	0.34	0.34	-2.36	-2.36	-8.36	-8.36
BH-G-11	539186.5	179469.8	3.26	3.26	1.96	1.96	-2.24	-2.24	-7.94	-7.94
BH-G-10A	539138	179492.2	2.55	2.55	-0.25	-0.25	-2.56	-2.56	-8.45	-8.45
BH-S-13	539933.5	180332.8	2.82	2.82	1.57	1.57	-5.18	-5.18	-6.93	-6.93
BH-S-14	539917	180425.3	5.38	5.38						
BH-S-15	539954.8	180443.1	5.13	5.13						
BH-S-16	539889.8	180518.4	3.65	3.65	-0.35	-0.35	-4.35	-4.35	-6.1	-6.1
BH-S-18	539893.4	180536.1	3.57	3.57	0.17	0.17	-3.83	-3.83	-6.13	-6.13
BH-S-19	539872	180583.2	3.37	3.37	1.37	1.37	-3.13	-3.13	-5.63	-5.63
TP-S-03	539907.4	180240.4	5.12	5.12	2.52	2.52				
TP-S-04	539923.2	180324	2.83	2.83						
TP-S-06	539956.4	180378.4	2.62	2.62						

*Measurement in metres OD

APPENDIX B LITHOLOGY DATASET

Bore	Depth1	Depth2	Key	Comment
BH-G-06	0	1.2	MADE GROUND	Greyish brown slightly silty gravelly sand. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of brick, concrete, and flint.
BH-G-06	1.2	1.3	MADE GROUND	Greyish brown slightly silty gravelly sand. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint, brick, and concrete.
BH-G-06	1.3	3	MADE GROUND	(Very dense) dark greyish brown slightly sandy gravelly clay. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint, concrete, and brick.
BH-G-06	3	4.1	MADE GROUND	(Very dense) greyish brown slightly silty gravelly sand. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint with occasional fragments (<30mm x 20mm) of brick.
BH-G-06	4.1	5.1	MADE GROUND	Grey sandy gravel. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint with rare fragments (<30mm x 40mm) of brick.
BH-G-06	5.1	10.1	SANDY GRAVEL	Medium dense grey sandy gravel. Sand is fine to coarse. Gravel is predominantly angular and subangular occasionally subrounded fine to coarse of flint.
BH-G-06	10.1	54	LONDON CLAY	Firm to stiff grey silty clay with rare pockets (<3mm x 3mm) of silt.
BH-G-07	0	0.3	MADE GROUND	Brown gravelly sand. Sand is fine to coarse. Gravel is subangular to rounded fine to coarse of brick, concrete, and flint.
BH-G-07	0.3	0.45	MADE GROUND	Tarmac
BH-G-07	0.45	1.2	MADE GROUND	(Very stiff) mottled brownish bluish grey gravelly clay. Gravel is angular to rounded fine to coarse of flint and rare brick and concrete with light brown sand partings and occasional wood fragments (<10mm x 20mm x 30mm).
BH-G-07	1.2	1.7	MADE GROUND	Mixed dark reddish brown/greyish brown fine, medium, and coarse gravelly clay with rare fine CBM fragments
BH-G-07	1.7	2.2	MADE GROUND	Firm light blue grey silty clay mottled with 2-3mm black flecks which smear, oxidizes to a light reddish brown. MADE GROUND possibly redeposited alluvium.
BH-G-07	2.2	3.7	SILTY CLAY	Soft and firm brownish grey mottled greenish blue silty clay with occasional pockets (< 8mm x 10mm) of organic material. Slight organic odour.
BH-G-07	3.7	3.75	PEAT	Mid reddish brown laminated peat with reed fragments.
BH-G-07	3.75	4.15	CLAYEY PEAT	Firm brown slightly clayey slightly decomposed pseudo-fibrous peat with occasional fragments (<20mm x 30mm) of wood.
BH-G-07	4.15	4.16	SAND	Loose light yellow grey medium to coarse sand.
BH-G-07	4.16	5.3	SILTY GRAVELLY SAND	Medium dense grey slightly silty gravelly sand. Sand is fine to coarse. Gravel is angular and subangular fine to coarse flint.
BH-G-07	5.3	5.35	SANDY GRAVEL	Loose wet medium to coarse mid yellow grey sand with subangular to subrounded gravels

Bore	Depth1	Depth2	Key	Comment
BH-G-07	5.35	10.6	SANDY GRAVEL	Medium dense locally dense grey sandy gravel. Sand is fine to coarse. Gravel is angular and subangular with occasional subrounded fine to coarse flint.
BH-G-07	10.6	55	LONDON CLAY	Firm and stiff grey silty clay with frequent selenite crystals (<1mm x 1mm).
BH-G-08	0	0.05	MADE GROUND	TARMACADAM
BH-G-08	0.05	0.3	MADE GROUND	Greyish brown sandy gravel. Sand is fine to coarse. Gravel is subangular to rounded, fine to coarse of flint and occasional brick and concrete.
BH-G-08	0.3	0.6	MADE GROUND	Black gravelly sand. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick clinker concrete and flint.
BH-G-08	0.6	1.2	MADE GROUND	(Firm and stiff) mottled brownish grey gravelly clay with light brown sand partings. Gravel is angular to subrounded fine to coarse of flint brick clinker and concrete.
BH-G-08	1.2	1.7	MADE GROUND	Light yellow brown silty clay with moderate Fe staining.
BH-G-08	1.7	2	MADE GROUND	Soft greyish brown clay with occasional pockets (<3mm x 5mm) of silt.
BH-G-08	2	2.4	SILTY CLAY	Light yellow brown silty clay with moderate Fe staining.
BH-G-08	2.4	3	SILTY CLAY	Light yellow grey silty clay.
BH-G-08	3	3.5	PEAT	Dark grey, brown to black well-formed peat, rare <2mm rootlets.
BH-G-08	3.5	3.9	CLAYEY PEAT	Firm black oxidizing to brown slightly clayey spongy slightly decomposed pseudo-fibrous peat with gravel sized fragments of rootlets (<2mm x 2mm).
BH-G-08	3.9	4.5	SAND	Wet light yellow grey medium to coarse sand predominately coarse with 1mm laminations of organics.
BH-G-08	4.5	4.7	GRAVELLY SAND	Medium dense grey slightly silty slightly gravelly fine to coarse sand. Gravel is angular and subangular fine and medium flint.
BH-G-08	4.7	10.7	SANDY GRAVEL	Medium dense grey sandy gravel. Sand is fine to coarse. Gravel is predominately angular and subangular with occasional subrounded fine to coarse flint.
BH-G-08	10.7	32.7	LONDON CLAY	Firm to stiff brownish grey clay with occasional burrows (2mm x 2mm) of silt. Rare partings of fine silty sand.
BH-G-10A	0	0.04	MADE GROUND	TARMACADAM
BH-G-10A	0.04	1.2	MADE GROUND	Black gravel. Gravel is angular and subangular fine to coarse of flint, brick and rare concrete, clinker, and fine ash. With rare rootlets (<10mm x 8mm).
BH-G-10A	1.2	1.65	MADE GROUND	Firm light yellow brown silty clay with CBM fragments.
BH-G-10A	1.65	2.25	MADE GROUND	Firm and stiff greyish brown slightly gravelly clay. Gravel is angular and subangular fine to coarse of brick with occasional concrete.
BH-G-10A	2.25	2.5	MADE GROUND	Firm light yellowish brown silty clay
BH-G-10A	2.5	2.8	MADE GROUND	Firm and stiff greyish brown slightly gravelly clay.

Bore	Depth1	Depth2	Key	Comment
BH-G-10A	2.8	3.2	SILTY CLAY	Firm blue grey mottled with yellow brown silty clay.
BH-G-10A	3.2	3.3	CLAYEY PEAT	Firm black oxidizing to dark brown slightly clayey slightly decomposed pseudofibrous peat with fragments (<30mm x 30mm) of organic wood. Occasional slightly decayed organic plant material. Slight organic odour. 3.30m to 3.80m; becomes very clayey.
BH-G-10A	3.3	3.8	PEAT	Black well-formed peat <5% 20mm long reed fragments, v. slightly silty.
BH-G-10A	3.8	4.1	PEAT	Dark reddish brown peat with rare lenses of sand (coarse).
BH-G-10A	4.1	4.3	SAND	Light yellowish grey coarse sand with some medium <5mm detrital peat fragments.
BH-G-10A	4.3	5.11	GRAVELLY SAND	Grey slightly silty, slightly gravelly sand. Sand is fine to coarse. Gravel is angular and subangular fine and medium flint.
BH-G-10A	5.11	11	SANDY GRAVEL	Medium dense grey sandy gravel. Sand is fine to coarse. Gravel is subangular and subrounded fine to coarse flint.
BH-G-10A	11	13	LONDON CLAY	Firm to stiff brownish grey clay with occasional pockets (2mm x 3mm) of silt.
BH-G-10A	13	15	LONDON CLAY	Stiff indistinctly fissured greyish brown silty micaceous clay.
BH-G-11	0	0.05	MADE GROUND	(Soft) dark brown slightly sandy clay with abundant roots, rootlets (<1mm x 7mm) and wood fragments (<5mm x 60mm). Sand is fine to medium.
BH-G-11	0.05	0.6	MADE GROUND	(Firm) dark brown slightly gravelly slightly sandy clay with frequent rootlets (<1mm x 8mm) and wood fragments (<5mm x 30mm). Sand is fine to medium. Gravel is subangular and subrounded, fine and medium of brick and concrete.
BH-G-11	0.6	1.3	MADE GROUND	(Stiff) brown occasionally locally mottled reddish brown slightly gravelly clay with rare rootlets (<2mm x 10mm). Gravel is subangular and subrounded, fine, of brick and concrete.
BH-G-11	1.3	2.4	SANDY CLAY	Very stiff orangish brown mottled brownish grey and reddish brown slightly sandy clay with occasional rootlets (8mm x 1mm), occasional pockets (10mm x 5mm x 5mm) of reddish brown clay, occasional shell fragments (4mm x 8mm).
BH-G-11	2.4	3.6	SILTY CLAY	Soft brownish grey locally with reddish brown and grey streaks slightly silty clay with occasional sand pockets (20mm x 30mm), occasional wood fragments (3mm x 4mm) and occasional reddish brown and grey lenses (10mm x 1mm).
BH-G-11	3.6	4.1	CLAY	Stiff grey clay with occasional brown pockets (5mm x 5mm) of organic matter and occasional wood fragments (4mm x 8mm).
BH-G-11	4.1	4.8	PEAT	Spongy dark grey locally dark brown and black clayey moderately decomposed pseudo-fibrous peat with frequent brown wood fragments (<2mmx 10mm x 50mm) and occasional black pockets (30mmx 50mm) of organic matter.

Bore	Depth1	Depth2	Key	Comment
BH-G-11	4.8	5.5	GRAVELLY SAND	Greenish grey locally dark greenish grey slightly gravelly silty sand. Sand is fine to coarse. Gravel is subrounded, fine of flint.
BH-G-11	5.5	11.2	SANDY GRAVEL	Dense yellowish brown silty sand and gravel. Sand is fine to coarse. Gravel is subangular to rounded, fine and medium, locally coarse of flint, quartzite, and sandstone.
BH-G-11	11.2	41.44	LONDON CLAY	Soft to firm locally stiff grey slightly gravelly silty clay. Gravel is subrounded, fine of flint.
BH-S-13	0	0.33	CONCRETE	Strong grey concrete comprising sand and cement paste matrix and 60-70% aggregate of subangular to rounded medium and coarse flint gravel. No voids.
BH-S-13	0.33	0.65	MADE GROUND	Brown sandy gravel with low cobble content. Sand is fine to coarse. Gravel is angular to rounded, fine to coarse, of brick, concrete, and flint. Cobbles (<70mm x 70mm x 90mm) are subangular and subrounded of concrete. Black ashy clinker.
BH-S-13	0.65	0.85	MADE GROUND	Recovered as subangular cobbles (<120mm x 160mm x 200mm) of yellow brick and one subrounded cobble (80mm x 80mm x 80mm) of concrete. Occasional fine to coarse sand.
BH-S-13	0.85	1.05	MADE GROUND	Dark greyish brown to black slightly clayey gravelly sand. With occasional pockets (<40mm x 60mm x 60mm) of soft dark grey clay and rare wood fragments (<30mm x 40mm x 100mm). Sand is fine to coarse. Gravel is subangular and subrounded, fine to coarse, of concrete, flint, and possible limestone.
BH-S-13	1.05	1.25	MADE GROUND	Recovered as cobbles (70mm x 70mm x 90mm) and cores (150mm) of strong grey concrete comprising of sand and cement paste matrix and 50-70% aggregate of subangular to rounded fine to coarse flint gravel. With occasional medium to large voids.
BH-S-13	1.25	1.5	SILT	Soft dark greenish grey silt, sightly clayey, peat lenses (black <5%, 50mm).
BH-S-13	1.5	2	SILT	Soft dark greenish grey silt, to moderately firm, homogenous, weak horizontal structure, organic odour (natural as opposed to contaminated).
BH-S-13	2	2.5	ORGANIC SILTY CLAY	Soft brownish grey mottled black slightly gravelly organic silty clay. Gravel is rounded, fine of flint. Moderate organic odour.
BH-S-13	2.5	3	CLAYEY SILT	Becoming moderately firm to soft mid to dark greenish grey clayey silt, rare white flecks (carbonate/tufa).
BH-S-13	3	3.8	CLAYEY SILT	Becoming firm, moderately plastic dark greenish grey homogenous clayey silt, inclusions of/clasts of black organic alluvium (reworked).
BH-S-13	3.8	4	PEAT	Firm dark brown poorly humified, fibrous peat. With frequent to abundant wood fragments (<10mm x 20mm x 50mm) and occasional rootlets (<1mm x 1mm x 5mm). Moderate peaty organic odour.
BH-S-13	4	4.75	SILTY PEAT	Moderately firm dark brown peaty organic silt with occassional wood fragments.

Bore	Depth1	Depth2	Key	Comment
BH-S-13	4.75	5	CLAY	Soft grey micaceous clay with occasional rootlets (<5mm x 5mm), occasional pockets (<20mm x 30mm x 30mm) of dark brown pseudo-fibrous peat (possible fall-in from above).
BH-S-13	5	5.5	SILTY SAND	Grey slightly clayey silty sand. Sand is fine and medium, predominantly fine.
BH-S-13	5.5	7.5	SANDY SILT	Grey slightly sandy clayey silt with rare- occasional clasts (<5mm x 15mm x 20mm) of dark brown organic material. Sand is fine and medium, predominantly fine.
BH-S-13	7.5	7.8	SILTY SAND	Grey silty sand, wood fragments (<2mm x 8mm) and rare fine gravel of light grey cemented sand. Sand is fine to coarse.
BH-S-13	7.8	7.9	ORGANIC SILT	Dark brown to black (peaty) organic silt with few plant inclusions.
BH-S-13	7.9	8	GRAVELLY SAND	Grey mottled black slightly clayey gravelly sand. Wood fragment (<5mm x 20mm). Frequent shell fragments (<2mm x 3mm). Sand is fine to coarse. Gravel is subangular and subrounded fine to coarse of flint and grey cemented sand.
BH-S-13	8	9.75	SANDY GRAVEL	Grey sandy gravel. Sand is fine to coarse. Gravel is subangular and subrounded fine to coarse of flint and quartz.
BH-S-13	9.75	45	LONDON CLAY	Stiff grey micaceous clay.
BH-S-14	0	0.1	MADE GROUND	Tarmac
BH-S-14	0.1	0.7	MADE GROUND	Soft brown gravelly silt. Gravel is subangular and subrounded, fine to coarse of brick, concrete, and flint.
BH-S-14	0.7	1.5	MADE GROUND	Firm dark brownish grey slightly sandy slightly gravelly clay. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick, concrete and flint.
BH-S-14	1.5	3.5	MADE GROUND	Soft brownish grey slightly sandy slightly gravelly clay. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick, concrete, and flint.
BH-S-14	3.5	5.5	MADE GROUND	Greyish brown slightly sandy gravel. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick, concrete and flint.
BH-S-14	5.5	5.75	CONCRETE	Strong grey concrete. Sand and cement matrix, 70-80% aggregate of subangular to rounded flint and brick.
BH-S-14	5.75	6.5	MADE GROUND	Brown slightly sandy gravel. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick, concrete and flint.
BH-S-14	6.5	7	MADE GROUND	Black slightly clayey sandy gravel. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick, concrete and flint.
BH-S-14	7	7.1	MADE GROUND	Timber, brick fragments, sand and gravel
BH-S-14	7.1	7.8	MADE GROUND	Black slightly clayey sandy gravel. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick, concrete and flint.
BH-S-14	7.8	8	MADE GROUND	Soft and very soft, mottled brownish grey gravelly clay. Gravel is angular to subrounded, fine to coarse of flint.
BH-S-14	8	8.1	MADE GROUND	Fine, medium and coarse subangular to subrounded gravels in orangey brown to black clayey matrix, <1% CBM fragments.

Bore	Depth1	Depth2	Key	Comment
BH-S-14	8.1	9	MADE GROUND	Soft and very soft, mottled brownish grey gravelly clay. Gravel is angular to subrounded, fine to coarse of flint.
BH-S-14	9	9.1	MADE GROUND	Light greyish brown coarse sandy silty clay, <1% 5mm - granular subangular gravels.
BH-S-14	9.1	9.7	MADE GROUND	Soft and very soft mottled brownish grey gravelly clay. Gravel is angular to subrounded, fine to coarse of flint.
BH-S-14	9.7	10	CONCRETE	Medium strong yellow concrete Sand and cement matrix, 40-50% aggregate of subangular to rounded flint.
BH-S-14	10	10.2	CONCRETE	Strong palr grey concrete. Sand and cement matrix, 70-80% aggregate of subangular to rounded flint and brick.
BH-S-14	10.2	11.7	MADE GROUND	Very soft dark bluish grey silty clay.
BH-S-14	11.7	12.2	CONCRETE	(Strong) creamish grey concrete. Sand and cement matrix 70-80% aggregate of subangular to rounded flint and brick.
BH-S-14	12.2	12.5	MADE GROUND	Grey slightly sandy gravel. Sand is fine to coarse. Gravel is subangular to rounded, fine to coarse of flint.
BH-S-14	12.5	12.9	CONCRETE	Strong, pale grey concrete. Sand and cement matrix 70-80% aggregate of subangular to rounded flint and brick.
BH-S-14	12.9	13.1	MADE GROUND	Brown sand and gravel. Sand is fine to coarse. Gravel is subangular to well rounded, fine to coarse of flint. (logged by JS as possible RTG)
BH-S-14	13.1	13.2	MADE GROUND	Coarse yellow grey sand with 5-40mm subangular to subrounded gravels. (logged by JS as possible RTG)
BH-S-14	13.2	14.25	MADE GROUND	Stiff brownish grey slightly sandy clay with occasional black silt partings (1mm). Sand is fine to coarse.
BH-S-14	14.25	14.3	MADE GROUND	Grey clay with 5% fine to medium subangular to subrounded gravels (seemed clean in isolation however obstruction encountered at 14.3m)
BH-S-15	0	0.5	MADE GROUND	Dark brown slightly sandy slightly gravelly silt. Sand is fine to coarse. Gravel is subangular and subrounded fine to coarse of flint, brick and concrete. With occasional wood fragments (<10mm x 10mm x 80mm), plastic fragments (<10mm x 20mm x 50mm) and a metal nail (< 10mm x 10mm x 70mm).
BH-S-15	0.5	0.8	MADE GROUND	Soft greyish brown gravelly clay. Gravel is subangular to rounded fine to coarse of flint, concrete and brick. Occasional wood fragments (<10mm x 10mm x 80mm).
BH-S-15	0.8	2.2	MADE GROUND	Soft, greyish brown gravelly silty clay with low cobble content. Gravel is subangular and subrounded fine to coarse of flint, brick and concrete. Cobbles (<100mm x 120mm x 160mm) are subangular of concrete.
BH-S-15	2.2	4	MADE GROUND	Soft greyish brown slightly sandy gravelly clay. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint, brick and concrete. With occasional pockets (<10mm x 30mm) of grey fine sand.
BH-S-15	4	5.5	MADE GROUND	Greyish brown sandy gravelly silt with medium cobble content. Sand is fine to coarse. Gravel is subangular and subrounded fine to coarse of concrete and flint. With occasional pockets (< 30mm x 50mm) of fine sand. Cobbles (<160mm x 180mm x 210mm) are subangular and rounded of flint and concrete.

Bore	Depth1	Depth2	Key	Comment
BH-S-15	5.5	6	MADE GROUND	Recovered as a subangular cobble (< 160mm x 180mm x 290mm) of concrete.
BH-S-15	6	7.5	MADE GROUND	Greyish brown slightly sandy gravelly silt. Sand is fine to coarse. Gravel is subangular and subrounded of flint, brick and concrete.
BH-S-16	0	0.6	MADE GROUND	Light brownish grey sandy gravel with low cobble content. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick and concrete. Cobbles (< 20mm x 80mm x 180mm) are subangular and subrounded of concrete.
BH-S-16	0.6	1.2	MADE GROUND	Dark brown gravelly sand with medium cobble content. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick and concrete. Occasional tarmacadam and occasional plastic fragments (<1mm x 2mm x 8mm). Cobbles (< 60mm x 80mm x 110mm) are subangular and rounded of concrete.
BH-S-16	1.2	2.1	MADE GROUND	Brownish grey clayey gravel with low boulder content. Gravel is angular to subrounded, fine to coarse of brick, clinker, concrete and flint.
BH-S-16	2.1	3.7	MADE GROUND	Soft greyish brown slightly sandy slightly gravelly clay. Sand is fine to coarse. Gravel is angular to subrounded, fine to coarse of brick, clinker, concrete and flint.
BH-S-16	3.7	4	MADE GROUND	Firm and stiff mottled greyish orangish brown slightly sandy clay. Sand is fine to coarse. With occasional fragments (<20mm x 30mm x 35mm) of brick, and occasional black silt partings (1mm).
BH-S-16	4	4.5	SILTY CLAY	Soft bluish black, grey silty clay.
BH-S-16	4.5	6	SANDY CLAY	Firm light yellow grey mottled with dark blue grey and black MC sandy clay. Mixed
BH-S-16	6	7.5	SANDY SILT	Firm dark blue grey to black fine slightly sandy silt with laminations of light yellow grey fine to medium sand
BH-S-16	7.5	8	SILTY GRAVELLY CLAY	Stiff mid blue grey mottled with light orange brown clay, 30% medium to coarse subangular to subrounded gravels.
BH-S-16	8	9.45	SANDY GRAVEL	Brown sandy gravel. Sand is fine to coarse. Gravel is subangular to rounded fine to coarse of flint.
BH-S-16	9.45	9.75	CLAY	Firm brownish grey slightly sandy slightly gravelly clay. Sand is fine to coarse. Gravel is subangular to rounded fine to coarse of flint.
BH-S-16	9.75	36.7	LONDON CLAY	Firm brownish grey slightly sandy clay. Sand is fine to coarse.
BH-S-18	0	1.2	MADE GROUND	Light brownish grey sandy gravel with fragments (<40mm x 50mm x 100mm) of wood and cables (<20mm x 20mm x 300mm). Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of brick concrete and flint.
BH-S-18	1.2	1.5	MADE GROUND	Soft brown slightly gravelly sandy silty clay. Sand is fine to coarse. Gravel is angular and subangular fine to coarse brick, concrete and flint.
BH-S-18	1.5	2.1	MADE GROUND	Dark grey slightly silty gravelly sand. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint with occasional brick and concrete.

Bore	Depth1	Depth2	Key	Comment
BH-S-18	2.1	2.5	MADE GROUND	Very soft to soft brownish grey slightly sandy gravelly silty clay. Sand is fine to coarse. Gravel is angular and subangular fine to coarse flint, brick and concrete.
BH-S-18	2.5	3	MADE GROUND	Wet dark brown clayey silt with rare fine sand, yellow stock brick inclusions.
BH-S-18	3	3.4	MADE GROUND	Firm brownish grey locally mottled dark grey slightly gravelly clay with occasional pockets (<10mm x 10mm) of silt. Gravel is angular and subangular fine to coarse brick, concrete with occasional flint. Yellow stock bricks.
BH-S-18	3.4	5.8	SILTY CLAY	Firm brownish grey and green clay with rare burrows (<1mm x 2mm) of silt. Slight organic odour. 3.95-4m Firm light blue grey mottled with light orange, brown silty clay. 4.95-5 Firm light blue grey oxidising to light orange, brown silty clay with Mn staining.
BH-S-18	5.8	6	SANDY SILT	Firm light reddish brown mottled with dark blue grey fine sandy silt with flecks of detrital organics, mixed structure
BH-S-18	6	6.5	SILTY SAND	Soft mid yellow grey silty sand [drillers: Soft to firm grey slightly sandy silty clay with occasional pockets (<5mm x 5mm) of dark grey fine silty sand. Slight organic odour.}
BH-S-18	6.5	7	SANDY SILT	Grey very sandy slightly clayey silt. Sand is fine to coarse.
BH-S-18	7	7.4	GRAVELLY CLAY	Wet light brownish grey medium to coarse clay with abundant fine to medium gravels subangular to subrounded 5-40mm (20%) x2 large wood fragments.
BH-S-18	7.4	8	CLAYEY SANDY GRAVEL	Medium dense dark grey clayey sandy gravel. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint.
BH-S-18	8	9.7	SANDY GRAVEL	Dense grey sandy gravel. Sand is fine to coarse. Gravel is angular and subangular subrounded fine to coarse of flint.
BH-S-18	9.7	41	LONDON CLAY	Firm and stiff brownish grey clay.
BH-S-19	0	0.6	MADE GROUND	Light brownish grey sandy gravel. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of brick, concrete and flint.
BH-S-19	0.6	1.2	MADE GROUND	Dark brown gravelly sand. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of brick, concrete and flint.
BH-S-19	1.2	2	MADE GROUND	Firm orange brown and black mottled grey slightly sandy gravelly clay. Sand is fine to coarse. Gravel is angular and subangular of brick and fine ash.
BH-S-19	2	3.2	CLAY	Soft brownish grey locally mottled brown clay with frequent pockets (<10mm x 20mm) of black organic material. Slight organic odour.
BH-S-19	3.2	5	CLAY	Soft and firm brownish grey locally mottled orange and brown clay. Slight organic odour.
BH-S-19	5	6.5	CLAY	Very soft and soft grey slightly sandy silty clay with occasional partings of fine silty sand. Rare pockets (<5mm x 8mm) of organic decomposed plant material. Sand is fine to coarse. Slight organic odour.
BH-S-19	6.5	9	SANDY GRAVEL	Medium dense sandy gravel. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of flint.

Bore	Depth1	Depth2	Key	Comment
BH-S-19	9	41	LONDON CLAY	Stiff fissured grey clay. Fissures are randomly orientated, extremely closely spaced, undulating.
TP-S-03	0	0.25	CONCRETE	Strong light grey renforced concrete, strong. Comprising of sand and cement matrix and 50% aggregate of angular to subrounded fine to coarse flint and occasional chalk gravel with un-ribbed reinforcement bars (< 5mm and <10mm diameter).
TP-S-03	0.25	0.9	MADE GROUND	Dark brown, locally light yellowish brown gravelly sand with roots. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of concrete, brick, clinker and occasional flint.
TP-S-03	0.9	1.1	MADE GROUND	Black gravelly sand. Sand is fine to coarse. Gravel is angular and subangular fine to coarse of clinker and charcoal with ash.
TP-S-03	1.1	1.4	MADE GROUND	Soft brownish grey mottled reddish brown slightly sandy slightly gravelly clay with yellowish brown sand pockets (<40mm x 40mm 50mm) and with fragments of wood (<12mm x 20mm x 50mm). Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of concrete, brick, clinker and flint.
TP-S-03	1.4	2.6	MADE GROUND	Dark brown locally greyish brown slightly gravelly clayey sand. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of brick, flint and concrete with occasional to frequent pockets (<250mm x 300mm x 350mm) of soft gravelly clay.
TP-S-03	2.6	3.1	CLAY	Soft bluish grey mottled dark grey slightly sandy slightly gravelly clay with dark grey bands. Sand is fine and medium. Gravel is subangular and subrounded fine to coarse of flint. [Possible ALLUVIUM]
TP-S-04	0	0.1	MADE GROUND	Tarmac
TP-S-04	0.1	0.38	CONCRETE	Strong light grey reinforced concrete. Comprising of sand and cement matrix and 50% aggregate of angular to subrounded fine to coarse flint and occasional chalk gravel. Reinforcement unribbed.
TP-S-04	0.38	0.55	MADE GROUND	Dark brown locally light grey gravelly sand with low to medium cobble content. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of concrete, brick, and clinker. Cobbles (<100mm x 150mm x 180mm) are angular of brick and concrete.
TP-S-04	0.55	0.75	CONCRETE	Possible medium strong light grey fractured concrete. Comprising sand and cement matrix and 40-50% aggregate of angular and subangular fine to coarse flint gravel. Recovered as Boulders (<200mm x 200mm x 300mm).
TP-S-04	0.75	1.15	MADE GROUND	Dark brown locally dark reddish brown and orange gravelly sand with low cobble content. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of concrete, brick, and clinker. Cobbles (<100mm x 150mm x 180mm) are angular and subangular of brick and concrete.
TP-S-04	1.15	1.35	CONCRETE	Concrete.

Bore	Depth1	Depth2	Key	Comment
TP-S-04	1.35	1.7	MADE GROUND	Dark grey locally dark orangish brown slightly sandy clayey gravel with low cobble content. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of concrete, brick, clinker and flint. Cobbles (<90mm x 150mm x 180mm) are angular of brick and concrete.
TP-S-06	0	0.3	MADE GROUND	Brown gravelly silty sand with low cobble content. Occasional fragments of glass (<3mm x 45mm x 50mm) and wood (<25mm x 35mm x 65mm). Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of concrete, brick and unidentified lithology. Cobbles (<70mm x 80mm x 90mm) are subangular of concrete.
TP-S-06	0.3	0.75	MADE GROUND	Pinkish brown gravelly sand with medium cobble content. Sand is fine to coarse. Gravel is angular and subangular of concrete and occasional brick. Cobbles (<70mm x 80mm x 100mm) are angular and subangular of concrete.
TP-S-06	0.75	2	MADE GROUND	Dark brown locally dark orange gravelly silty sand with low cobble and boulder content. With occasional pockets (<50mm x 70mm x 80mm) of very soft light yellowish grey and locally dark pinkish brown clay. Sand is fine to coarse. Gravel is angular to subrounded fine to coarse of concrete, brick and occasional flint. Cobbles (<100mm x 150mm x 160mm) and boulders (<400mm x 550mm x 600mm) are subangular and subrounded of brick and concrete.
TP-S-06	2	2.4	MADE GROUND	Dark greyish brown locally dark pinkish brown sandy silty gravel with occasional pockets (<50mm x 70mm x 80mm) of very soft yellowish grey locally dark pinkish brown clay. Sand is fine to coarse. Gravel is subangular and subrounded fine to coarse of concrete, flint and brick.
TP-S-06	2.4	2.7	MADE GROUND	Soft dark grey locally black and dark pinkish brown slightly sandy slightly gravelly clay. Sand is fine to coarse. Gravel is subangular and subrounded fine to coarse of flint. (Possibly Made Ground).

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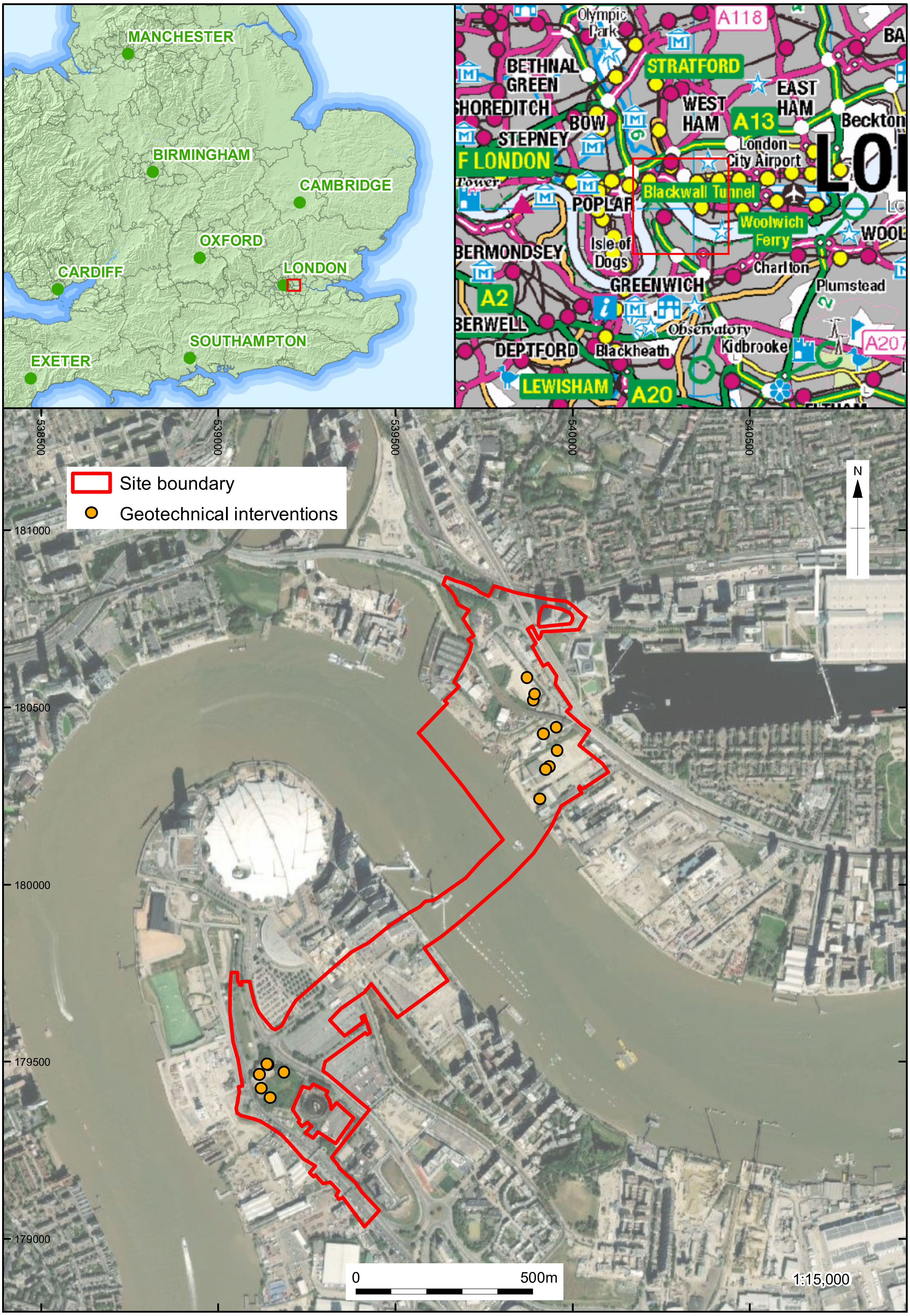

Figure 1: Site location

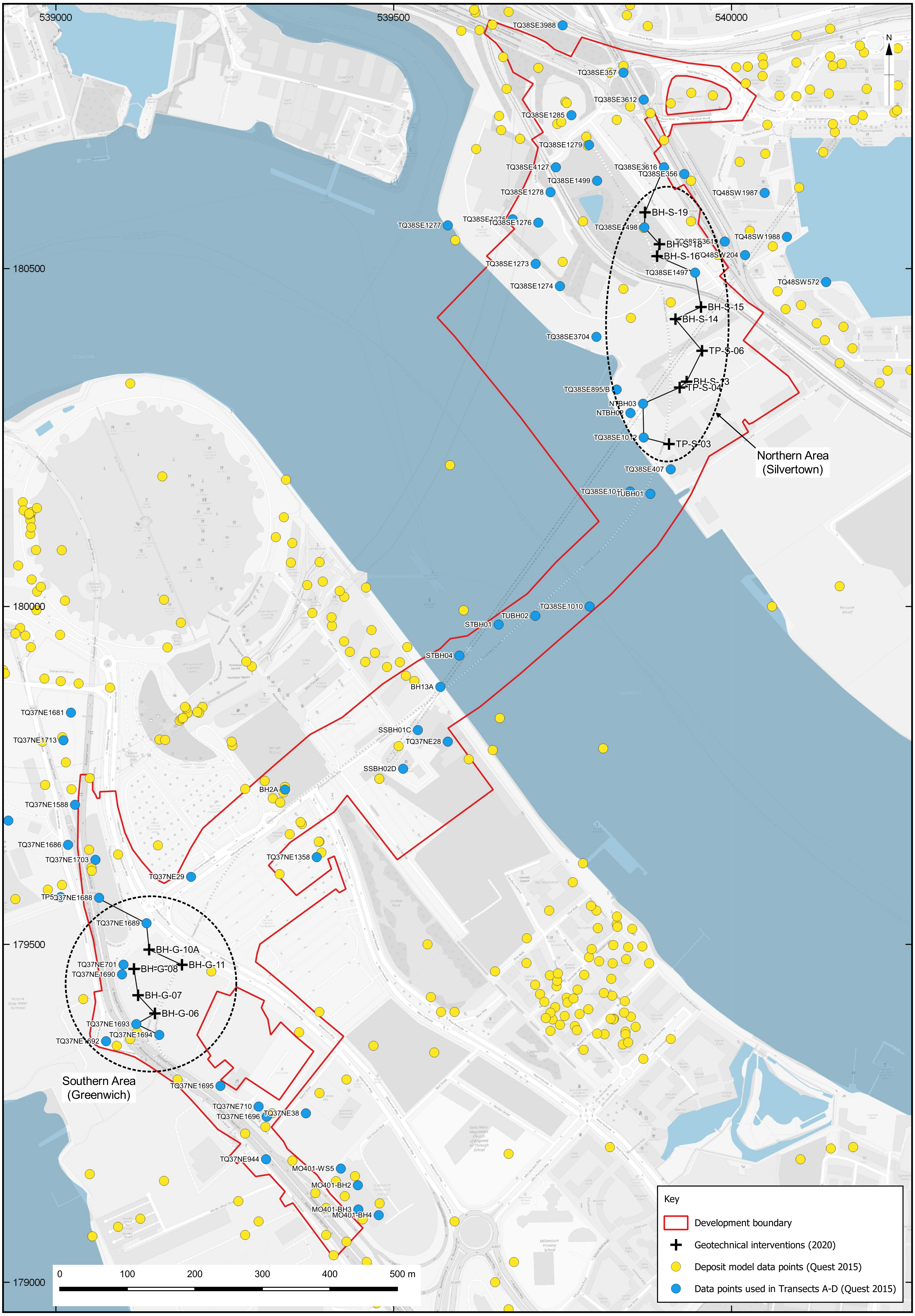

Figure 2: Location of geotechnical interventions and previous deposit model data points

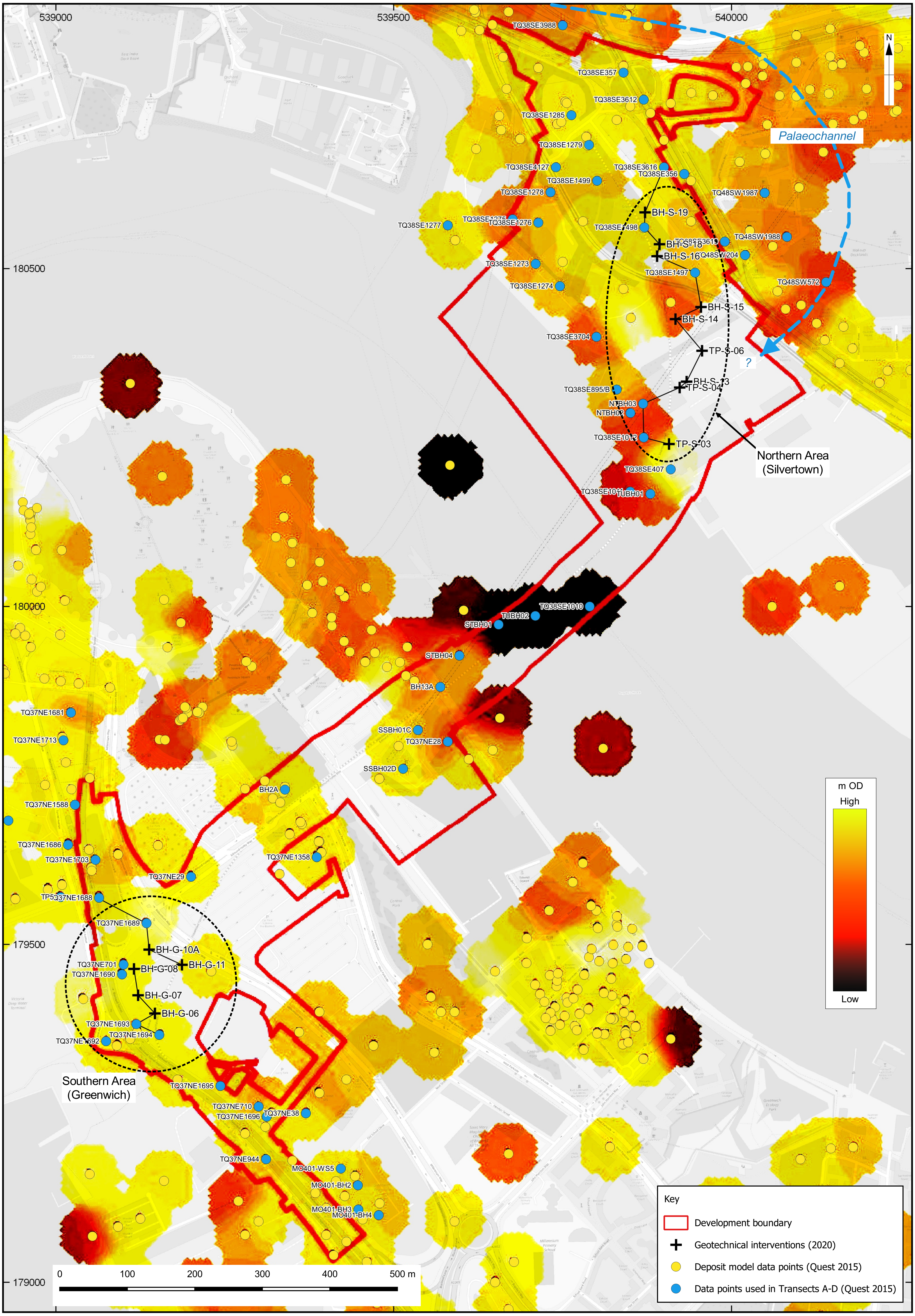

Figure 3: Modelled elevation of the buried surface of the Shepperton Gravel (Quest 2015)

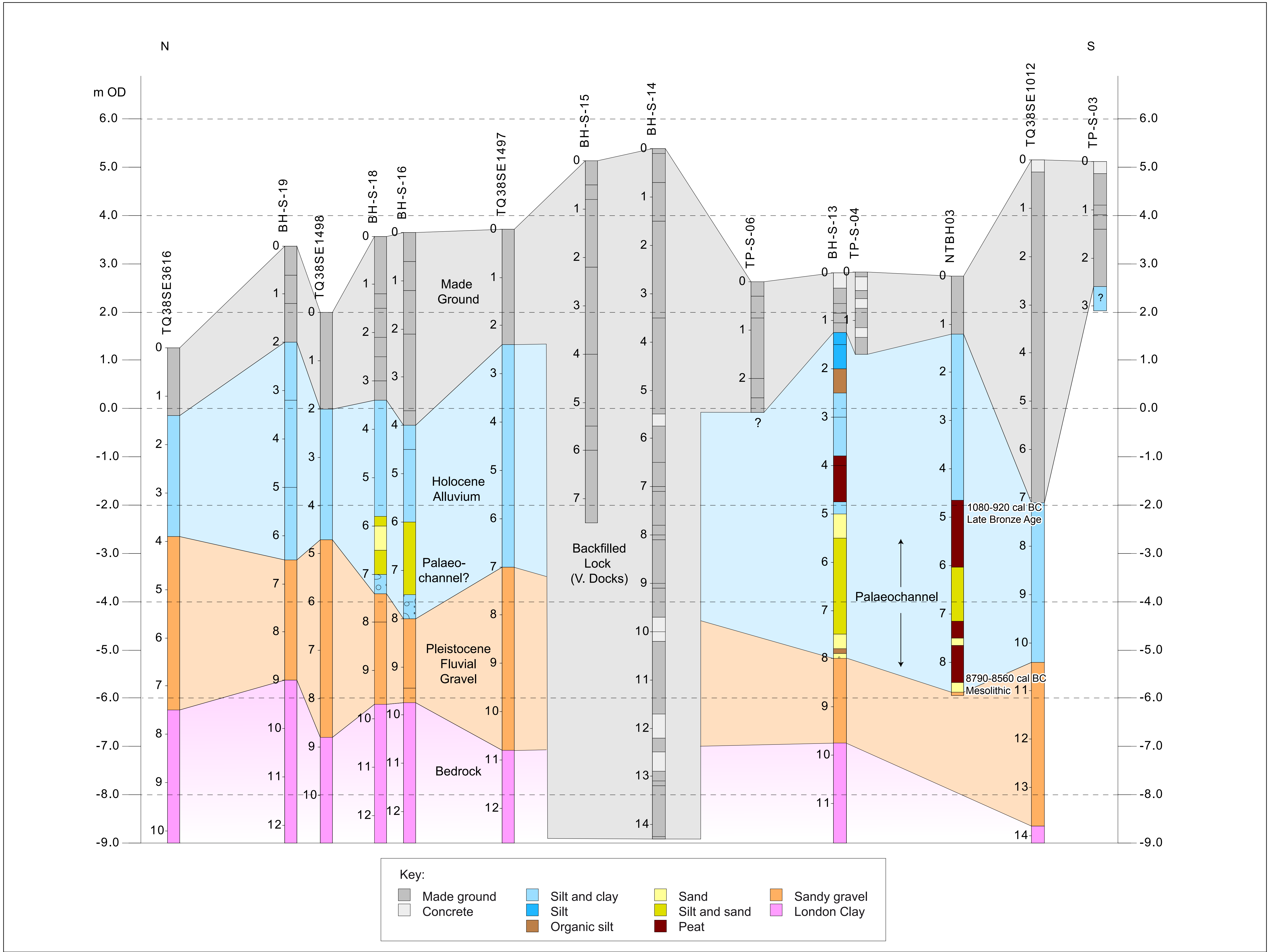

Figure 4: Borehole transect, Silvertown

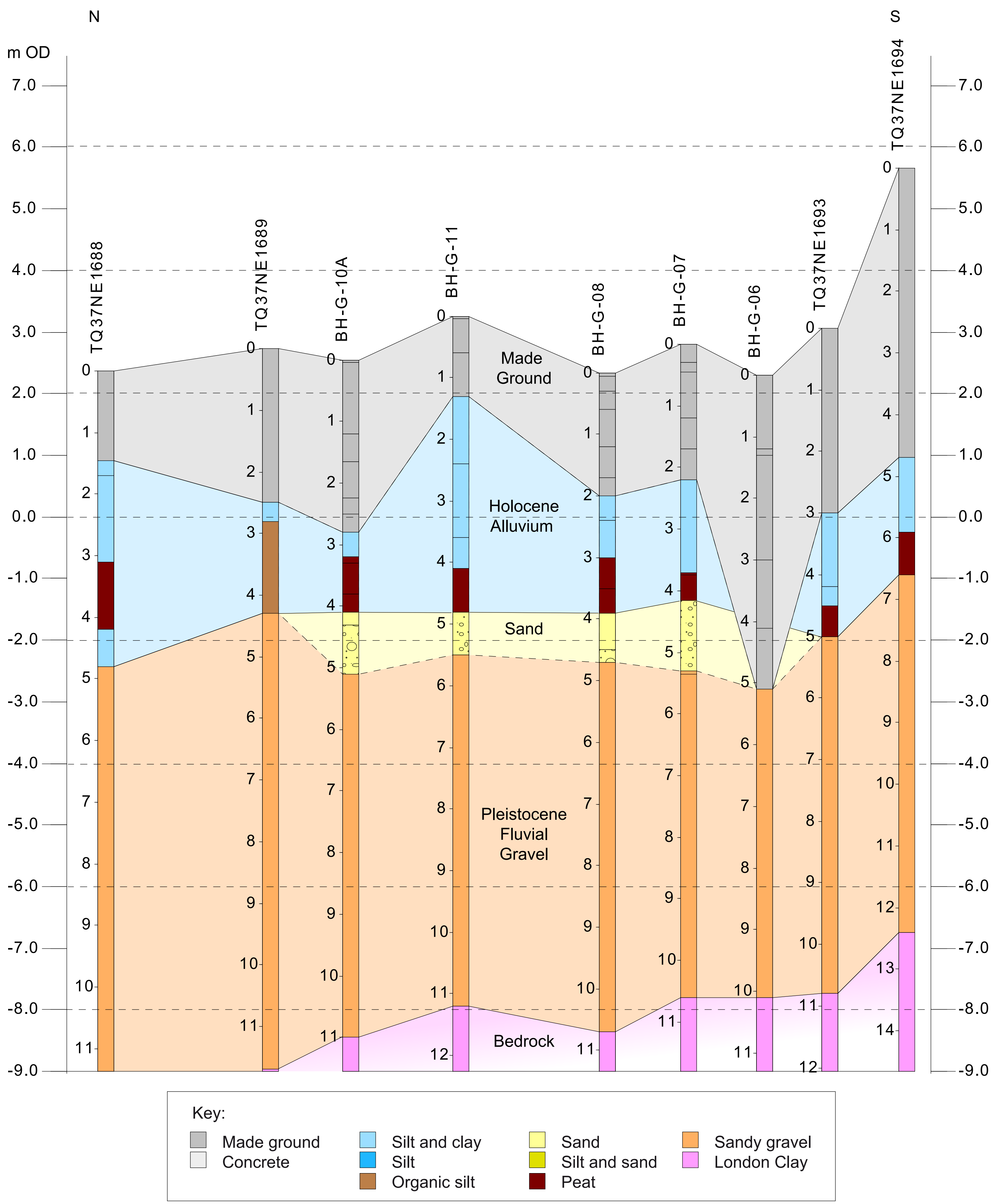

Figure 5: Borehole transect, Greenwich