PERUVIAN WHARF NORTH WOOLWICH ROAD SILVERTOWN LONDON BOROUGH OF NEWHAM

Geoarchaeological Fieldwork & Updated Deposit Model Report

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Written by: C.R. Batchelor, C.P. Green & D.S. Young

QUEST, School of Archaeology, Geography and Environmental Science, Whiteknights, University of Reading, RG6 6AB

Tel: 0118 378 7978 / 8941
Email: c.r.batchelor@reading.ac.uk
http://www.reading.ac.uk/quest

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1. NON TECHNICAL SUMMARY

A program of geotechnical borehole monitoring and deposit modelling was carried out by Quaternary Scientific (University of Reading) in connection with the proposed development of land at Peruvian Wharf, North Woolwich Road, Silvertown, London Borough of Newham in February 2016. As a consequence of this work, a further stage of geoarchaeological fieldwork and updated deposit modelling was required which forms the basis of the following report. The work was commissioned by CgMs Consulting. The aims of the investigation were: (1) to clarify the composition, nature and distribution of the sediments beneath the site; (2) to evaluate the potential of these sediments for providing information on the environmental history of the site, and evidence of human activity.

In order to address these aims, four geoarchaeological boreholes were put down across the site. The resultant records were combined with over geotechnical logs which were inspected and evaluated, together with records from nearby archaeological/geoarchaeological investigations. The depth, thickness and nature of each major sedimentary unit was extracted and entered into geological modelling software, from which a series of topographic surface and thickness maps were produced.

The results of this exercise demonstrate a sequence of River Terrace Gravels (the Shepperton Gravel), overlain by floodplain deposits of Peat and Upper Alluvium (silts and clays) beneath the site. The nature of the sediments is relatively consistent across the site, and accumulated between the early Neolithic and late Bronze Age. Since this timeframe is represented by many local sites for which detailed records exist, no further palaeoenvironmental work is recommended. However, when compared with these other sites, the nature and age of the sediments is highly variable and therefore important. As such, it is recommended that findings are integrated into an ongoing publication encompassing south-west Newham and Greenwich Peninsula. Such a document will build upon similar recent regional site investigations carried out along the Barking Reach, Plumstead and Erith Marshes and the Lower Lea Valley.

2. INTRODUCTION

2.1 Site context

This report summarises the findings arising out of the fieldwork and updated deposit modelling undertaken by Quaternary Scientific (University of Reading) in connection with the proposed development at Peruvian Wharf, North Woolwich Road, Silvertown, London Borough of Newham (National Grid Reference centred on: TQ 40340 80150; site code: PWF16; Figures 1-3). The Peruvian Wharf site is approximately 4 hectares in size and rests at an elevation of *ca*. 1.5 to 2m OD. It lies on the floodplain of the Lower Thames where the Woolwich Reach of the river forms a broad southward bend. The ground across the area originally formed part of the natural floodplain of the Thames and is underlain by Holocene alluvial deposits (British Geological Survey (BGS) 1:50,000 Sheets 257 Romford 1996), which consisted of fine-grained mineral-rich sediments and peat. Beneath the alluvium, sand and gravel is present and is assigned by Gibbard (1994) to the Late Devensian Shepperton Gravel. The bedrock beneath this is the Lower Tertiary Lambeth Group.

A program of geoarchaeological deposit modelling based upon geotechnical investigations undertaken by Chelmer Site Investigations (2016) and Waterman Environmental (2000) was carried out in February 2016 (Batchelor & Green, 2016). When combined with historical records held by the British Geological Survey (BGS), over 100 well-distributed boreholes and test-pits have been put down on, and immediately adjacent to the site. Of these however, only 19 record the entire sedimentary sequence and contain reliable data for modelling purposes; furthermore, only 8 were from the site itself. There were also stark contrasts between the Waterman Environmental/BGS and Chelmer Site Investigation geotechnical records, both in terms of the nature of the deposits and their elevation.

The results of the modelling indicated a Shepperton Gravel surface mainly between -2.5 and -4m OD with a potential W-E aligned margin beyond the southern boundary of the Peruvian Wharf site. Beyond this point, the Gravel surface appears to reduce in height to at least -5m OD. The sediments overlying the Shepperton Gravel surface in stratigraphic order consist of the Lower Alluvium, Peat and Upper Alluvium. The Lower Alluvium is defined here as a generally silty or sandy (sometimes organic) deposit that accumulated during the Early to Middle Holocene (Mesolithic cultural period) within a fluvial or estuarine environment. In many cases across the Lower Thames Valley it is separated from the widespread, more clayey and inorganic Middle to Late Holocene Upper Alluvium by a thick horizon of Peat representative of a shift towards semi-terrestrial environment supporting the growth of fen woodland. Across the Peruvian Wharf site and wider modelled area, the Peat is not always present, generally preventing definitive distinction between the Lower Alluvium and Upper Alluvium.

The Lower Alluvium is almost entirely absent across the Peruvian Wharf site, and is recorded inconsistently across the wider area. Instead, where present, Peat tends to rest directly on the surface of the Shepperton Gravel. There are however, stark contrasts between the Waterman Environmental/BGS records (which indicate peat horizons 1.2-3.6m thick directly resting on the Shepperton Gravel) and those resulting from the Chelmer Site Investigation works (which contain considerably thinner or absent peat horizons) (Tables 1 & 2). Three potential reasons were suggested for this: (1) natural variations in the presence of Peat across the site; (2) varying types of drilling/sediment description, or (3) truncation of the sequences during demolition; only further geoarchaeological boreholes are likely to elucidate the pattern of the alluvial deposits across the site.

Where present, the Peat surface is overlain by silty and clayey deposits of the Upper Alluvium. These deposits vary between 0.3 and 6m thick, with an upper surface resting between 0 and +1m OD when not truncated by Made Ground. In a small number of randomly distributed test-pits, an upper Peat horizon of 20cm and 90cm was recorded at the interface between the Upper Alluvium and Made Ground (Table 2). The elevation of this Peat is unusually high however (between 1 & 2m OD), when compared to the likely natural level of the Thames floodplain prior to artificial raising (0 to 1m OD). Thus it is uncertain whether or not this represents a natural or redeposited Peat horizon.

2.2 Palaeoenvironmental and archaeological significance

The existing records therefore indicate variations in the height of the Shepperton Gravel surface, and uncertainties in the type, thickness and age of the subsequent Holocene deposits. Such variations are significant as they represent different environmental conditions that would have existed in a given location. For example: (1) the varying surface of the Shepperton Gravel may represent the location of former channels (towards the south of the site) and bars (towards the north); (2) the presence of peat represents former terrestrial or semi-terrestrial land-surfaces, and (3) the Lower and Upper Alluvium represent periods of inundation/flooding by estuarine or fluvial waters. Thus by studying the sub-surface stratigraphy across the site in greater detail, it will be possible to build an understanding of the former landscapes and environmental changes that took place across space and time.

Organic-rich sediments (in particular Peat) also have high potential to provide a detailed reconstruction of past environments on both the wetland and dryland from the Mesolithic to Late Bronze Age periods. In particular, there is the potential to increase knowledge and understanding of the interactions between relative sea level, human activity, vegetation succession and climate in this area of the Lower Thames Valley. Significant vegetation changes include the Mesolithic/Neolithic decline of elm woodland, the Neolithic colonisation and decline of yew woodland; the Late Neolithic/Early Bronze Age growth of elm on Peat, and the general decline of wetland and dryland woodland during the Bronze Age. Such investigations are carried out through the assessment/analysis of palaeoecological remains (e.g. pollen, plant macrofossils & insects) and radiocarbon dating. So-called palaeoenvironmental reconstructions have also been carried out on the sedimentary sequences from West Silvertown (Wilkinson et al., 2000), Fort Street (Wessex Archaeology, 2000) and the London Cable Car North Intermediate Tower (Batchelor *et al*., 2015). Commonly the peat forms during the Middle Holocene between 6500 and 2500 cal BP equating to the late Mesolithic, Neolithic, Bronze Age and Iron Age cultural periods. However, the sequences from West Silvertown and the London Cable Car North Intermediate Tower also included organic-rich deposits dating from the late Devensian / early Holocene (*ca*. 12,000 cal BP) equating to the early Mesolithic cultural period.

Finally, areas of high gravel topography, soils and peat represent potential areas that might have been utilised or even occupied by prehistoric people, evidence of which may be preserved in the archaeological (e.g. features and structure) and palaeoenvironmental record (e.g. changes in vegetation composition). Prehistoric structures have been identified in the peat locally to the site at Fort Street (Wessex Archaeology, 2000; Crockett *et al*., 2003; Figure 1); here a Neolithic trackway was recorded within the Peat between -0.99 to -1.28m OD, overlying a sand and gravel surface ranging between 0.53 and -1.28m OD. On the basis of the findings from initial modelling exercise, the Shepperton Gravel surface and Peat sediments from the northern part of the site have some potential, particularly when considering the presence of the known archaeological remains on the Fort Street site. However, even this is considered to be moderate at best, since the surface of the Shepperton Gravel does not appear to rise above -2.50m OD.

2.3 Aims and objectives

The results of the initial deposit modelling exercise are considered to make a valuable contribution to our knowledge and understanding of the evolution of the floodplain landscape along this stretch of the Lower Thames Valley, against which the archaeological record can considered. However, insufficient reliable records from the southern part of the Peruvian Wharf site resulted in voids in the model; it was therefore recommended that four geoarchaeological boreholes were put down in these areas of the site to complete the study, and clarify the extent of Peat formation. It was also recommended that any peat sequences present are radiocarbon dated to improve the chronological framework of deposition. The placement of these boreholes should also enable investigation of the suspect Peat horizon in the Upper Alluvium identified in select records. Palaeoenvironmental investigation is unlikely to be required unless unusual findings are made; detailed reconstructions have already been carried out in the nearby area (e.g. the London Cable Car [Batchelor *et al*., in press], Fort Street [Wessex Archaeology, 2000; Crockett *et al*., 2003] and West Silvertown [Wilkinson et al., 2000]). The following report aims to address these recommendations and those outlined within the Written Scheme of Investigation (Young, 2016).

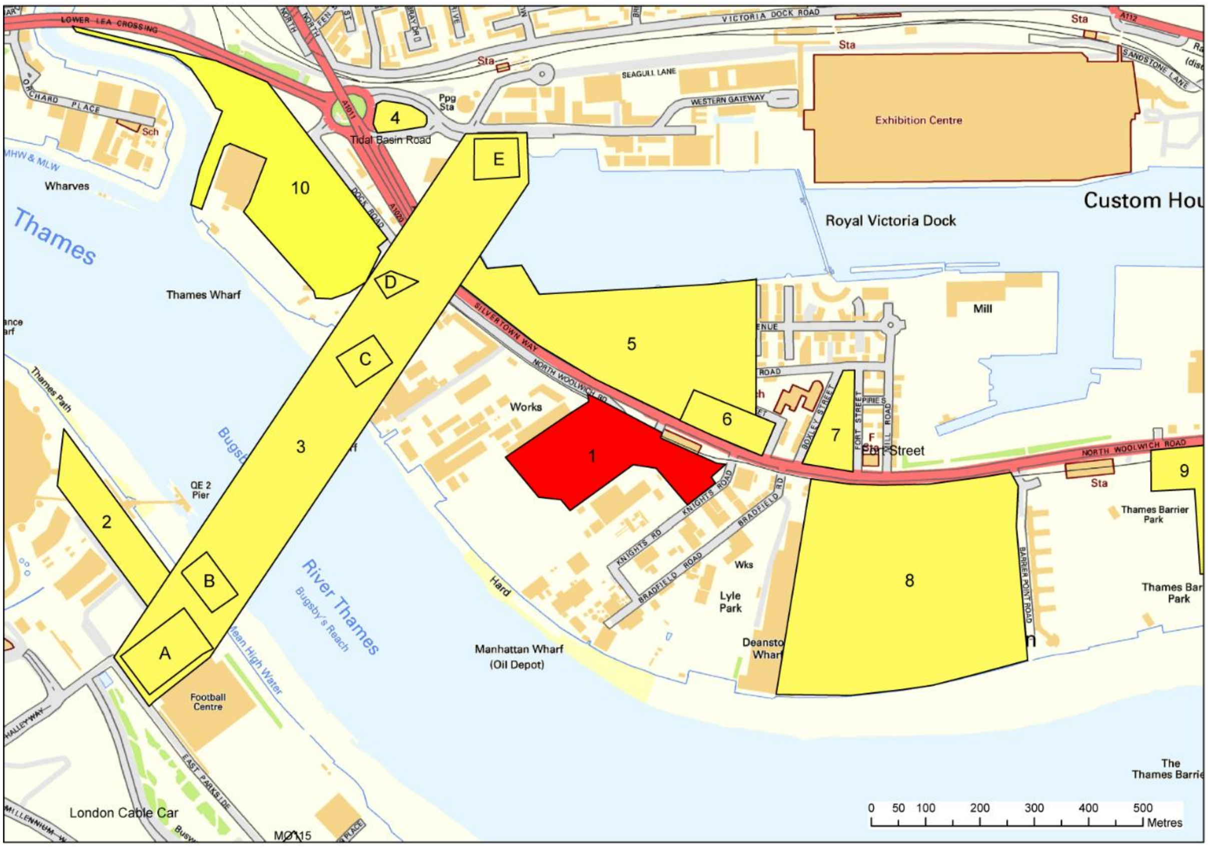

Figure 1: Location of (1) the Peruvian Wharf site and other nearby geoarchaeological/ archaeological investigations: (2) Greenwich Peninsula Central East (Young et al., 2015); (3) the Cable Car route (CAB11; Batchelor et al., 2015) (A) North Station; (B) North Intermediate Tower; (C) North Tower; (D) South Tower; (E) South Station); (4) Tidal Basin Road (Young & Batchelor, 2013); (5) West Silvertown (Wilkinson et al., 2000); (6) Barnwood Court (Farid, 1997); (7) Fort Street (Wessex Archaeology, 2000; Crockett et al., 2003); (8) Minoco Wharf / Royal Wharf (Batchelor et al., 2014); (9) Thames Barrier Park East (Green et al., 2006) and (10) Thames Wharf (TWF07; MoLAS). Contains Ordnance Survey data © Crown copyright and database right [2016].

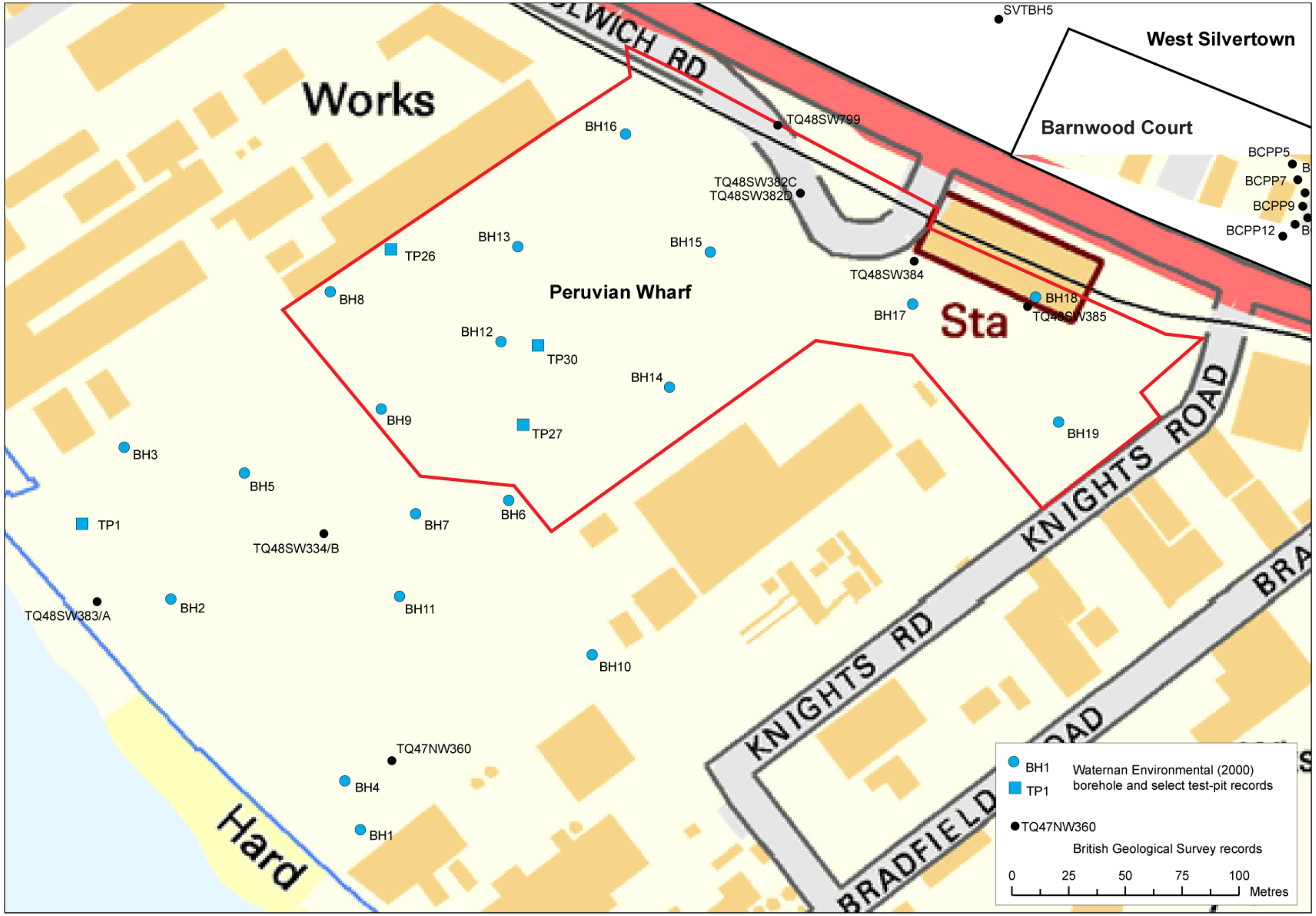

Figure 2: Detailed plan of Peruvian Wharf, London Borough of Newham, illustrating the location of complete Holocene historical geotechnical and archaeological sequences on and adjacent to the site. Contains Ordnance Survey data © Crown copyright and database right [2016]

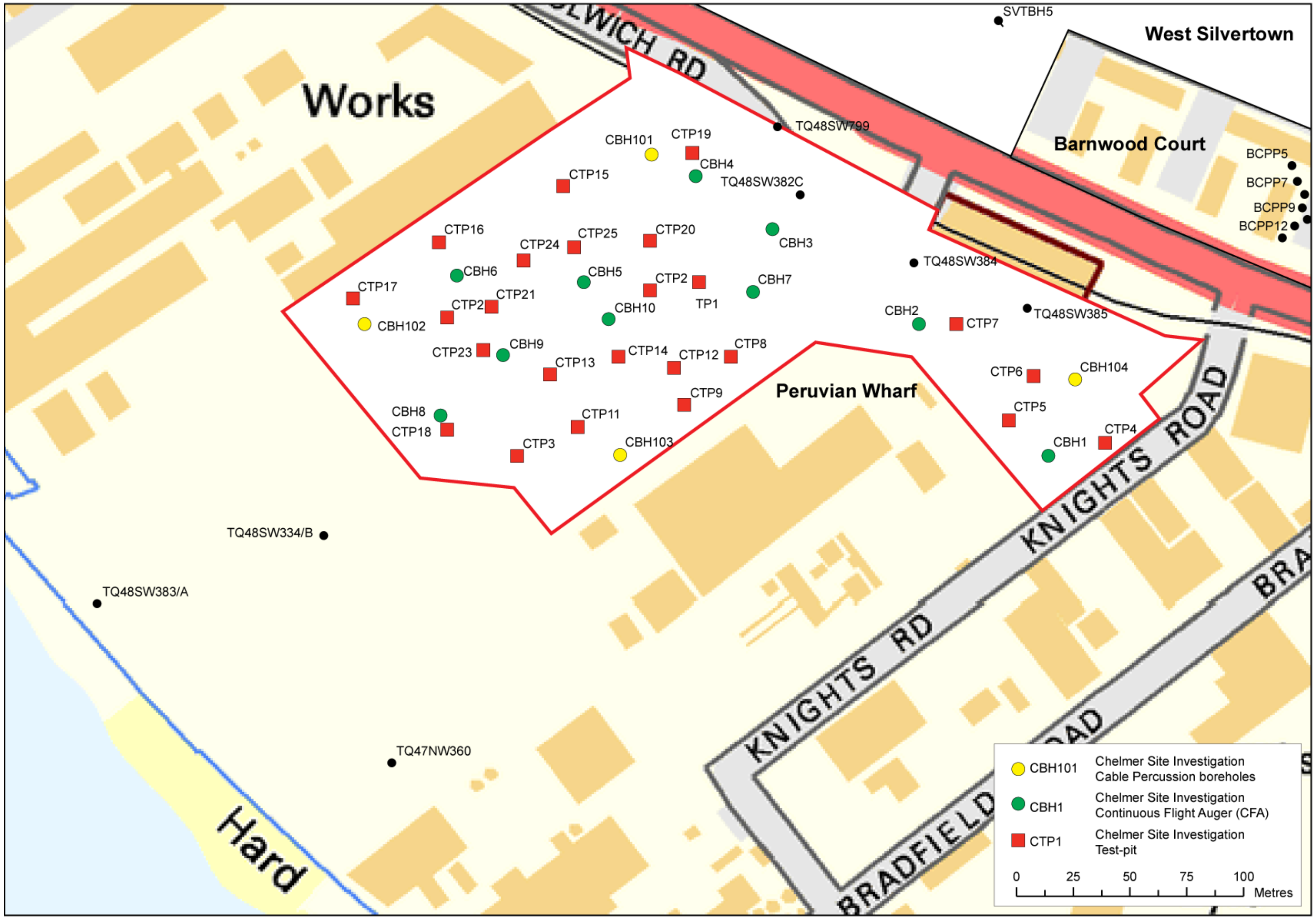

Figure 3: Detailed plan of Peruvian Wharf, London Borough of Newham, illustrating the location of recent geotechnical works on the site carried out by Chelmer Site Investigations. *Contains Ordnance Survey data © Crown copyright and database right [2016]*

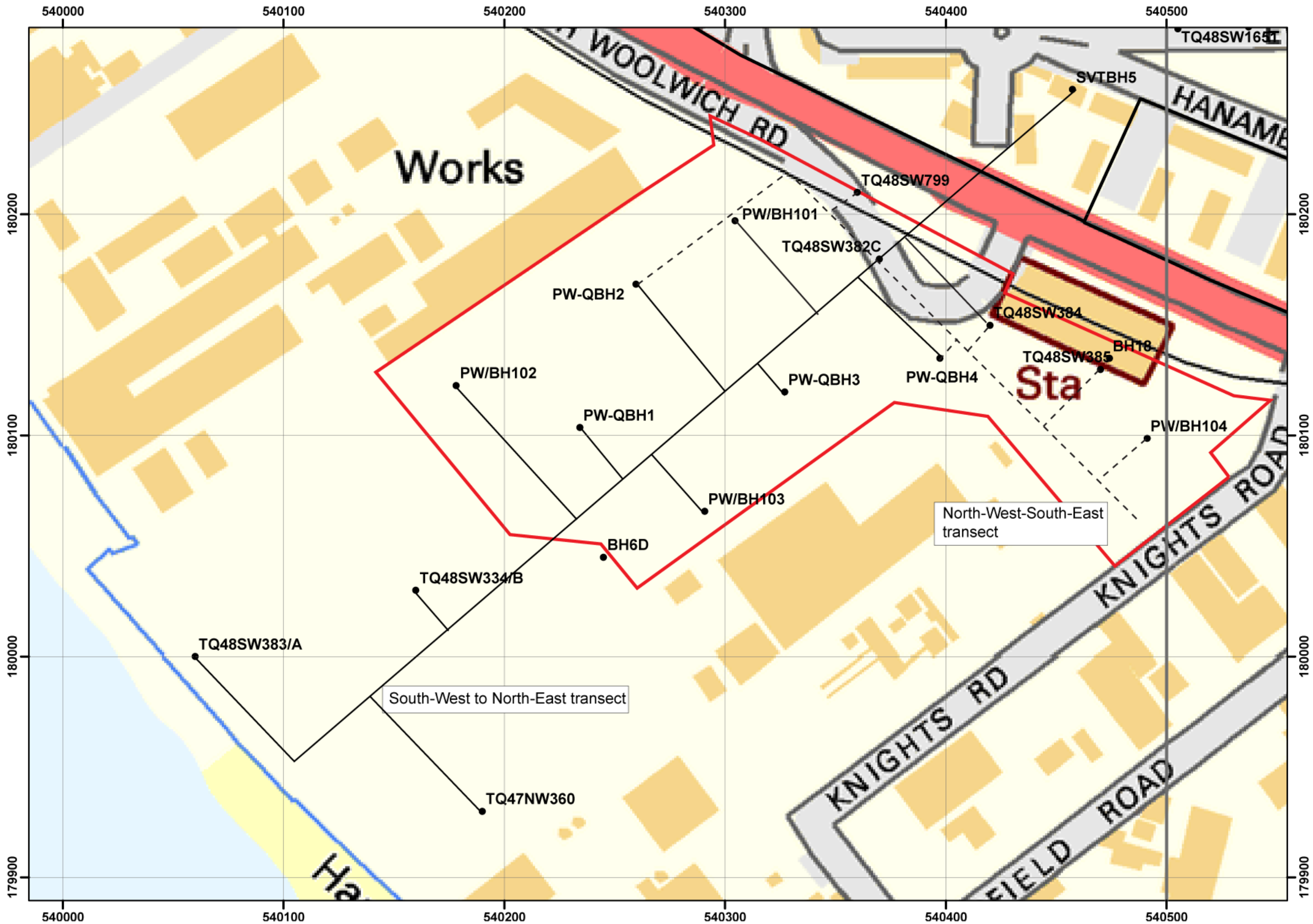

Figure 4: Detailed plan of Peruvian Wharf, London Borough of Newham, illustrating the location of the new geoarchaeological boreholes and those used in the deposit modelling exercise. Also illustrating the location of borehole transects. ***Contains Ordnance Survey data © Crown copyright and database right [2016]***

Table 1: Select summary of the Waterman Environmental (2000) geotechnical records

Borehole / Test-Pit	Easting	Northing	Approximate Elevation (m OD)	Depth (m bgl)				
				Top of Alluvium	Top of Peat	Top of Lower Alluvium	Top of Gravel	Top of London Clay
BH1	540176	179900	1-2	4.2	6.9		9.3	
BH2	540092	180001	1-2	2.5	4.4		7.5	
BH3	540072	180068	1-2	2.4	3.7	4.9	5.6	12.6
BH4	540169	179922	1-2	1.1	5.7		9.2	12.3
BH5	540124	180057	1-2	2.3			5.8	
BH6	540245	180045	1-2	1.5	2.8		5.1	
BH7	540200	180040	1-2	1.4			5.3	
BH8	540162	180137	1-2	1.8	2.8		4.8	
BH9	540185	180085	1-2	0.5	3		4.8	
BH10	540278	179976	1-2	1.45			5.6	
BH11	540194	180003	1-2				6	11.9
BH12	540238	180114	1-2	2.2	2.45		6	
BH13	540245	180157	1-2	2	3.6		4.9	12.1
BH14	540312	180094	1-2	1.1			4	
BH15	540331	180155	1-2	2	2.8		5.8	
BH16	540292	180207	1-2	1.3	2.95		5.1	12.1
BH17	540420	180131	1-2	1			6.1	12.2
BH18	540474	180135	1-2	1.1	4		5.2	
BH19	540484	180078	1-2	1.3	2.4		3.8	10.9
TP1	540053	180034	1-2	4.1			4.7	
TP26	540189	180156	1-2	1.1	4.3		4.4	
TP27	540247	180078	1-2	1.8	4.1		4.7	
TP30	540254	180114	1-2	1.9			3.8	

N.B. Table excludes records that do not reach the Shepperton Gravel surface

Table 2: Summary of the Chelmer Site Investigation geotechnical records

Borehole / Test-Pit name	Easting	Northing	Height	Top of Upper Alluvium (m bgl)	Top of Peat (m bgl)	Top of Gravel (m bgl)	Notes
CBH101 / PWBH101	540304.5	180197.3	1.82	1.4		4.5	Alluvium described as organic in places
CBH102 / PWBH102	540178.3	180122.7	1.80			5	Made Ground onto Gravel; concrete slab at interface
CBH103 / PWBH103	540290.8	180066	1.8	3		4.5	
CBH104 / PWBH104	540491	180099	1.8	2		5	Alluvium contains bands of Peat
CBH1	540479.4	180065.8	1.51	3		4.8	Alluvium contains bands of Peat

CBH2	540421.9	180123.2	2.12	0.9		2.5	
CBH3	540357.9	180164.3	2.23	2		3.6	Alluvium contains bands of Peat
CBH4	540323.7	180188.2	2.14	2		4.8	
CBH5	540274.4	180140.8	1.99				No data
CBH6	540218.4	180144.2	1.99				No data
CBH7	540349.2	180137.4	2.02	1.3		3.8	Alluvium contains bands of Peat
CBH8	540211.8	180082.4	2.02	2.3		3.6	
CBH9	540238.9	180109.6	2.12				No data
CBH10	540286	180124.9	2.09				No data
CTP1	540325.7	180142	1.96				
CTP2	540304.1	180138	1.91	1.9			
CTP3	540245.5	180065.2	1.98				
CTP4	540504.2	180070.9	1.34	0.7			
CTP5	540461.9	180081.4	2.06	0.6			
CTP6	540472.9	180099.6	1.9	1.1			
CTP7	540439.1	180122.9	1.83	0.7			
CTP8	540338.8	180109.1	1.76				
CTP9	540319.3	180087.5	1.88	1.6			Vertical timber beams penetrating deeper into the alluvium here
CTP11	540271.9	180078.1	1.84	1.35			
CTP12	540314.4	180104.2	1.75	1.2			20cm peat horizon between MG & Alluvium
CTP13	540259.8	180100.9	1.72	1.5			20cm peat horizon between MG & Alluvium
CTP14	540289.4	180108.4	1.95	1.1			
CTP15	540266.1	180183.7	1.79	0.3			90cm peat horizon between MG and Alluvium
CTP16	540210.9	180159.5	1.63	0.6			
CTP17	540172.9	180134.2	1.64				
CTP18	540214.3	180076.9	2.06	1.2			
CTP19	540322.2	180198.5	2.01	1.1			20cm peat horizon between MG & Alluvium
CTP20	540304	180159.5	2				No data
CTP21	540233.8	180130.9	1.85				No data
CTP22	540214.1	180126.2	1.89				No data
CTP23	540230.2	180112.1	2				No data
CTP24	540247.8	180151.5	2				No data
CTP25	540270	180157.8	2.1				No data

3. METHODS

3.1 Field investigations

Four geoarchaeological boreholes (boreholes PW-QBH1 to PW-QBH3) were put down at the site in October 2016 (Figure 4) by Quaternary Scientific. The borehole core samples were recovered using an Eijkelkamp window sampler and gouge set using an Atlas Copco TT 2-stroke percussion engine. This coring technique is a suitable method for the recovery of continuous, undisturbed core samples and provides sub-samples suitable for not only sedimentary and microfossil assessment and analysis, but also macrofossil analysis. The borehole locations were obtained using a Leica Differential GPS.

Borehole / Test-Pit name	Easting	Northing	Height
PW-QBH1	540234.2	180103.7	2.07
PW-QBH2	540259.6	180168.5	2.05
PW-QBH3	540327.0	180119.8	1.81
PW-QBH4	540397.3	180135.0	2.00

3.2 Lithostratigraphic description

The lithostratigraphy of the core samples was described in the field and laboratory using standard procedures for recording unconsolidated sediment and organic sediments, noting the physical properties (colour), composition (gravel, sand, clay, silt and organic matter) and inclusions (e.g. artefacts) (Tröels-Smith, 1955). The procedure involved: (1) cleaning the sample using a scalpel; (2) recording the physical properties, most notably colour using a Munsell Soil Colour Chart; (3) recording the composition; gravel (Grana glareosa; Gg), fine sand (Grana arenosa; Ga), silt (Argilla granosa; Ag) and clay (Argilla steatoides); (4) recording the degree of peat humification and (5) recording the unit boundaries e.g. sharp or diffuse. The results of the geoarchaeological descriptions of the monitored boreholes are displayed in Tables 3 to 6.

3.3 Deposit modelling

The updated deposit model combined the four new geoarchaeological boreholes, with borehole records and test-pits put down by Waterman Environmental and Chelmer Site Investigation during previous investigations. This provided over 30 complete Holocene stratigraphic records for the site and its immediate surroundings, in addition to approximately 70 test-pit records. Of these, it was only possible to confidently use 20 sequences for the purposes of modelling. This is due to: (1) incomplete spatial data in the 2000 Waterman Environmental records (the boreholes were put down prior to demolition and there is no record of the elevation at the time, a variable that is vital for deposit modelling), and (2) the Chelmer Site Investigations CFA boreholes are insufficiently reliable at recording both the nature of, and boundaries between each stratigraphic unit; they are also inconsistent with other records from the site.

Sedimentary units from the boreholes were classified into five groupings: (1) Shepperton Gravel; (2) Lower Alluvium; (3) Peat; (4) Upper Alluvium and (5) Made Ground. The classified data for groups 1-7 were then input into a database with the RockWorks geological utilities software. Borehole transects are displayed in Figure 5. Models of surface height were generated for the Gravel (Figure

6), Peat (Figure 7) and the Upper Alluvium (Figure 9). Thickness of the Peat (Figure 8), Upper Alluvium (Figure 9) and combined Holocene alluvial sequence (Figure 11) were also modelled (also using a nearest neighbour routine). The Gravel surface was also modelled across a wider area (Figure 12).

Because of the 'smoothing' effect of the modelling procedure, the modelled levels of stratigraphic contacts may differ slightly from the levels recorded in borehole logs and section drawings. As a consequence of this the modelling procedure has been manually adjusted so that only those areas for which sufficient stratigraphic data is present will be modelled. In order to achieve this, a maximum distance cut-off filter equivalent to a 50m radius around each record is applied to all deposit models, Finally, it is important to recognise that multiple sets of boreholes are represented, put down at different times and recorded using different descriptive terms and subject to differing technical constraints in terms of recorded detail including the exact levels of the stratigraphic boundaries.

3.3 Radiocarbon dating

Four subsamples of unidentified twig wood (<2-3 years old) or *Alnus glutinosa* (alder) catkin were extracted from the base of the peat in borehole PW-QBH2 for radiocarbon dating. The samples were submitted for AMS radiocarbon dating to the BETA Analytic Radiocarbon Dating Facility, Miami, Florida. The results have been calibrated using OxCal v4.2 (Bronk Ramsey, 1995; 2001 and 2007) and the IntCal13 atmospheric curve (Reimer *et al.*, 2013). The results are displayed in Figure 13 and in Table 7.

4. RESULTS, INTERPRETATION AND DISCUSSION OF THE DEPOSIT MODELLING

The geoarchaeological descriptions of the four new geoarchaeological boreholes are displayed in Tables 3 to 6; the results of the radiocarbon dating are displayed in Table 7. The results of the deposit modelling are displayed in Figures 5 to 12. Figure 5(a) and (b) are two dimensional transects across the site; Figures 6 to 12 represent surface elevation and thickness models for each of the main stratigraphic units across the site and immediate surrounding area. Figure 12 is a surface elevation model for the Shepperton Gravel across the wider area. Figure 13 is a west-east transect of radiocarbon dated palaeoenvironmental sequences across various surrounding sites.

A sufficient number of reliable boreholes/test-pits with spatial co-ordinates have now been put down to permit modelling with a high level of confidence across the entire site. The full sequence of sediments recorded in the boreholes comprises:

Made Ground
Upper Alluvium – widely present
Peat – present across the site and wider area
Lower Alluvium – largely absent across the site; locally present and occasionally peaty across the wider area
Gravel (Shepperton Gravel)

The Shepperton Gravel

The Shepperton Gravel was present beneath the Holocene alluvial sediments in all the boreholes that penetrated to the bottom of the Holocene sequence. It comprises the deposits of a high-energy braided river system which, while it was active would have been characterised by longitudinal gravel bars (eyots) and intervening low-water channels in which finer-grained sediments might have been deposited. Such a relief pattern would have been present on the valley floor at the beginning of the Holocene when a lower-energy fluvial regime was being established.

The results of the deposit modelling of the Shepperton Gravel indicate the presence of a broad upstanding gravel surface mainly between -2.5 and -3.5m OD, with a lower gravel surface in the region of PW-QBH3 of -4.5m OD. Beyond the southern margin of the site, the Gravel surface appears to reduce in height to at least -5m OD, (possibly more depending upon the surface height of the Waterman Environmental records; Table 1; Figures 5 and 6). However, this boundary is much more prominent on the Royal Wharf site where it is aligned WNW-ESE (Batchelor et al., 2014; Figure 12). Here, the gravel surface falls away steeply towards the modern channel of the River Thames. The downward slope is apparently dissected by a number of depressions with roughly N-S alignments. Some of these depressions are substantially deep; (-8.25m OD and -7.20m OD in some borehole records).

The more elevated gravel surface on the Peruvian Wharf site and beyond has a gently undulating relief which probably indicates the presence of low gravel bars and intervening channels, but in general the relief amplitude is only 1.0-2.0m. On the Peruvian Wharf site, the gravel surface is not recorded above -2.50m OD within the boreholes selected for modelling. This confirms that the gravel surface on the Peruvian Wharf site is lower than the -1.5m OD height recorded at Fort Street, where a potential Neolithic trackway was recorded in the overlying sediments (Wessex Archaeology, 2000; Crockett *et al.*, 2003).

The Holocene Alluvial Sequence

The sediments overlying the Shepperton Gravel surface in stratigraphic order consist of the Lower Alluvium, Peat (Figures 7 & 8) and Upper Alluvium (Figure 9). The Lower Alluvium is defined here as a generally silty or sandy (sometimes organic) deposit that accumulated during the Early to Middle Holocene (Mesolithic cultural period) within a fluvial or estuarine environment. In many cases across the Lower Thames Valley it is separated from the widespread, more clayey and inorganic Middle to Late Holocene Upper Alluvium by a thick horizon of Peat representative of a shift towards semi-terrestrial environment supporting the growth of fen woodland. Across the Peruvian Wharf site and wider modelled area, the Peat is not always present, generally preventing definitive distinction between the Lower Alluvium and Upper Alluvium.

The Lower Alluvium is almost entirely absent across the Peruvian Wharf site, and is recorded inconsistently across the wider area. Instead, where present, Peat tends to rest directly on the surface of the Shepperton Gravel. The new geoarchaeological boreholes and results of the modelling (Tables 1-4; Figures 6 & 7), indicate the peat deposits range between 1.75 and 3m thick across the site, with a relatively level surface between -0.5 and -1.0m OD. These findings confirm that the Waterman Environmental records provide a more accurate reflection of the Holocene Alluvial and Peat deposits than the Chelmer Site Investigations. This in part is undoubtedly due to truncation of the sequences by previous development / demolition (e.g. PWBH102), but generally reflects the drilling and description methodology.

However, the inconsistent presence of peat is a common feature on the neighbouring Royal Wharf site. Here, on the southern part of the site, the Peat is almost completely absent and the limited sequences in which it does occur tend to overlie the more elevated parts of the gravel surface (i.e. the areas intervening between the N-S depressions that dissect the gravel surface in this area of the site; see above). Thicker occurrences of Peat are recorded on the higher gravel surface on the northern part of the site and beyond, though even in these areas Peat development was found to be irregular. Where present, the Peat generally varies between 1 and 3m thick, although thicker horizons up to 4m are occasionally recorded (Batchelor *et al.*, 2014).

The results of the radiocarbon dating suggest that peat formation commenced on the Peruvian Wharf site shortly before 5890-5640 cal BP (early Neolithic) and continued until 3160-2960 cal BP (late Bronze Age). Peat formation was not continuous however; a period of wetter conditions is indicated by a unit of mineral-rich alluvium in three of the four boreholes between ca. 4810-4440 to 4070-3870 cal BP (late Neolithic to early Bronze Age). The sequence from PW-QBH3 was somewhat different. In addition to containing the lowest Gravel surface, only a lower unit of peat was recorded; the rest of the sequence contained mineral-rich alluvium with sand and frequent Mollusca remains. The presence of this unit might suggest the position of a minor channel either during the latter stages of peat formation, or subsequently truncating it. Figure 13 displays a west-east transect of palaeoenvironmental sequences across the nearby area. This figure suggests that there is little relationship between the elevation, thickness and age of the Holocene sedimentary sequence as might be expected. For example the sequence from the neighbouring Silvertown BH8 sequence is of approximately the same overall thickness and height, but spans a much longer period of time – 12,380-11,770 to 2680-2350 cal BP (late Glacial to Iron Age). The Cable Car sequence spans a similar period, but the sequence is much thicker and at a lower elevation. These results therefore demonstrate considerable variety and complexity of the Holocene alluvial sequence in this area of the Lower Thames Valley; a finding of particular interest.

Where present, the Peat surface is overlain by silty and clayey deposits of the Upper Alluvium. These deposits vary between 0.3 and 6m thick, with an upper surface resting between 0 and +1m OD when not truncated by Made Ground. In a small number of the Chelmer Site Investigation test-pits, an upper Peat horizon of 20cm (CTP12, CTP13 & CTP19) and 90cm (CTP15) was recorded at the interface between the Upper Alluvium and Made Ground (Table 2). The elevation of this Peat is unusually high however (between 1 & 2m OD), when compared to the likely natural level of the Thames floodplain prior to artificial raising (0 to 1m OD). Thus it is uncertain whether or not this represents a natural or redeposited Peat horizon. No evidence of such a horizon was recorded during the geoarchaeological investigations, though similar findings were made on the south-east of the Royal Wharf site, where thin Peat horizons were recorded above 2m OD (Batchelor *et al.*, 2014).

Holocene landscape evolution

The pattern of alluvial deposits indicates the presence of two contrasting landscapes across the wider modelled area, throughout much of the Holocene. Beyond the southern margins of the site (particularly evident at Royal Wharf), it seems likely that deposition of mineral-rich alluvium reflects the presence of active river channels, probably the main channel of the River Thames and short N-S aligned steams draining off the slightly more elevated area to the north. Peat formation here was restricted to the more elevated remnants of the gravel surface between the depressions in which fluvial deposition persisted for much of the Holocene.

To the north (and where Peruvian Wharf is located) there are no obvious deep depressions that might have been the site of Peat formation early in the Holocene. Moreover the pattern of Peat accumulation shows very little relationship to the relief of the surface of the Shepperton Gravel on which the Peat rests as is suggested by modelling exercises elsewhere along the River Thames (see below). This might reflect post-formational erosion of the Peat, or it may reflect a pattern of formation controlled by subtle variations of relief and hydrological conditions which are not recognisable at the level of resolution possible in the modelling exercise.

Table 3: Lithostratigraphic description of borehole PW-QBH1, Peruvian Wharf, North Woolwich Road, Silvertown, London Borough of Newham

Depth (m OD)	Depth (m bgl)	Description
2.07 to 0.77	0 to 0.1.30	Made Ground; timber planks and steaks at base of unit. Sharp contact into:
0.77 to -0.63	1.30 to 2.70	10YR 5/1; As3, Ag1; Grey silty clay with chalk fragments towards the top; sharp contact into:
-0.63 to -0.78	2.70 to 2.85	10YR 4/3; Sh2, As2, Tl+; Humo 3; Brown well-humified peat and clay with wood remains; sharp contact into:
-0.78 to -1.47	2.85 to 3.54	10YR 4/1; As3, Sh1, Tl+; Dark grey clay with unidentifiable peat and traces of wood; sharp contact into:
-1.47 to -1.79	3.54 to 3.86	10YR 3/3; $Tl^2$3, Sh1, As1; Humo 3; Dark brown well humified wood and unidentifiable peat with clay; sharp contact into:
-1.79 to -2.18	3.86 to 4.25	10YR 4/1; As3, Sh1, Tl+; Dark grey clay with unidentifiable peat and traces of wood; sharp contact into:
-2.18 to -2.83	4.25 to 4.90	10YR 4/2; As2, Sh1, $Tl^3$1; Dark greyish brown clay with well-humified wood and unidentifiable peat; sharp contact into:
-2.83 to -4. 63	4.90 to 6.70	10YR 4/1; Ga3, Gg1; Dark grey sandy gravel. Gravel is sub-rounded to sub-angular.

Table 4: Lithostratigraphic description of borehole PW-QBH2, Peruvian Wharf, North Woolwich Road, Silvertown, London Borough of Newham

Depth (m OD)	Depth (m bgl)	Description
2.05 to 0.55	0 to 1.50	Made Ground
0.55 to -0.80	1.50 to 2.85	Gley 2 6/5B; As3, Ag1; Greyish blue silty clay with occasional rootlets; diffuse contact into:
-0.80 to -1.52	2.85 to 3.57	2.5YR 4/3; Sh2, Ag2, Tl+, Th+; Humo 3; Reddish brown well-humified peat and silt with traces of wood and herbaceous remains; diffuse contact into:
-1.52 to -1.95	3.57 to 4.00	Gley 2 4/5B; Ag2, As1, Dl1; Dark grey clayey silt with detrital wood; unknown contact into:
-1.95 to -2.55	4.00 to 4.60	2.5YR 3/3; Sh2, Ag1, $Tl^2$1 Gg+; Humo 2/3; Dark reddish brown moderately humified unidentifiable and wood peat with silt and traces of gravel; sharp contact into:
-2.55 to -2.95	4.60 to 5.00	10YR 4/1; Gg3, Ga1; Dark grey sandy gravel. Gravel is sub-rounded to sub-angular.

Table 5: Lithostratigraphic description of borehole PW-QBH3, Peruvian Wharf, North Woolwich Road, Silvertown, London Borough of Newham

Depth (m OD)	Depth (m bgl)	Description
1.81 to 0.41	0 to 1.40	Made Ground
0.41 to -0.59	1.40 to 2.40	Gley 2 6/5B; As3, Ag1; Greyish blue silty clay; diffuse contact into:
-0.59 to -1.69	2.40 to 3.50	Gley 2 6/5B; As3, Ag1, Gg+; Greyish blue silty clay with traces of gravel; sharp contact into:
-1.69 to -2.09	3.50 to 3.90	10YR 4/1; Ag2, Ga1, Dl1, As+; Dark grey sandy silt with detrital wood; frequent Mollusca fragments between 3.40 and 3.50m; Sharp contact into:
-2.09 to -3.29	3.90 to 5.10	Gley 2 4/5B; Ag2, As1, Dl1; Dark grey clayey silt with detrital wood; diffuse contact into:
-3.29 to -4.29	5.10 to 6.10	2.5YR 3/3; Sh2, Ag1, $Tl^2$1 Gg+; Humo 2/3; Dark reddish brown moderately humified unidentifiable and wood peat with silt and traces of gravel; sharp contact into:
-4.29 to -4.59	6.10 to 6.40	10YR 4/1; Gg2, Ga1, Ag1; Dark grey silty sandy gravel. Gravel is sub-rounded to sub-angular.

Table 6: Lithostratigraphic description of borehole PW-QBH4, Peruvian Wharf, North Woolwich Road, Silvertown, London Borough of Newham

Depth (m OD)	Depth (m bgl)	Description
2.00 to 0.70	0 to 1.30	Made Ground
0.70 to -0.30	1.30 to 2.30	Gley 2 6/5B; As3, Ag1; Greyish blue silty clay; diffuse contact into:
-0.30 to -0.50	2.30 to 2.50	Gley 2 6/5B; As3, Ag1, Sh+, Dh+; Greyish blue silty clay with traces of organic and detrital plant remains; diffuse contact into:
-0.50 to -1.30	2.50 to 3.30	2.5YR 3/3; Sh2, Ag1, $Tl^2$1; Humo 2; Dark reddish brown moderately humified unidentifiable and wood peat with silt; diffuse contact into:
-1.30 to -1.90	3.30 to 3.90	10YR 4/1; Ag3, Dl1, Sh+; Dark grey silt with detrital wood and traces of organic remains; sharp contact into:
-1.90 to 2.30	3.90 to 4.30	2.5YR 3/3; Sh2, Ag1, $Tl^2$1; Humo 2; Dark reddish brown moderately humified unidentifiable and wood peat with silt; diffuse contact into:
-2.30 to -2.80	4.30 to 4.80	2.5YR 3/3; Sh2, Ag1, $Tl^2$1, Th+; Humo 2; Dark reddish brown moderately humified unidentifiable and wood peat with silt and traces of herbaceous peat; diffuse contact into:
-2.8 0 to -3.00	4.80 to 5.00	2.5YR 3/3; Sh2, Ag1, Gg1, Tl+, Th+; Humo 2/3; Dark reddish brown moderately humified unidentifiable peat with silt and traces of herbaceous and wood peat; sharp contact into:
-3.00 to -4.30	5.00 to 6.30	10YR 4/1; Gg3, Ga1; Dark grey sandy gravel. Gravel is sub-rounded to sub-angular.

Table 7: Results of the radiocarbon dating, PW-QBH2, Peruvian Wharf, North Woolwich Road, Silvertown, London Borough of Newham

Laboratory code / Method	Material and location	Depth (m OD)	Uncalibrated radiocarbon years before present (yr BP)	Calibrated age BC/AD (BP) (2-sigma, 95.4% probability)	**δ13C (‰)**
BETA-447517	PW-QBH2; top of peat	-0.80 to -0.84	2920 ± 30	1220-1020 cal BC 3160-2960 cal BP	-26.8
BETA-447518	PW-QBH2; top of inorganic unit within of peat	-1.38 to -1.45	3620 ± 30	2120-1890 cal BC 4070-3840 cal BP	-27.0
BETA-447519	PW-QBH2; base of inorganic unit within of peat	-1.95 to -2.04	4090 ± 30	2860-2490 cal BC 4810-4440 cal BP	-30.1
BETA-447516	PW-QBH2; base of peat	-2.29 to -2.39	4990 ± 30	3940-3690 cal BC 5890-5640 cal BP	-27.3

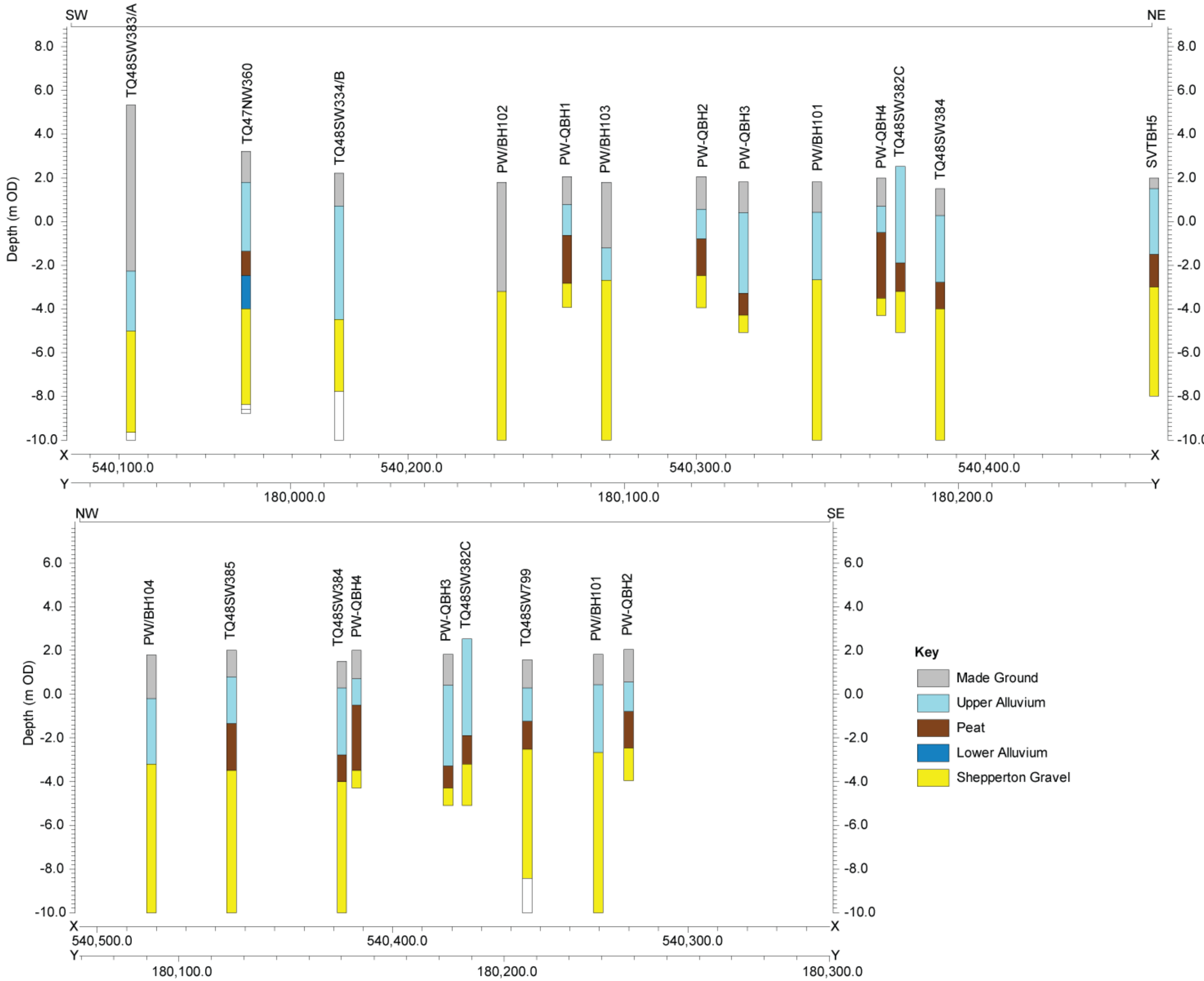

Figure 5: (a) South-West to North-East borehole transect and (b) North-West to South-East borehole transect, Peruvian Wharf, London Borough of Newham

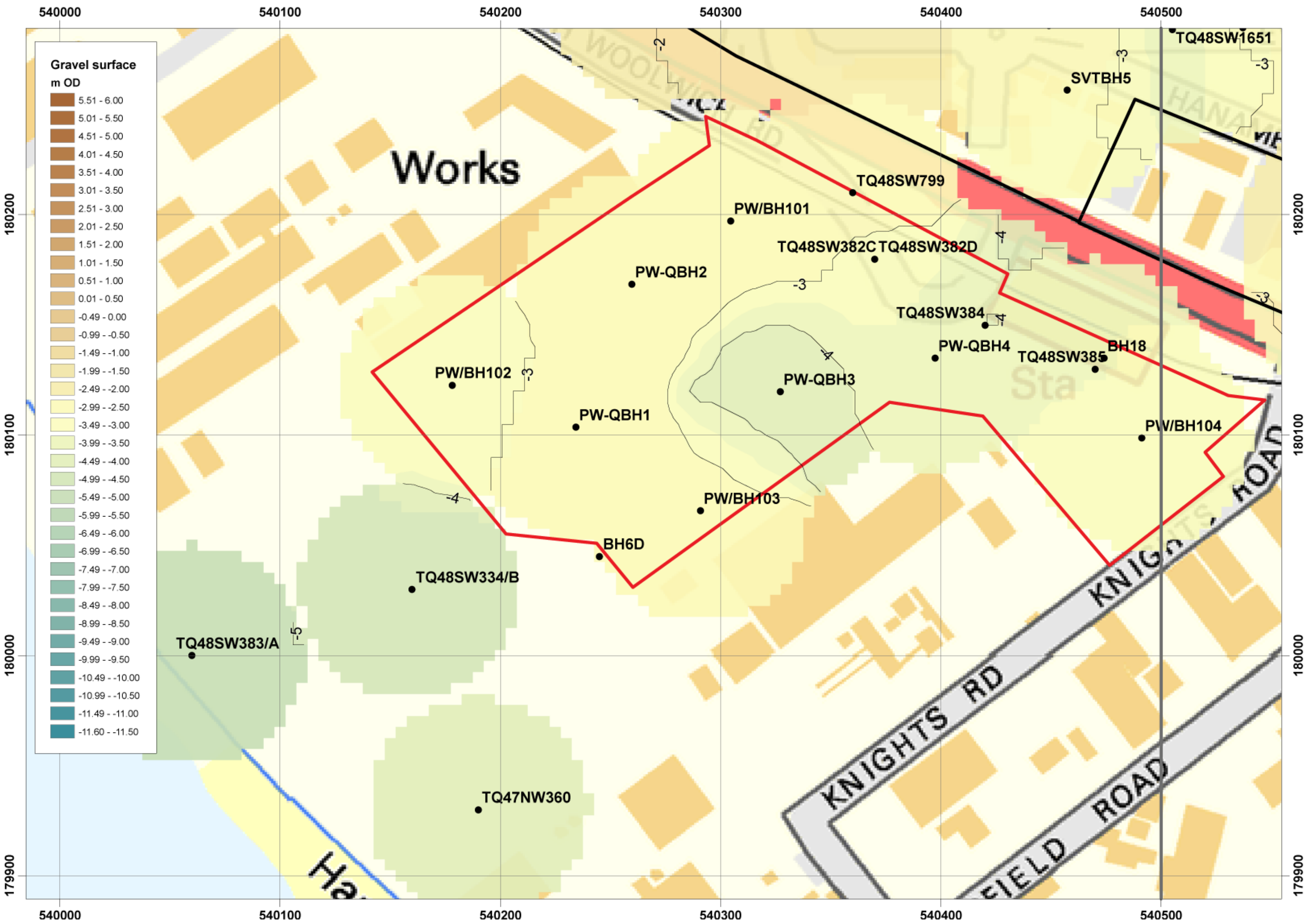

Figure 6: Modelled surface of the Shepperton Gravel (m OD)

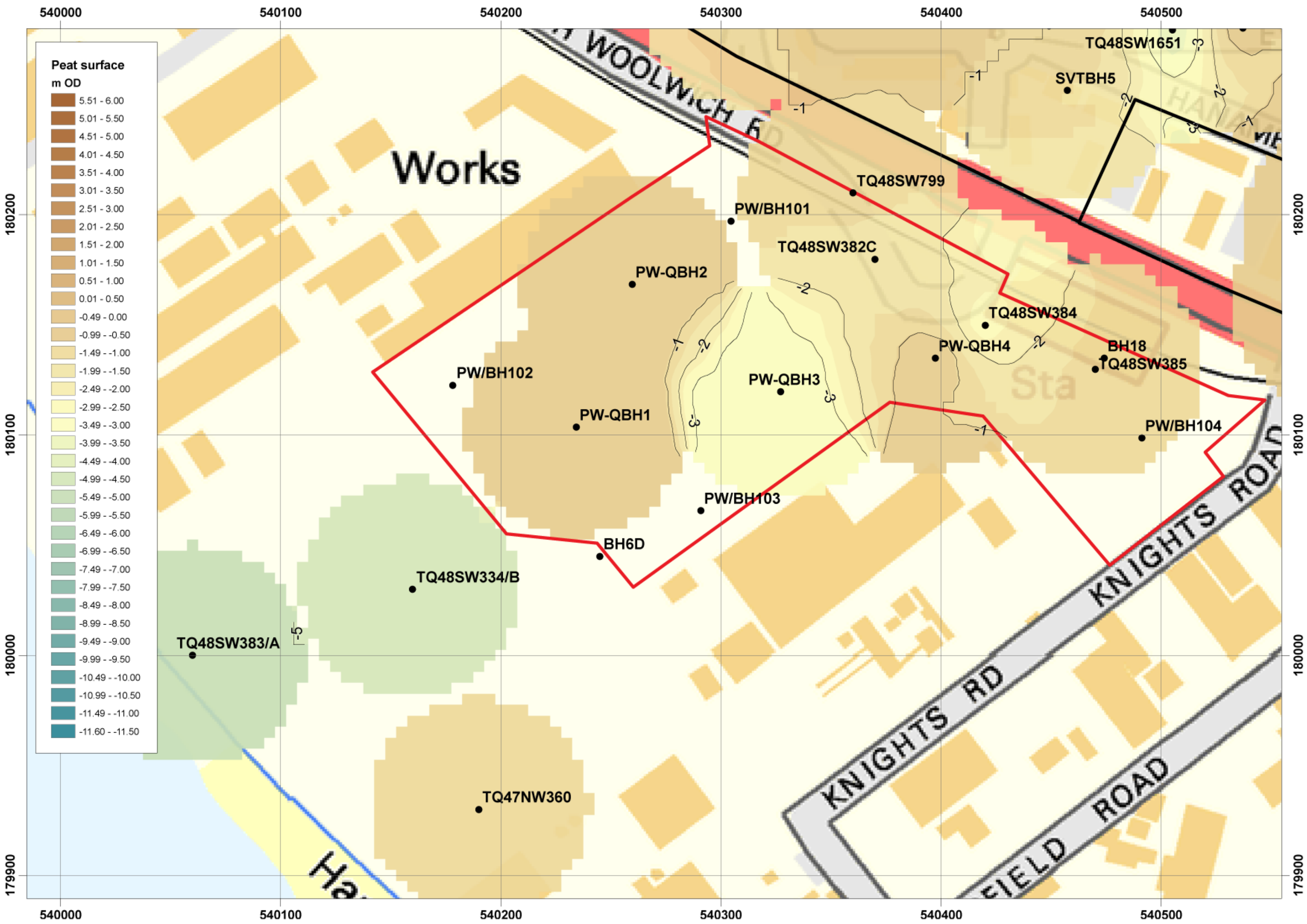

Figure 7: Modelled surface of the Peat (m OD)

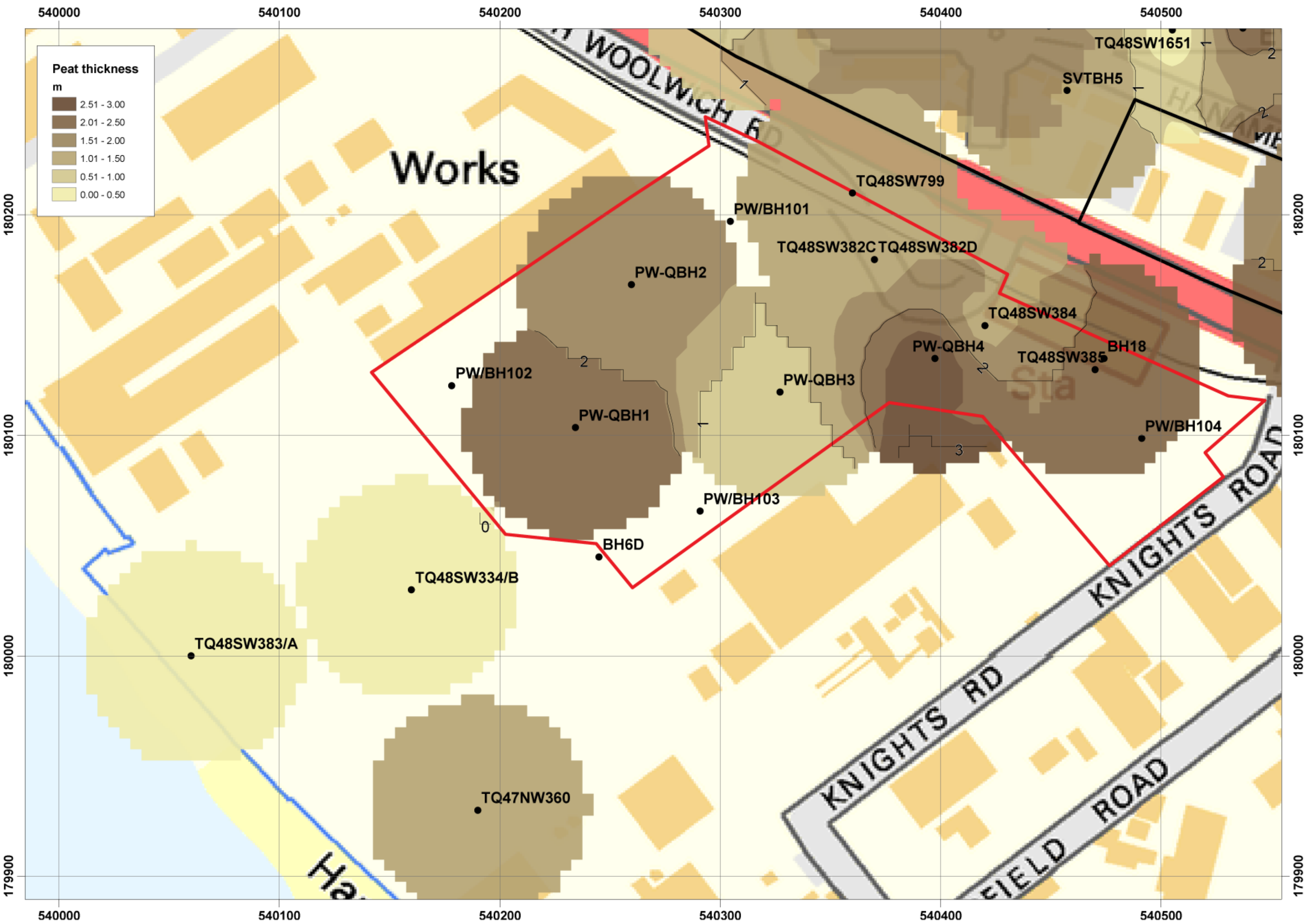

Figure 8: Modelled thickness of the Peat (metres)

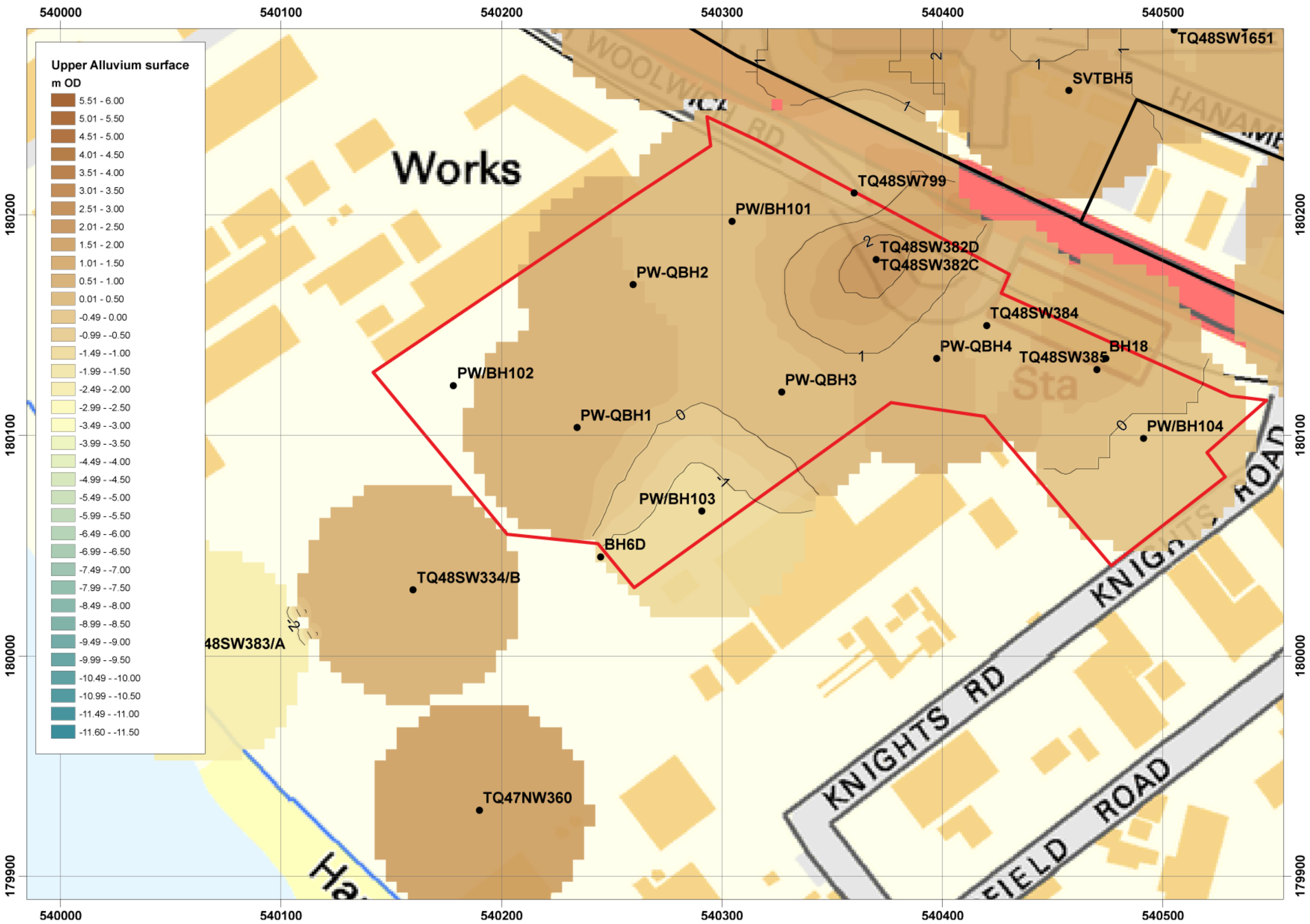

Figure 9: Modelled surface of the Upper Alluvium (metres OD)

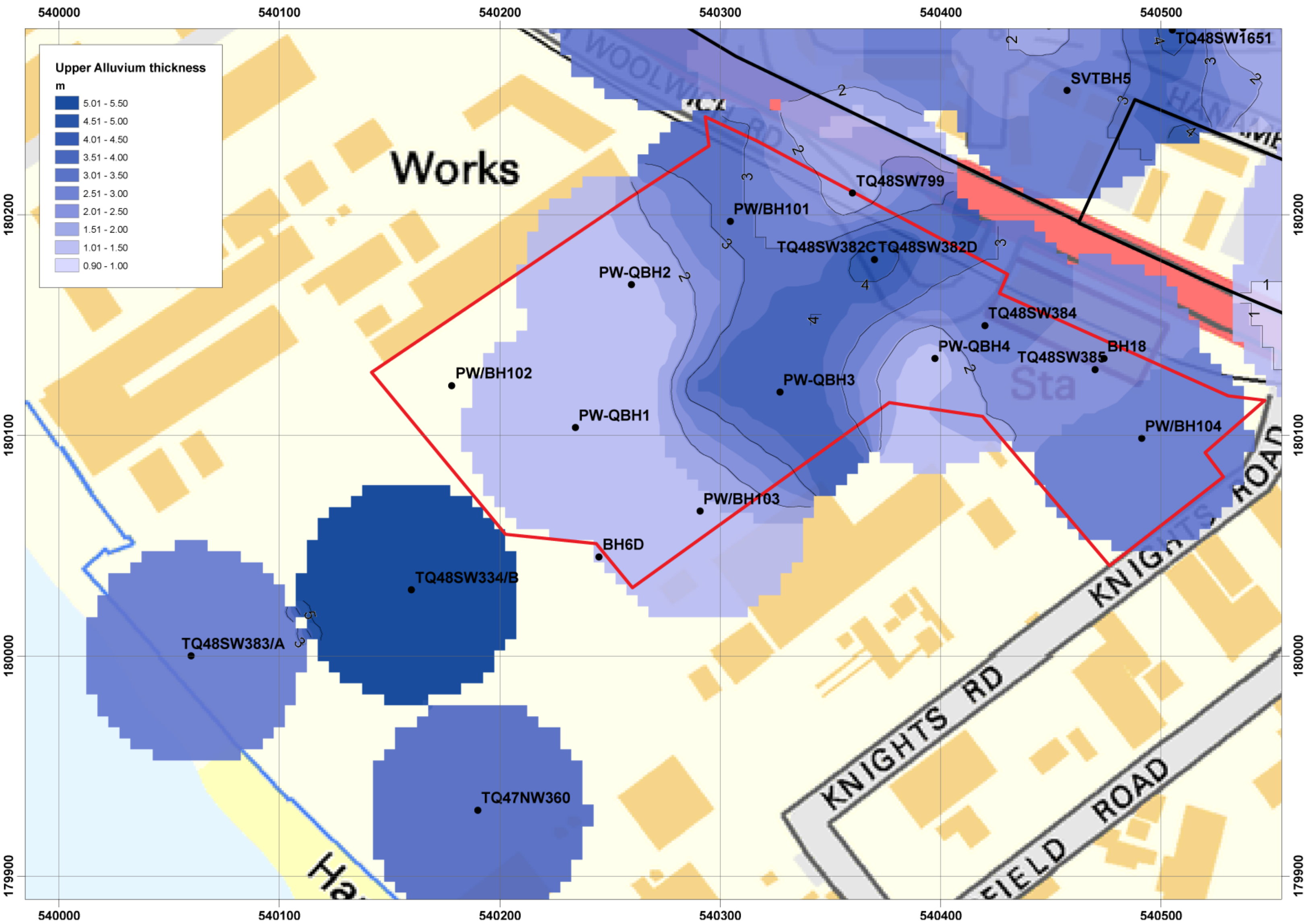

Figure 10: Modelled thickness of the Upper Alluvium (metres)

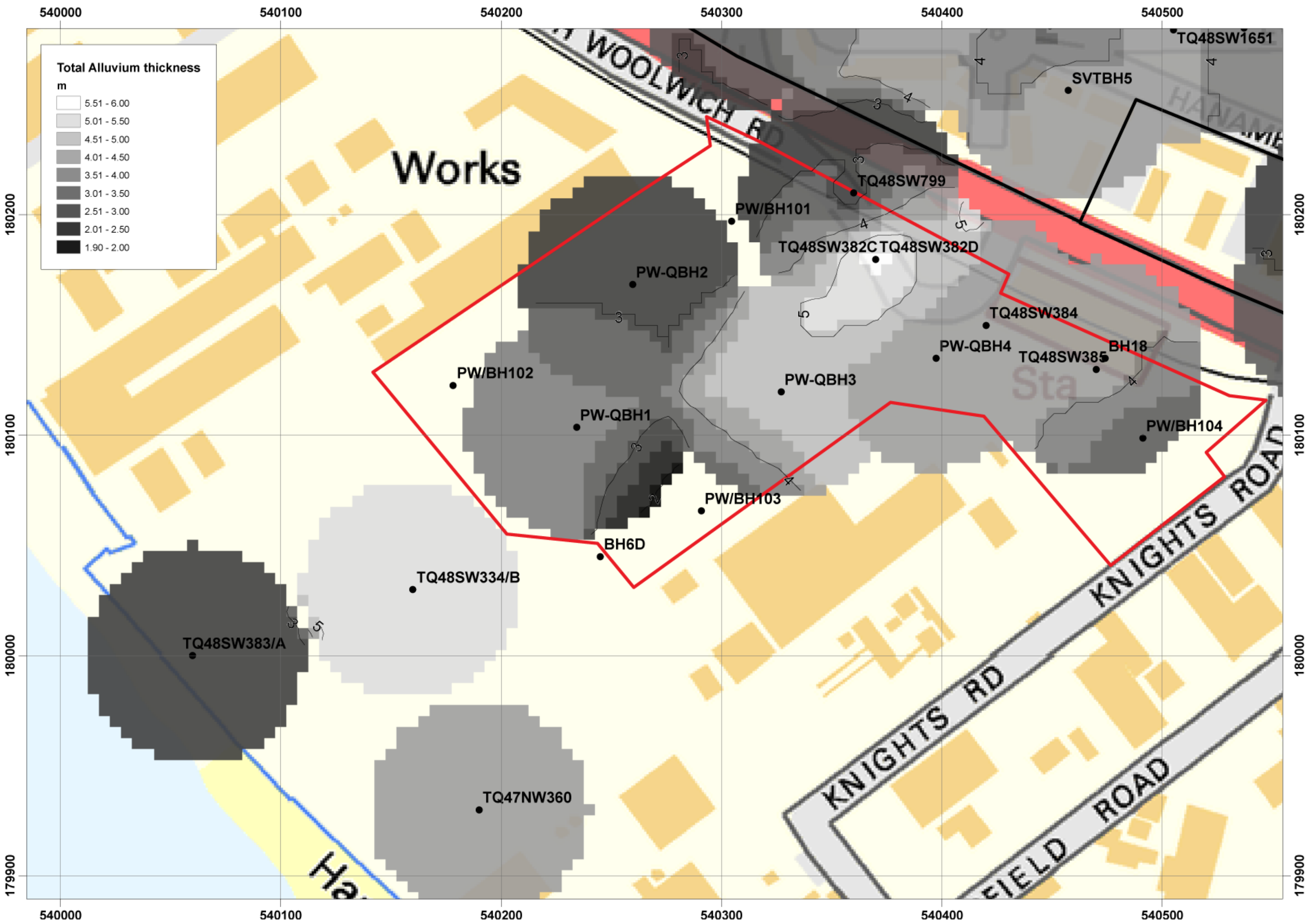

Figure 11: Modelled thickness of the Total Alluvium (metres)

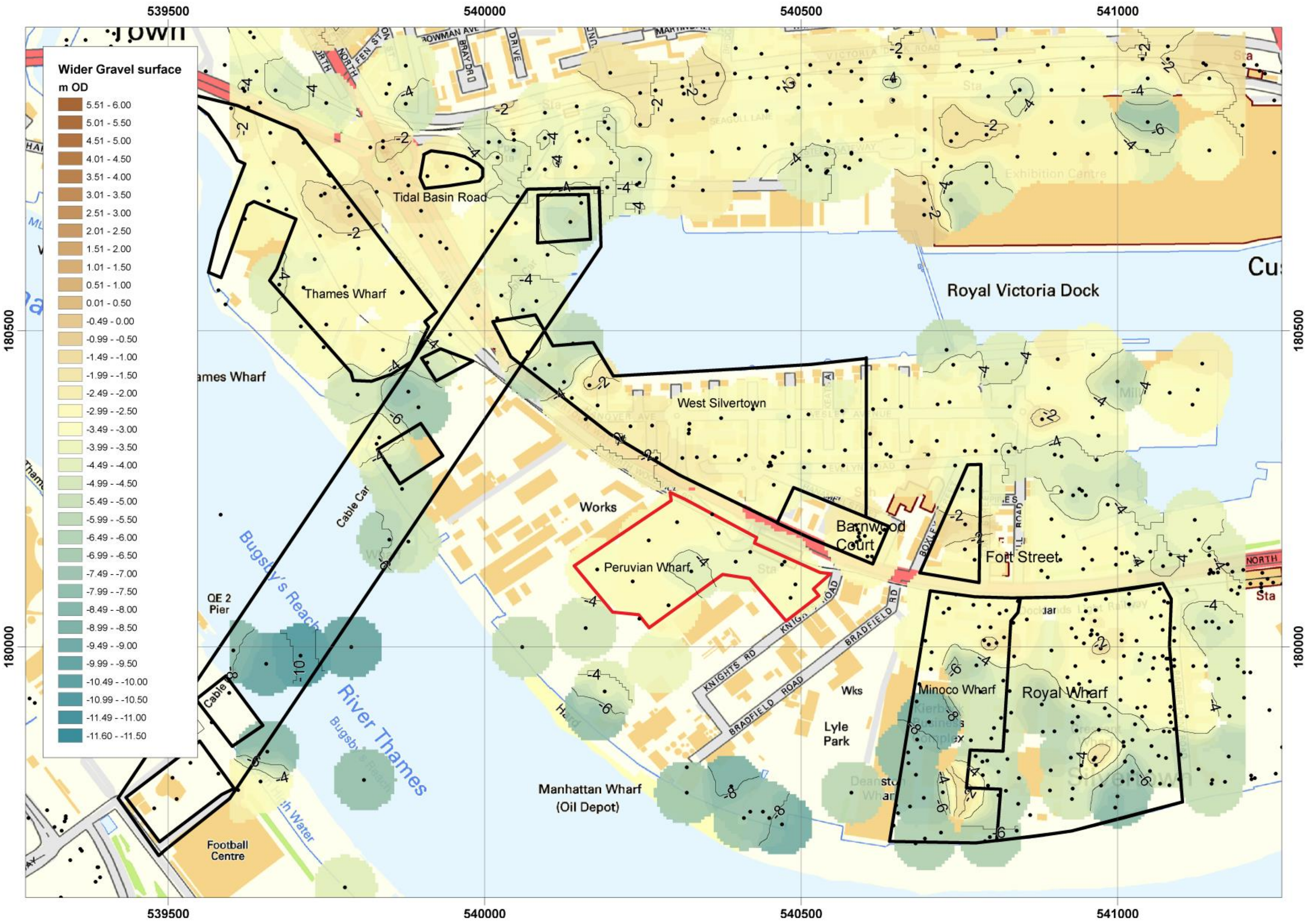

Figure 12: Modelled surface of the Shepperton Gravel (m OD) across the wider area

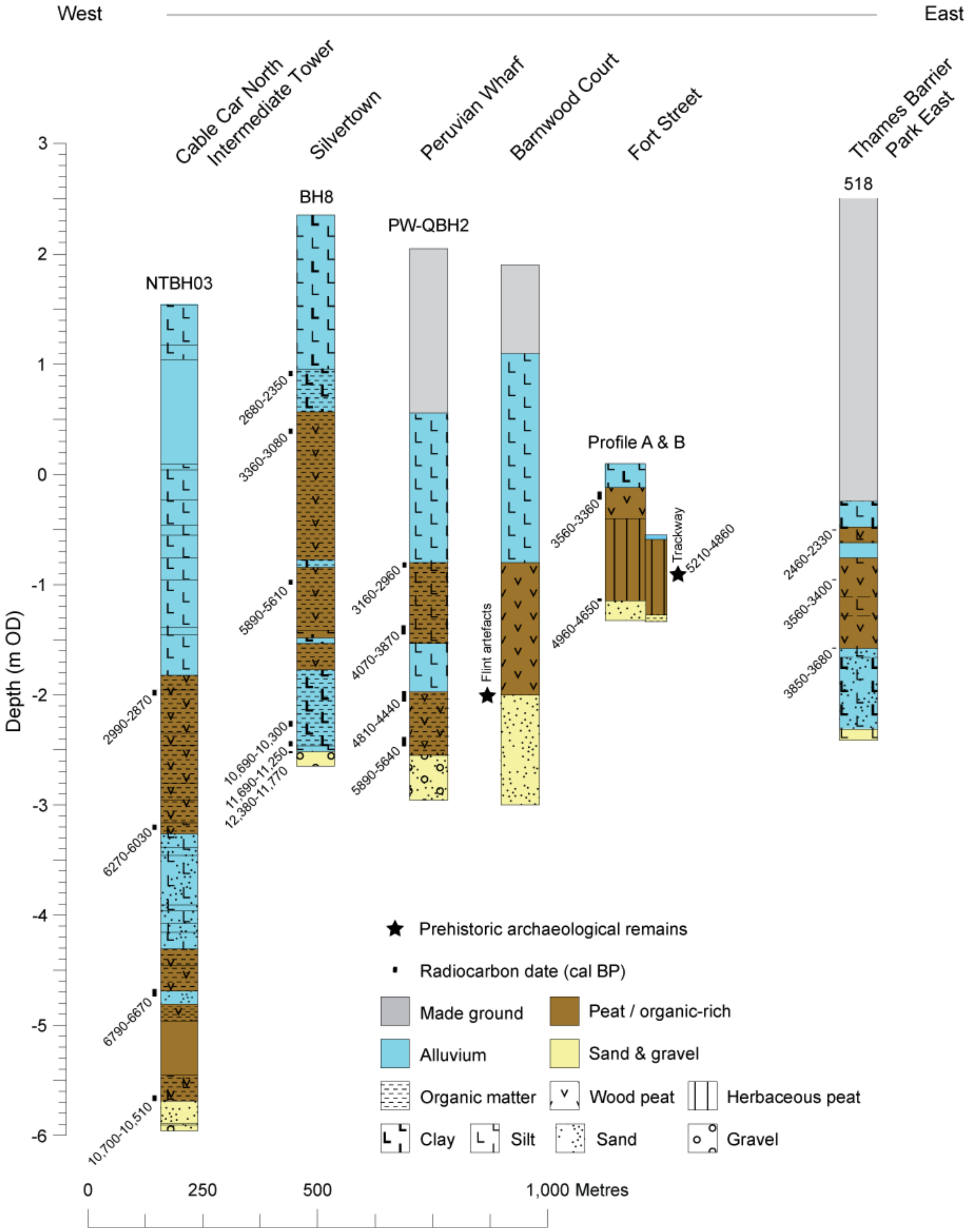

Figure 13: West-east transect of sites locally to Peruvian Wharf with radiocarbon dated palaeoenvironmental sequences (see Figure 1 for locations)

5. CONCLUSIONS & RECOMMENDATIONS

The results of the geoarchaeological boreholes and updated deposit modelling exercise have successfully reconstructed the nature and age of the sedimentary sequence beneath the Peruvian Wharf site. The distribution and age of sediments across the site and surrounding area is quite different to those recorded during recent large-scale modelling exercises carried out on the Greenwich Peninsula (e.g. Batchelor *et al*., 2012) and further along the Lower Thames Valley floodplain (e.g. the Barking Reach [Green *et al*., 2012] and on the Plumstead and Erith Marshes [Quest, in prep]), where thicker Peat horizons tend to be associated with areas of lower rather than higher Shepperton Gravel topography, and age tends to be associated with elevation. There are however, some similarities with the conditions described by Corcoran et al (2011) in the Lower Lee valley where they were able to recognise contrasts between areas affected by persistent Holocene river activity and characterised by mineral-rich sediment sequences, and more stable areas where Peat accumulation had occurred.

The findings from Peruvian Wharf are considered to make a valuable contribution to our knowledge and understanding of the evolution of the floodplain landscape along this stretch of the Lower Thames Valley, against which the archaeological record can considered. The nature and age of the sequences is relatively consistent across the site, but is highly variable across the surrounding area. However, the early Neolithic to late Bronze Age timeframe is recorded at multiple published sites nearby for which detailed palaeoenvironmental records already exist (e.g. Silvertown [340m], Cable Car North Intermediate Tower [400m], Fort Street [500m] and Cable Car South Station [800m]; Figure 1). For this reason, further palaeoenvironmental investigation is not required. However, the results are considered important; it is therefore recommended that they are integrated into an ongoing publication encompassing south-west Newham and Greenwich Peninsula. Such a document will build upon similar recent regional site investigations carried out along the Barking Reach, Plumstead and Erith Marshes and the Lower Lea Valley.

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7. APPENDIX 1: OASIS

OASIS ID: quaterna1-266373

Project details	
Project name	Peruvian Wharf
Short description of the project	A program of geoarchaeological fieldwork and deposit modelling was carried out on the site. The sequence consisted of Shepperton Gravel overlain by peat and alluvium capped by made ground. Radiocarbon dating of one sequence indicated that the peat was deposited between the early Neolithic and late Bronze Age. No further work was recommended due to the number of nearby palaeoenvironmental sequences. However, the results should be integrated into a regional publication.
Project dates	Start: 03-10-2016 End: 24-10-2016
Previous/future work	Yes / No
Any associated project reference codes	PWF16 - Sitecode
Type of project	Environmental assessment
Monument type	PEAT Late Prehistoric
Significant Finds	PEAT Late Prehistoric
Survey techniques	Archaeology
Project location	
Country	England
Site location	GREATER LONDON NEWHAM NEWHAM Peruvian Wharf
Postcode	E16
Study area	300 Square metres
Site coordinates	TQ 40340 80150 51.502334831617 0.022212143994 51 30 08 N 000 01 19 E Point
Project creators	
Name of Organisation	Quaternary Scientific (QUEST)
Project brief originator	Consultant
Project design originator	Dr C.R. Batchelor
Project director/manager	C.R. Batchelor
Project supervisor	C.R. Batchelor
Type of sponsor/funding body	Developer
Project archives	
Physical Archive Exists?	No
Digital Archive Exists?	No
Paper Archive recipient	LAARC
Paper Media available	"Report"

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	PERUVIAN WHARF NORTH WOOLWICH ROAD SILVERTOWN LONDON BOROUGH OF NEWHAM: GEOARCHAEOLOGICAL FIELDWORK AND UPDATED DEPOSIT MODEL
Author(s)/Editor(s)	Batchelor, C.R.
Author(s)/Editor(s)	Green, C.P.
Author(s)/Editor(s)	Young, D.S.
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