SURREY HOUSE, 20 LAVINGTON STREET, LONDON BOROUGH OF SOUTHWARK, SE1 0NZ (SITE CODE: LVI11): ENVIRONMENTAL ARCHAEOLOGICAL ASSESSMENT REPORT

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INTRODUCTION

This report summarises the findings arising out of the environmental archaeological assessment undertaken by Quaternary Scientific (University of Reading) in connection with the proposed development at Surrey House, 20 Lavington Street, London Borough of Southwark, SE1 ONZ (National Grid Reference: TQ 32087 80160; 2.8m OD; site code: LVI11; Figure 1). The site is on the valley floor of the River Thames in its tidal reach on the south side of the river and about 0.4km from the modern waterfront. Previous investigations in this part of Southwark (Batchelor *et al*, 2011a, 2011b, 2011c; Branch *et al*, 2002; Cowan *et al*, 2009; Dicks, 2010; Dunwoodie 2006; Sidell *et al*, 2000; Thompson *et al* 1998) have led to the recognition of a substantial palaeochannel (the Bankside Channel) aligned broadly NE to SW from Bankside towards Waterloo alongside the River Thames, with at least two tributary channels joining it from the south - the Borough Channel and Southwark Street Channel. The British Geological Survey (BGS) (1:50,000 Sheet 256 North London 1994) shows the site underlain by Alluvium overlying London Clay bedrock. Borehole records associated with the previous investigations in and around the Bankside Channel indicate the presence of Holocene sediments infilling the palaeochannel and overlying sands and gravels of Late Devensian Lateglacial age (The Shepperton Gravel). The Shepperton Gravel rises from beneath the floor of the palaeochannel both northward and southward to form gravel bars that define the margins of the channel.

To the west of the present site, the form of the Bankside Channel can be made out between Union Street in the south and Southwark Street in the north. In the presumed axis of the channel, at the South Point site on the Blackfriars Road, the surface of the Shepperton Gravel is at -3.49m OD (Branch *et al* 2002) and at nearby sites in Joan Street and Union Street (Sidell *et al* 2000) the surface is between -2.00m and -3.00m OD. Towards the northern edge of the Bankside Channel at Bear Lane and Bear House (Tan, 2008; Batchelor *et al*., 2011a), the gravel surface rises northward from -2.70m to -0.60m OD and further north again in Blackfriars Road (Batchelor *et al* 2008) the gravel rises to 2.67m OD. The form of the channel is also apparent to the east of the present site, where the surface of the Shepperton Gravel is at -3.64m OD at Anchor Terrace (Thompson *et al* 1998), probably close to the axis of the palaeochannel, but rises northward to 0.66m OD in Skinmarket Place

(Thompson *et al* 1998) and southward to 0.8m OD at 97-101 Union Street (Capon 2006). Close to the present site the gravel surface was recorded at -1.6m OD south and east of the site at 65 Southwark Street (Batchelor *et al* 2011b) and between -1.22m and -2.95m OD to the north at St Christopher's House (Howell 2003).

At Surrey House, the combined results of recent geoarchaeological fieldwork (Green & Batchelor 2011) and an archaeological watching brief (Turner, 2010) indicate the Shepperton Gravel surface dips from south (-2.95m OD; Borehole 3) to north (-4.55m OD; Borehole 4; Figures 2 & 3) across the site. Significantly, the depths towards the northern edge of the site are the lower than recorded elsewhere in the Bankside Channel, at -3.49m OD at the South Point site (Branch *et al*., 2002); and -3.64m OD at Anchor Terrace (Thompson *et al*., 1998); and substantially below the levels recorded in two sites immediately to the north and south of the Surrey House site, respectively at -2.95m OD at St Christopher House (Howell 2003) and at -1.60m OD at 65 Southwark Street to the east (Batchelor *et al*., 2011b; Figure 4). The low level of the base of the Holocene sediment sequence at the Surrey House site may indicate the presence of a continuous deep narrow channel occupying the axis of the Bankside depression or, and perhaps more likely, a localised scour hollow in the surface of the Shepperton Gravel.

Infilling the Bankside Channel is a sequence of Holocene sediments which includes at most sites a bed of peat, either resting directly on the Shepperton Gravel or separated from it by units of organic sand or silt. Overlying the peat are alluvial silts which in general are less richly organic than the underlying sediments. These transitions from peat to alluvium represent important palaeoenvironmental transitions, with peat representing periods of semi-terrestrial conditions and frequently in the Lower Thames Valley, the growth of fen carr woodland, whilst the alluvium represents periods of inundation. At the Surrey House site itself, the same recent investigations (Green & Batchelor, 2011; Turner, 2010) have revealed 3-4m of peat and alluvium overlying the Shepperton Gravel, capped by Made Ground. Geoarchaeological investigations from the neighbouring 65 Southwark Street (Figure 1), recorded a similar, but shorter alluvial sequence (Batchelor *et al*., 2011b).

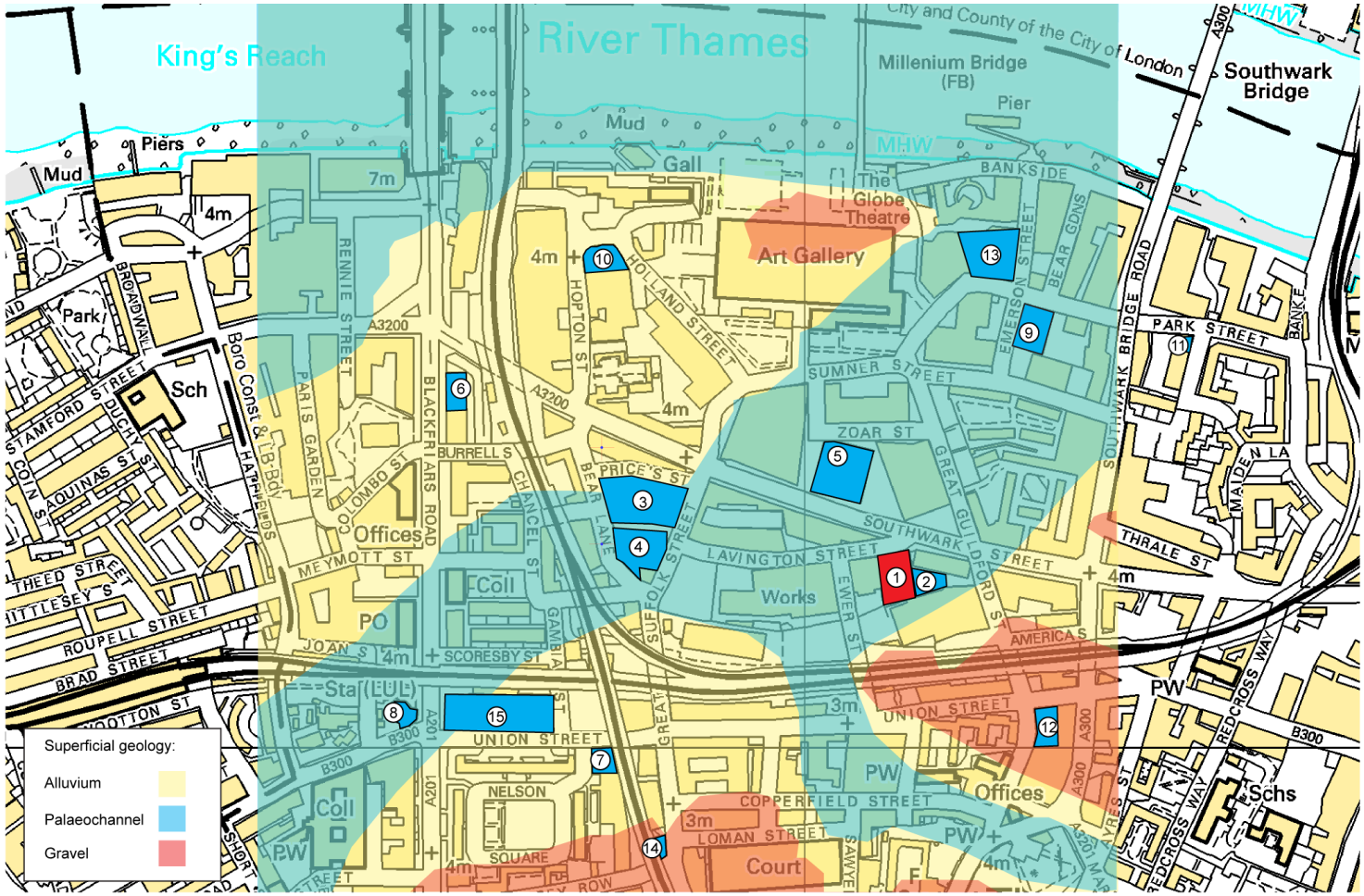
Investigations at 65 Southwark Street indicated that the peat accumulated between 5610-5480 and 4290-4090 cal BP equating to the Middle to Late Neolithic cultural period. Elsewhere at Bear House (Batchelor et al., 2011a) and Bear Lane (Tan, 2008), radiocarbon dating indicates that towards the northern edge of the Bankside Channel the peat deposits accumulated from at least 4820-4570 to 3140-2870 cal BP (Late Neolithic to Late Bronze

Age). At sites towards the middle of the projected course of the Bankside Channel such as St Christopher House (*ca*. 100m northeast of the site; Maloney, 2003, 2004) radiocarbon dating indicate that the channel dated from at least 10,650-10,250 cal BP and included both peat and alluvial deposits (Maloney, 2004), whilst historic records indicate it had infilled by the Late 17th Century (Turner, 2009). The close location of Surrey House to 65 Southwark Street might suggests that the new sequence is most likely to be of similar date, however, following the results of the geoarchaeological fieldwork, this appears unlikely since the new site has a substantially deeper gravel surface, and much thicker peat sequence suggesting a different (probably older) chronology. Furthermore, the radiocarbon determinations listed above demonstrate the large temporal variations in the onset and cessation of peat formation along the course of the Bankside Channel.

The potential for tracking prehistoric cultural activity is also demonstrated from sites along the Bankside Channel. At St Christopher's House for example, three timber structures dated to 3450-3240 cal BP (2 structures) and 2750-2350 cal BP (1 structure) were recorded within the channel's sedimentary sequence (Maloney, 2004). Whilst at two sites located on a gravel eyot further to the north of the site (44-47 Hopton Street, Maloney, 2001; 245 Blackfriars Road, Thompson *et al*., 2008), various artefacts reflective of occupation dating from the Neolithic cultural period onwards have been recorded. The sedimentary sequence at Surrey House therefore also has good potential to provide evidence of prehistoric and historic human activity both on the wetland and on dryland surfaces adjacent to the site, which should be compared with existing evidence.

As a consequence of the findings of the recent geoarchaeological fieldwork, an environmental archaeological assessment of borehole 4 was recommended to elucidate the age of the thickest and deepest alluvial sequence, and to evaluate the potential for reconstructing the past environmental conditions of the site and its environs. In order to achieve this aim, the following objectives were proposed: (1) rangefinder radiocarbon dating, to provide an age for the onset and cessation of peat formation; (2) organic matter determinations to aid identification of the sedimentary units; (3) assessment of the archaeobotanical remains (pollen, waterlogged wood and seeds) to provide a provisional reconstruction of the vegetation history; (4) assessment of the diatoms to provide an indication of the palaeohydrology (e.g. marine, brackish or freshwater), and (5) assessment of the zooarchaeological remains (insects and Mollusca) to provide information on the general environmental conditions, climatic change and hydrology of the site. The assessment will also highlight any indications of nearby human activity, and provide

recommendations for further analysis (if necessary).



① Surrey House (LVI11)
② 65 Southwark Street (SOU11; Batchelor *et al.*, 2011)
③ Bear House (BJH10; Batchelor *et al.*, 2011)
④ Bear Lane (BLZ07; Tan *et al.* 2008)
⑤ St. Christopher's House (SCH03; London Archaeologist, 2004)
⑥ 231-241 Blackfriars Rd (BFX08; Batchelor *et al.*, 2008)
⑦ Jubillee Line, Union St (UNL08; Sidell *et al.*, 2000)
⑧ Joan St (JOA91; Sidell *et al.*, 2000)
⑨ 135 Park St (PKP09; Batchelor and Young, 2009)
⑩ 44-47 Hopton St (HNT94; London Archaeologist, 2001)
⑪ Anchor Terrace (Thompson *et al.*, 1998)
⑫ 97-101 & 103 Union Street (Capon, 2006)
⑬ Skinmarket Place (Thompson *et al.*, 1998)
⑭ Great Suffolk Street (GUF10; Batchelor *et al.*, 2011)
⑮ South Point (BKA02; Branch *et al.*, 2002)

Figure 1: Location of Surrey House and nearby sites. The projected course of the Bankside Channel, as indicated by Dunwoodie *et al*. (2006) and adapted after Young *et al*. (2010), is also shown.

Figure 2: Location of the archaeological and geoarchaeological boreholes at Surrey House, London Borough of Southwark (site code: LVI11)

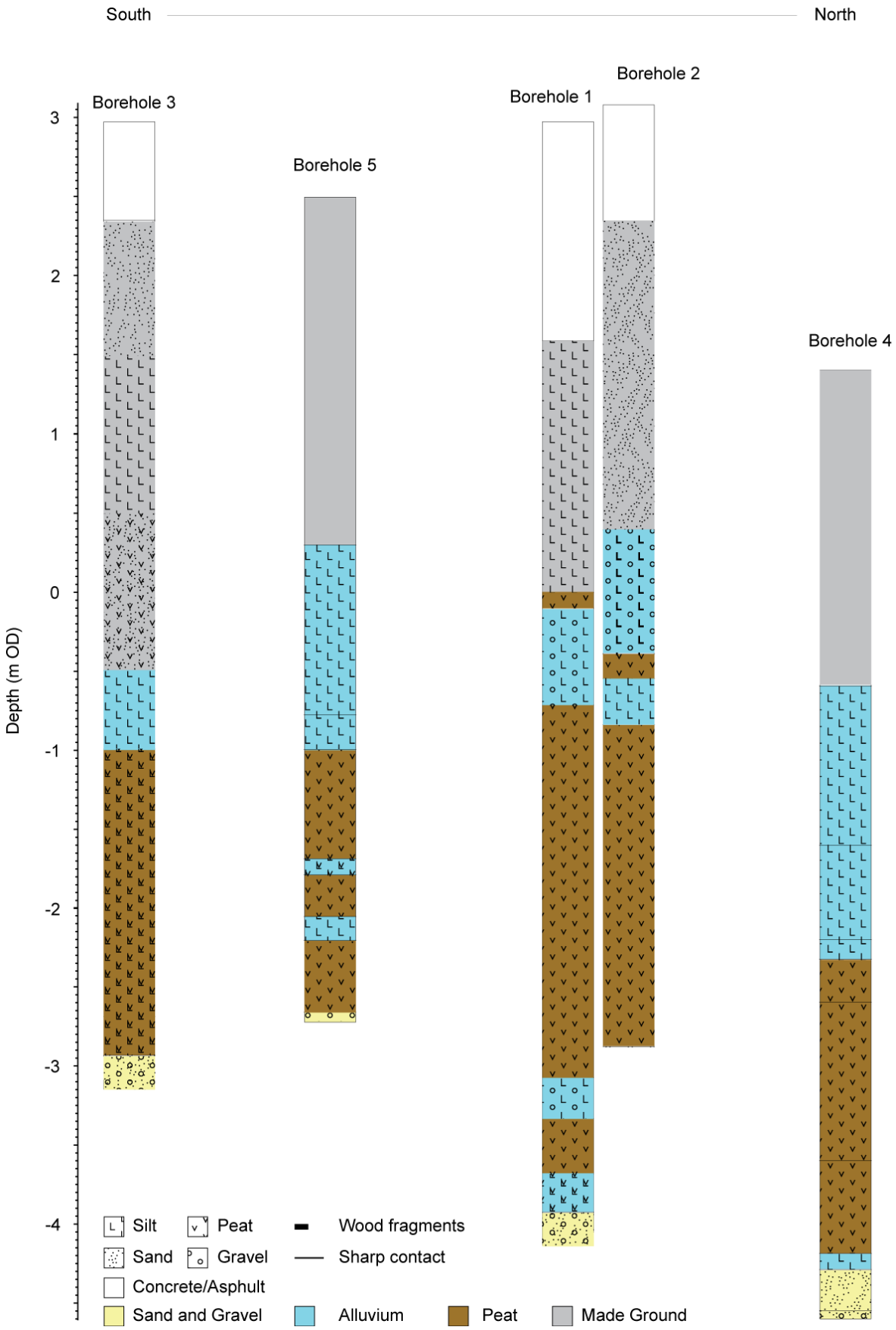


Figure 3: North-south transect of boreholes across Surrey House, London Borough of Southwark (site code: LVI11)

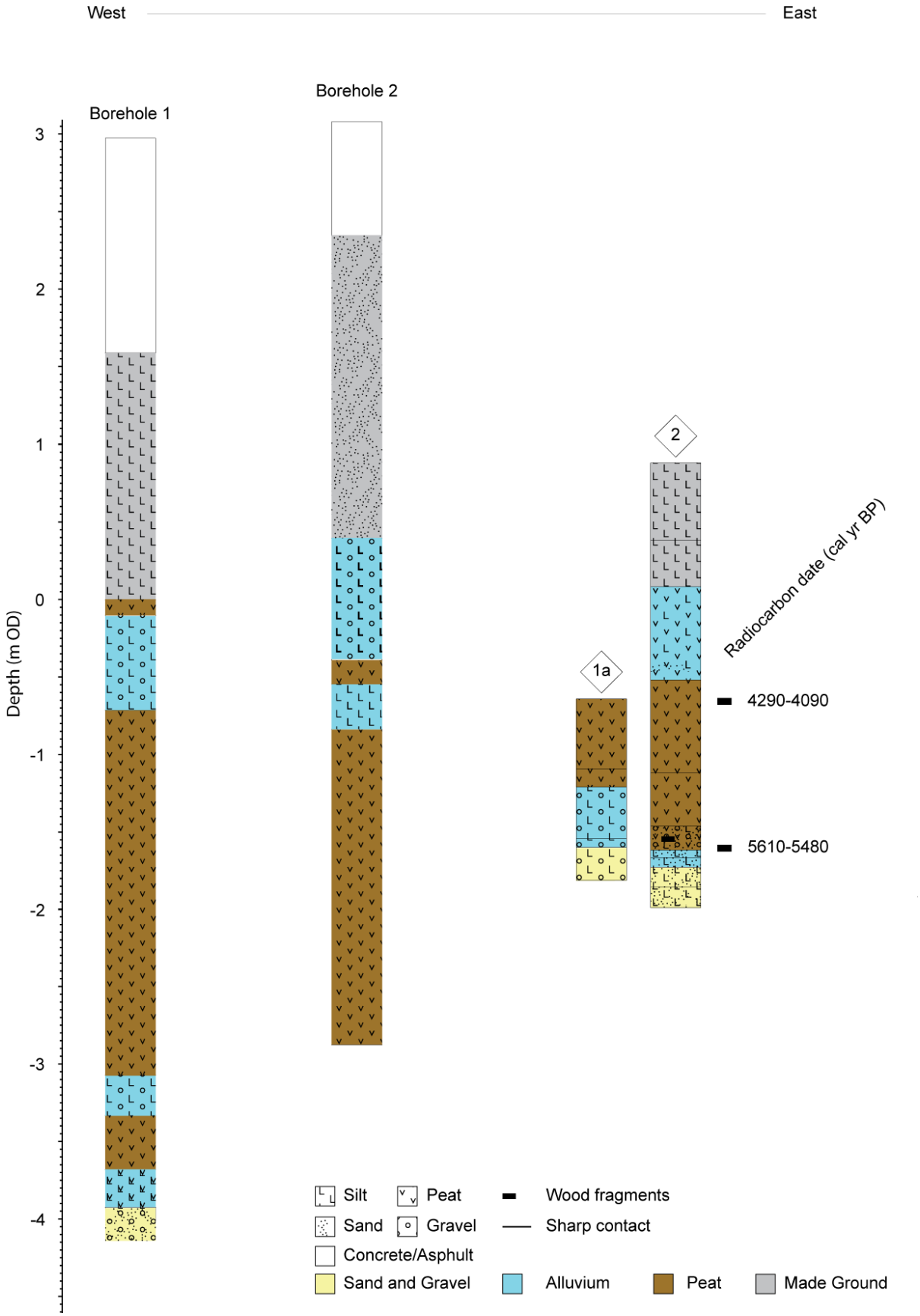


Figure 4: West-East transect of boreholes across Surrey House and 65 Southwark Street (site codes: LVI11 and SOU11)

METHODS

Field investigations

Two boreholes (Boreholes 4 and 5) were put down at the site in June 2011 (Figure 2). The boreholes were recovered using an Eijkelkamp window sampler and gouge set driven by an Atlas Copco TT 2-stroke percussion engine. Each borehole was put down until coarse grained unconsolidated sediments had been recorded. The spatial attributes of each proposed borehole location were recorded by Bowmer and Kirkland Ltd (Table 1). The spatial attributes for the original archaeological watching brief boreholes are also shown (boreholes 1 to 3), and the spatial attributes of recent geoarchaeological boreholes from 65 Surrey House are presented in Table 1 only. During the course of the Surrey House watching brief, surface heights relative to ordnance datum were not recorded. These have instead been interpolated here from a pre-demolition survey.

Table 1: Borehole attributes, Surrey House, London Borough of Southwark (site code: LVI11)

Borehole number	Easting	Northing	Elevation (m OD)
Surrey House geoarchaeological boreholes			
Borehole 4	532082.057	180176.900	1.40
Borehole 5	532089.102	180151.952	2.80
Surrey House archaeological watching brief boreholes			
Borehole 1	532072	180162	*3.00*
Borehole 2	532056	180199	*3.08*
Borehole 3	532087	180140	*3.00*
65 Southwark Street geoarchaeological boreholes			
Borehole <1a>	532108.773	180148.300	2.86
Borehole <2>	532118.593	180158.858	2.88

Lithostratigraphic descriptions

Borehole core samples were retained and described in the laboratory using standard procedures for recording unconsolidated sediment and peat, noting the physical properties (colour), composition (gravel, sand, clay, silt and organic matter) and inclusions (e.g. artefacts). The procedure involved: (1) cleaning the samples with a spatula or scalpel blade and distilled water to remove surface contaminants; (2) recording the physical properties, most notably colour; (3) recording the composition e.g. gravel, fine sand, silt and clay; (4) recording the degree of peat humification, and (5) recording the unit boundaries e.g. sharp or diffuse. The results are displayed in Tables 2 and 3, and Figures 3 and 4. The archaeological watching brief descriptions are provided in Tables 4 to 6 and displayed in Figures 3 and 4, adjusted to the interpolated ordnance datum height.

Organic matter determinations

Thirty-nine sub-samples from borehole BH4 were taken for determination of the organic matter content (Table 2; Figure 7*)*. These records were important as they can identify increases in organic matter possibly associated with more terrestrial conditions. The organic matter content was determined by standard procedures involving: (1) drying the sub-sample at 110^0C for 12 hours to remove excess moisture; (2) placing the sub-sample in a muffle furnace at 550°C for 2 hours to remove organic matter (thermal oxidation), and (3) re-weighing the sub-sample obtain the 'loss-on-ignition' value (see Bengtsson and Enell, 1986).

Range-finder radiocarbon dating

Two sub-samples of peat were extracted from near the top and base of the Peat in borehole BH4. Each sample was processed by wet sieving and the macrofossil remains were picked out and identified. From the near base of the peat, unidentifiable plant remains were selected for dating, and from the near top, an identified twig remain. The samples were submitted for AMS radiocarbon dating to Beta Analytic INC, Radiocarbon Dating Laboratory, Florida, USA. The results have been calibrated using OxCal v4.0.1 Bronk Ramsey (1995, 2001 and 2007) and IntCal04 atmospheric curve (Reimer et al., 2004). The results are displayed in Table 8.

Pollen assessment

Fourteen sub-samples from borehole BH4 were extracted for an assessment of pollen content. The pollen was extracted as follows: (1) sampling a standard volume of sediment (1ml); (2) adding two tablets of the exotic clubmoss *Lycopodium clavatum* to provide a measure of pollen concentration in each sample; (3) deflocculation of the sample in 1% Sodium pyrophosphate; (4) sieving of the sample to remove coarse mineral and organic fractions (>125µ); (5) acetolysis; (6) removal of finer minerogenic fraction using Sodium polytungstate (specific gravity of 2.0g/cm^3); (7) mounting of the sample in glycerol jelly. Each stage of the procedure was preceded and followed by thorough sample cleaning in filtered distilled water. Quality control is maintained by periodic checking of residues, and assembling sample batches from various depths to test for systematic laboratory effects. Pollen grains and spores were identified using the University of Reading pollen type collection and the following sources of keys and photographs: Moore *et al* (1991); Reille (1992). The assessment procedure consisted of scanning the prepared slides, and recording the concentration and preservation of pollen grains and spores, and the principal taxa on four transects (10% of the slide; Table 9). The addition and counting of *Lycopodium* spores has also permitted the calculation of total land pollen concentration (grains/cm^3).

Diatom assessment

Six sub-samples from borehole BH4 were extracted for the assessment of diatoms. The diatom extraction involved the following procedures (Battarbee *et al.,* 2001):

1. Treatment of the sub-sample (0.2g) with Hydrogen peroxide (30%) to remove organic material and Hydrochloric acid (50%) to remove remaining carbonates
2. Centrifuging the sub-sample at 1200 for 5 minutes and washing with distilled water (4 washes)
3. Removal of clay from the sub-samples in the last wash by adding a few drops of Ammonia (1%)
4. Two slides prepared, each of a different concentration of the cleaned solution, were fixed in mounting medium of suitable refractive index for diatoms (Naphrax)

The assessment procedure consisted of scanning the slides and recording the concentration, preservation and diversity of taxa. The results are displayed in Table 10.

Macrofossil assessment

A total of eleven small bulk samples from borehole BH4 were extracted for the recovery of macrofossil remains including waterlogged plant macrofossils, waterlogged wood, insects and Mollusca. The extraction process involved the following procedures: (1) removing a sample up to 10cm in thickness; (2) measuring the sample volume by water displacement, and (3) processing the sample by wet sieving using 300µm and 1mm mesh sizes. Each sample was scanned under a stereozoom microscope at x7-45 magnifications, and sorted into the different macrofossil classes. The concentration and preservation of remains was estimated for each class of macrofossil (Table 11).

Preliminary identifications of the waterlogged plant macrofossils have been made using modern comparative material and reference atlases (Cappers *et al.* 2006). Nomenclature used follows Stace (2005). The quantities of waterlogged seeds and wood were recorded for each sample, with identifications of the main taxa (Table 12).

RESULTS AND INTERPRETATION OF THE LITHOSTRATIGRAPHIC DESCRIPTIONS AND ORGANIC MATTER DETERMINATIONS

The sediment sequences from the two geoarchaeological boreholes (Boreholes 4 and 5; Tables 2 and 3) those recorded during the course of the archaeological watching brief (Boreholes 1, 2 and 3; Tables 4 to 6) are broadly similar and with sequences recorded elsewhere in the Bankside Channel. The results of the organic matter determinations carried out on borehole BH4 are displayed in Table 7 and Figure 5.

In Borehole BH4 (Table 2), gravel (Unit 1) is recorded at -4.55m OD beneath a thin (0.37m) sequence of fine-grained organic sediments (Units 2 and 3), and thick (1.85m) of peat between -4.18 and -2.13m OD (Unit 4). The peat is overlain by a sequence of 1.73m of moderately organic silt (Unit 5) to -0.60m OD. In Borehole BH5 (Table 3), a total thickness of 1.65m of peat is separated into two sub-units (Units 2 and 4) by a thin (0.14m) bed of organic silt (Unit 3). The lower peat sub-unit rests on inorganic gravelly sand at -2.64m OD (Unit 1) and the upper peat sub-unit is overlain by 1.29m of silt with common detrital plant remains from -0.99m OD (Unit 5). In both boreholes the upper silty beds are probably truncated by historic ground modification. The peat units recorded in archaeological Boreholes 1, 2 and 3 (Tables 4 to 6) were similarly thick (around 2m) either directly lying on the gravel surface, or separated by a thin layer of alluvium. The gravel surface was recorded at -3.95m OD in Borehole 1 and -2.95m OD in Borehole 3. Frequent wood fragments were recognised within the new geoarchaeological boreholes, a find analogous to the vast majority of peat sequences in the Lower Thames Valley, and also highlighted during the archaeological watching brief. These remains suggest that the peat surface was colonised by fen carr woodland.

The combined results of the geoarchaeological fieldwork and archaeological watching brief indicate a dipping Shepperton Gravel surface from south (-2.95m OD; Borehole 3) to north (-4.55m OD; Borehole BH4) across the Surrey House site (Figure 3). Significantly, the depths towards the northern edge of the site are the lower than recorded elsewhere in the Bankside Channel, at -3.49m OD at the South Point site (Branch *et al*., 2002); and -3.64m OD at Anchor Terrace (Thompson *et al*., 1998); and substantially below the levels recorded in two sites immediately to the north and south of the Surrey House site, respectively at -2.95m OD at St Christopher House (Howell 2003) and at -1.60m OD at 65 Southwark Street to the east (Batchelor *et al*., 2011b; Figure 4). The low level of the base of the Holocene sediment sequence at the Surrey House site may indicate the presence of a continuous deep narrow channel occupying the axis of the Bankside depression or, and perhaps more likely, a

localised scour hollow in the surface of the Shepperton Gravel.

The results of the organic matter content determinations (Table 7; Figure 5) indicate that the organic matter content is low (throughout units 1 (gravel; <2%), 2 (sand; <3%), 3 (lower alluvium; <10%) and 5 (upper alluvium; <25%) as would be expected. Through the peat, organic matter content varies between 20% and 70% suggesting large variability in the amount of flooding occurring during its accumulation.

RESULTS AND INTERPRETATIONS OF THE RADIOCARBON DATING

The results of the radiocarbon dating are displayed in Table 8 and Figure 5. At the base of the peat sequence, three contiguous 10cm samples were processed by wet sieving in an attempt to obtain terrestrial macrofossil remains suitable for radiocarbon dating. Unfortunately these samples derived no waterlogged wood, and all the seed remains were aquatic (and thus potentially derived). It was therefore decided to submit a sample of bulk peat (-4.13 to -4.18m OD) to the radiocarbon laboratory and radiocarbon date the extractable plant remains. Whilst not an ideal situation, this at least allowed a determination to be gained from the base of the sequence which could be tested at a later stage of work (if necessary). The sample was radiocarbon dated to 10,130-9690 cal BP.

Towards the top of the peat between -2.50 and -2.55m OD, an unidentifiable twig was extracted and radiocarbon dated to 4840-4640 cal BP.

The δ13C (‰) values for both samples are consistent with that expected for peat sediment, and there is no evidence for mineral or biogenic carbonate contamination. The results indicate that the Peat in borehole BH4 dates from the Early Mesolithic to Late Neolithic, and provides an interesting comparison to the peat recorded at nearby 65 Southwark Street, which it mostly predates (Batchelor *et al*.,2011b).

Table 2: Lithostratigraphic description of Borehole BH4, Surrey House, London Borough of Southwark (site code: LVI11)

Depth (m BGL)	Depth (m OD)	Unit	Description
0 to 2.00	1.40 to -0.60	-	Made Ground
2.00 to 3.00	-0.60 to -1.60	5	5Y3/1 very dark grey; very well sorted silt; horizontally bedded alternations of plant-rich and mineral-rich sediment; common to very common detrital plant remains; wood debris including round wood to 10mm Ø; moderate acid reaction.
3.00 to 3.61	-1.60 to -2.21	5	2.5Y5/1 grey to 2.5Y3/1 very dark grey; well sorted organic silt; horizontally bedded alternations of plant-rich and mineral-rich sediment; common to very common detrital plant remains; vivianite; moderate acid reaction; well-marked transition to:
3.61 to 3.73	-2.21 to -2.33	5	2.5Y3/1 very dark grey to black; well sorted organic silt with irregular peaty inclusions; massive; very common detrital plant remains; common broken mollusc shell with concentration at base of ubit (-2.29 to -2.33m OD); moderate acid reaction; gradual transition to:
3.73 to 4.00	-2.33 to -2.60	4	Black; peat, slight visible mineral content decreasing downward; scattered broken mollusc shell.
4.00 to 5.00	-2.60 to -3.60	4	Black; woody peat including roundwood to 10mm Ø, with large piece of wood at 3.89-4.02m OD, no acid reaction.
5.00 to 5.58	-3.60 to -4.18	4	Black; peat with slight visible mineral content below -4.80m OD; massive; no acid reaction; sharp contact with:
5.58 to 5.69	-4.18 to -4.29	3	2.5Y4/1 dark grey and 2.5Y5/4 olive brown; very well sorted marly silt; weakly developed horizontal bedding; strong acid reaction; sharp contact with:
5.69 to 5.95	-4.29 to -4.55	2	Black, dark grey and olive brown, moderately sorted very slightly silty sand with scattered flint granules; horizontally bedded; scattered detrital plant rermains; no acid reaction; sharp contact with:
5.95 to 6.00	-4.55 to -4.60	1	Dark brown, moderately well sorted clast-supported gravel of well-rounded and sub-angular flint (with very sparse sand matrix); no acid reaction.

Table 3: Lithostratigraphic description of Borehole BH5, Surrey House, London Borough of Southwark (site code: LVI11)

Depth (m BGL)	Depth (m OD)	Unit	Description
0 to 2.50	2.80 to 0.30		Made Ground
2.50 to 3.50	0.30 to -0.70	5	10YR4/1 dark grey with black specks; very well sorted silt with inclusion of 10YR3/2 very dark greyish brown peaty silt at -0.03 to -0.11m OD; massive; common Fe-stained root channels becoming less common downward; scattered root remains; common detrital plant remains (black specks); very scattered broken mollusc shell.
3.50 to 3.79	-0.70 to -0.99	5	2.5Y3/1 very dark grey; very well sorted organic silt; massive becoming laminated towards base of unit

			(below -0.90m OD); very common detrital plant remains increasing downward especially below -0.90m OD; no acid reaction; sharp contact with:
3.79 to 4.48	-0.99 to -1.68	4	Black; peat with scattered twigs.
4.48 to 4.50	-1.68 to -1.70	4a	10YR3/1 very dark grey; very well sorted silt enclosing piece of wood.
4.50 to 4.84	-1.70 to -2.04	4	Black; peat with scattered twigs; sharp contact with:
4.84 to 4.98	-2.04 to -2.18	3	10YR3/1 very dark grey; very well sorted silt; massive, common detrital plant remains; common detrital wood fragments; sharp contact with:
4.98 to 5.44	-2.18 to -2.64	2	Black; woody peat; sharp contact with:
5.44 to 5.50	-2.64 to -2.70	1	Dark grey passing down to olive brown; poorly sorted gravelly sand with clasts of sub-angular flint (up to 30mm).

Table 4: Archaeological watching brief description of Borehole 1, Surrey House, London Borough of Southwark (site code: LVI11)

Depth (m BGL)	Depth (m OD)	Description	Archaeological interpretation
0 to 1.70	3.00 to -1.30	Concrete and asphalt	
1.70 to 3.00	-1.30 to 0	Grey gravelly clay with ash and brick fragments	Made Ground
3.00 to 3.10	0 to -0.10	Fibrous peat	Peat
3.10 to 3.72	-0.10 to -0.72	Silty clay with black organic rootlets	Alluvium
3.72 to 3.75	-0.72 to -0.75	Burnt gravels, <5mm sub-angular with black charcoal/silt matrix	Possible Fire
3.75 to 6.09	-0.75 to -3.09	Silty clay fibrous peat with frequent twigs and wood fragments	Peat
6.09 to 6.35	-3.09 to -3.35	Silty clay, light brownish grey	Alluvium
6.35 to 6.70	-3.35 to -3.70	Fibrous peat	Peat
6.70 to 6.95	-3.70 to -3.95	Silty clay, light brownish grey, silty clay	Alluvium
6.95 to 9.00	-3.95 to -6.00	Medium density grey gravel	Sand and Gravel

Table 5: Archaeological watching brief description of Borehole 2, Surrey House, London Borough of Southwark (site code: LVI11)

Depth (m BGL)	Depth (m OD)	Description	Archaeological interpretation
0 to 0.74	3.08 to 2.34	Concrete and asphalt	
0.74 to 2.70	2.34 to 0.38	Dark brown silty sand with brick, concrete and occasional shell fragments	Made Ground
2.70 to 3.50	0.38 to -0.42	Firm, greyish brown clay with occasional fine to medium gravel	Alluvium
3.50 to 3.65	-0.42 to -0.57	Fibrous peat with frequent twigs/brushwood and wood fragments	Peat
3.65 to 3.95	-0.57 to -0.87	Silty clay, light grey	Alluvium
3.95 to 6.00	-0.87 to -2.92	Dark brown fibrous peat with occasional twigs	Peat

Table 6: Archaeological watching brief description of Borehole 3, Surrey House, London Borough of Southwark (site code: LVI11)

Depth (m BGL)	Depth (m OD)	Description	Archaeological interpretation
0 to 0.60	3.00 to 2.40	Concrete and asphalt	
0.60 to 1.50	2.40 to 1.50	Brown clayey sand with gravel, concrete and brick fragments	Made Ground
1.50 to 2.50	1.50 to 0.50	Firm, dark grey clay	Alluvium
2.50 to 3.50	0.50 to -0.50	Dark brown silty sand, slightly peaty with modern brick fragments	Made Ground
3.50 to 4.00	-0.50 to -1.00	Silty clay, light grey	Alluvium
4.00 to 4.70	-1.00 to -1.70	Fibrous peat with occasional twigs	Peat
4.70 to 4.90	-1.70 to -1.90	Silty clay fibrous peat, greyish brown with occasional twigs	Peat
4.90 to 5.70	-1.90 to -2.70	Silty clay, mid grey and slightly peaty	Peat
5.70 to 5.95	-2.70 to -2.95	Fibrous peat with occasional twigs	Peat
5.95+	-2.95+	Medium density grey gravel	Sand and Gravel

Table 7: Results of the organic matter determinations from borehole BH4, Surrey House, London Borough of Southwark (site code: LVI11)

Depth (m OD)	Organic matter content (%)
-1.64	11.34
-1.72	21.60
-1.8	12.89
-1.88	13.91
-1.96	15.46
-2.04	25.83
-2.12	12.26
-2.2	19.02
-2.28	15.30
-2.36	24.29
-2.44	37.32
-2.52	38.97
-2.6	41.60
-2.68	36.17
-2.76	30.88
-2.84	33.74
-2.92	40.97
-3	41.87
-3.08	63.13
-3.16	64.35

Depth (m OD)	Organic matter content (%)
-3.24	57.60
-3.32	39.26
-3.4	53.06
-3.48	44.08
-3.56	23.76
-3.64	25.58
-3.72	36.31
-3.8	58.79
-3.88	68.29
-3.96	58.76
-4.04	69.37
-4.12	49.26
-4.16	20.29
-4.2	7.02
-4.28	3.05
-4.36	0.77
-4.44	0.54
-4.52	0.79
-4.59	1.96

Table 8: Results of the radiocarbon dating of borehole BH4, Surrey House, London Borough of Southwark (site code: LVI11)

Laboratory code / Method	Borehole number	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-316286	BH4	Unidentified twig extracted from bulk peat	-2.50 to -2.55	4200 ± 30	2890-2700 cal BC (4840-4640 cal BP)	-26.8
Beta-316287	BH4	Unidentified plant remains extracted from bulk peat	-4.13 to -4.18	8810 ± 40	8180-7740 cal BC (10,130-9690 cal BP)	-28.6

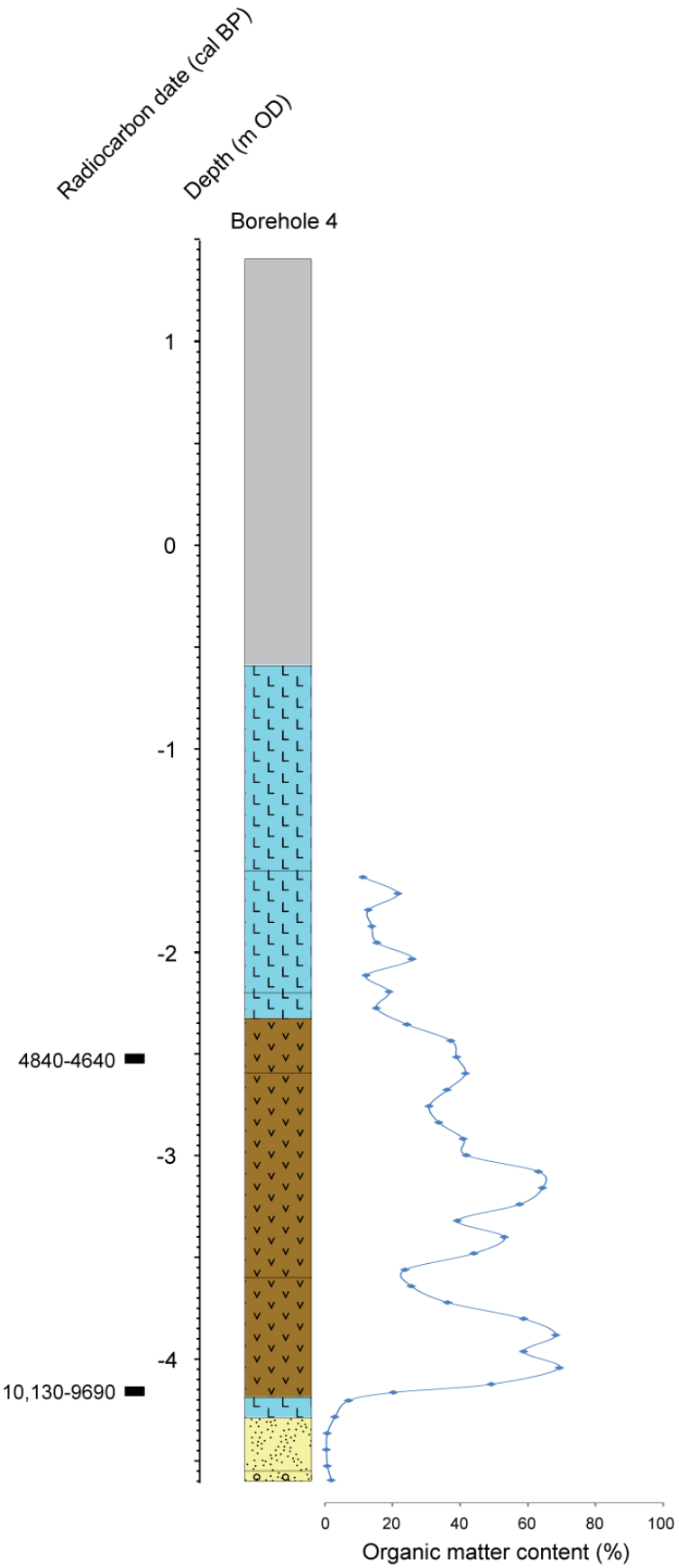


Figure 5: Results of the organic matter determinations and radiocarbon dating for borehole BH4, Surrey House, London Borough of Southwark (site code: LVI11)

RESULTS AND INTERPRETATIONS OF THE POLLEN ASSESSMENT

Fourteen sub-samples were selected from borehole BH4 for assessment of the pollen content (Table 9). The results of the assessment indicate that the concentration and preservation of pollen was very poor in the one sample assessed from Unit 1 (gravel) with only 2 grains of *Pinus* (pine) and one of Poaceae (grass family) recorded. Within Unit 3 (lower alluvium), the single sample assessed contained a poor to moderate concentration of pollen including *Pinus*, Poaceae, Cyperaceae (sedge family) and possibly *Quercus* (oak).

The concentration and preservation of remains varied between poor-moderate and excellent through the nine samples assessed from Unit 4 (peat). Within this unit, the samples assessed can be divided into two groups. Samples at -4.12 to -4.13m OD and -4.04 to -4.05m OD are dominated by *Pinus*, Poaceae and Cyperaceae with *Betula* (birch) and *Sparganium* type (bur-reed). The samples below -4.04m OD (including those from Units 1 and 3) suggest that during this period grasses, sedges, mixed herbs and bur-reed grew on the wetland, whilst pine, birch and possibly oak grew nearby on the dryland. This assemblage is potentially indicative of cold climatic conditions, such as that experienced during the Late Glacial/Early Holocene.

The samples from the rest of the peat contain a pollen assemblage mainly dominated by *Alnus* (alder), *Quercus* and *Corylus* type (e.g. hazel) with occasional *Salix* (willow), *Betula*, *Ulmus* (elm), *Tilia* (lime), *Pinus*, Poaceae, Cyperaceae, various mixed herbs, aquatics and spores. This assemblage is indicative of a wetland environment dominated by mixed alder-willow carr woodland, with an understorey of grasses and sedges. Birch, elm and hazel may also have grown within the wetland woodland, but are equally likely to have grown on the dryland, forming mixed deciduous woodland with oak and lime. The sporadic occurrence of elm and lime suggests there is the potential to enhance our knowledge and understanding of the decline of both woodland types in this area of the Lower Thames Valley.

Three samples were assessed from Unit 5, all of which contained a very high concentration of pollen in a very good state of preservation. Within these samples, the sample woodland taxa are recorded as in the upper samples from Unit 4, but notably there is a higher concentration and diversity of herbaceous and aquatic taxa including grasses, sedges, buttercups (*Ranunculus* type), bulrush (*Typha latifolia*) and water milfoil (*Myriophyllum* type). This assemblage suggests more open and wet conditions developing at the site.

Table 9: Results of the borehole BH4 pollen assessment, Surrey House, London Borough of Southwark (site code: LVI11)

Sample number	Unit number	Main pollen taxa			Concentration 0-5	Concentration grains/cm^3	Preservation 0- 5	Microcharcoal 0 - 5
		Latin name	Common name	Number				
-1.64 to -1.65	5	*Alnus*	alder	3	5	89807	4	1
		Quercus	oak	4				
		Corylus type	e.g. hazel	9				
		Calluna vulgaris	heather	1				
		Poaceae	grass family	7				
		Cyperaceae	sedge family	2				
		Chenopodium type	e.g. fat hen	1				
		Plantago lanceolata	ribwort plantain	1				
-1.88 to -1.89	5	*Alnus*	alder	11	5	41696	4	1
		Quercus	oak	5				
		Pinus	pine	1				
		Ulmus	elm	1				
		Fraxinus	ash	1				
		Betula	birch	1				
		Corylus type	e.g. hazel	3				
		Poaceae	grass family	6				
		Cyperaceae	sedge family	2				
		cf *Polygonum aviculare*	knotgrass	1				
		Typha latifolia	bulrush	1				
		Myriophyllum type	water milfoil	1				
-2.12 to -2.13	5	*Alnus*	alder	7	5	60649	4	1
		Quercus	oak	8				
		Corylus type	e.g. hazel	6				
		Calluna vulgaris	heather	1				
		Poaceae	grass family	2				
		Cyperaceae	sedge family	2				
		Lactuceae	dandelion family	1				
		Chenopodium type	e.g. fat hen	3				
		Ranunculus type	buttercup	1				
		Asteraceae	daisy family	1				
-2.36 to -2.37	4	*Alnus*	alder	8	3	22006	4	0
		Quercus	oak	2				
		Tilia	lime	3				
		Pinus	pine	1				
		Corylus type	e.g. hazel	4				

		Chenopodium type *Polypodium vulgare*	e.g. fat hen polypody fern	1 1				
-2.60 to -2.61	4	*Alnus* *Quercus* *Tilia* *Pinus* *Corylus* type Poaceae *Polypodium* type	alder oak lime pine e.g. hazel grass family polypody fern	8 2 3 2 1 1 2	3	54525	4	0
-2.84 to -2.85	4	*Alnus* *Quercus* *Pinus* *Corylus* type Lactuceae cf *Galium* *Polypodium vulgare*	alder oak pine e.g. hazel dandelion family bedstraw polypody fern	10 3 1 1 1 1 2	4	66713	4	0
-3.08 to -3.09	4	*Alnus* *Quercus* *Ulmus* *Corylus* type	alder oak elm e.g. hazel	4 1 1 2	30	11119	3-4	0
-3.32 to -3.33	4	*Alnus* *Quercus* *Ulmus* *Pinus* *Betula* *Corylus* type Poaceae *Artemisia* *Polypodium vulgare*	alder oak elm pine birch e.g. hazel grass family mugwort polypody fern	12 4 3 1 1 1 1 1 1	4	47653	4	0
-3.56 to -3.57	4	*Pinus* *Quercus* *Betula* *Ulmus* *Corylus* type *Salix*	pine oak birch elm e.g. hazel willow	4 5 1 2 17 2	5	430859	4	0
-3.80 to -3.81	4	*Alnus* *Quercus* *Betula*	alder oak birch	13 2 1	4	119876	3-4	0

		Tilia	lime	2				
		Corylus type	e.g. hazel	3				
		Salix	willow	1				
		Hedera	ivy	1				
		cf *Ranunculus* type	buttercup	1				
		Polypodium vulgare	polypody fern	1				
-4.04 to -4.05	4	*Pinus*	pine	7	4	92658	4	0
		Alnus	alder	2				
		Betula	birch	1				
		Poaceae	grass family	6				
		Cyperaceae	sedge family	4				
		Sparganium type	bur-reed	1				
-4.12 to -4.13	4	*Pinus*	pine	4	5	133427	4-5	0
		Betula	birch	3				
		Poaceae	grass family	15				
		Cyperaceae	sedge family	7				
		Artemisia	mugwort	2				
		cf *Galium* type	bedstraw	1				
		Sparganium type	bur-reed	6				
-4.25 to -4.26	3	*Pinus*	pine	3	2	3790	3	1
		cf *Quercus*	oak	1				
		Poaceae	grass family	3				
		Cyperaceae	sedge family	3				
-4.44 to -4.45	1	*Pinus*	pine	2	1	1303	2-3	1
		Poaceae	grass family	1				

Key:
Concentration: 0 = 0 grains; 1 =1-75 grains, 2 = 76-150 grains, 3 = 151-225 grains, 4 = 226-300, 5 = 300+ grains per slide
Preservation: 0 = none, 1 = very poor, 2 = poor, 3 = moderate, 4 = good, 5 = excellent
Charcoal: 0 = none, 1 = negligible, 2 = occasional, 3 = moderate, 4 = frequent, 5 = abundant

RESULTS AND INTERPRETATIONS OF THE DIATOM ASSESSMENT

Six sub-samples were selected from borehole BH4 for assessment of the diatom content. The assessment revealed that no diatoms were preserved in the samples assessed from Units 2 and 3 towards the base of the sequence, but were preserved in varying concentrations within the upper alluvium of Unit 5. The diversity of remains also varied between very low in the lower two of these samples and moderate to high in the upper two.

A number of factors influence diatom preservation, and it is probable that in the sediments examined here diatom concentrations were always low and that post-depositional destruction of the frustules has occurred due to drying-out, abrasion and possibly unfavourable chemical conditions. Dissolution of the diatom silica, for example, can occur as a response to the ambient dissolved silica concentration, the pH in open water, and the interstitial water in sediments. Using both fossil and modern diatoms, these and other environmental factors have been shown to affect the quality of preservation of assemblages (Flower, 1993; Ryves *et al*., 2001).

Table 10: Results of the borehole BH4 diatom assessment, Surrey House, London Borough of Southwark (site code: LVI11)

Depth (m OD)	Unit number	Concentration	Preservation	Diversity
-1.88 to -1.89	5	High	Moderate to good	Moderate to high
-2.12 to -2.13	5	High	Good	Moderate to high
-2.28 to -2.29	5	Very rare	Moderate	Very low
-2.36 to -2.37	4	Rare	Fragmented	Very low
-4.20 to -4.21	3	None	-	-
-4.36 to -4.37	2	None	-	-

RESULTS AND INTERPRETATION OF THE MACROFOSSIL ASSESSMENT

A total of eleven small bulk samples from units 4 (peat) and 5 (upper alluvium) of borehole BH4 were extracted for the recovery of macrofossil remains including waterlogged plant macrofossils, waterlogged wood, insects and Mollusca (Table 11). The results of the macrofossil rapid assessment indicated that waterlogged seeds were present in eight of the samples, while waterlogged wood was present in seven samples. Fragments of insects were present in two samples (-2.21 to -2.31 and -2.60 to -2.70m OD); however, these lacked the diagnostic features necessary for identification. Fragments of Mollusca (mostly unidentifiable) were present in the uppermost sample in the sequence (-2.21 to -2.31m OD). No charred seeds, charcoal or bone were found during the assessment.

RESULTS AND INTERPRETATION OF THE WATERLOGGED PLANT MACROFOSSIL ASSESSMENT (SEEDS)

The results of the macrofossil rapid assessment indicated that waterlogged seeds were present in eight of the eleven samples assessed, and thus these samples underwent a more detailed assessment. The results of the borehole BH4 waterlogged seed assessment is displayed in Table 12.

The waterlogged seeds in borehole BH4 are characterised by two different assemblages; below *ca*. -3.93m OD the assemblage is dominated entirely by aquatic taxa including *Ranunculus* cf. *fluitans*/*aquatilis* (water crowfoot), *Scirpus* sp. (bulrush) and *Potamogeton* sp. (pondweed). Above *ca*. -3.93m OD the assemblage is dominated by tree and shrub taxa including *Alnus glutinosa* (alder), *Cornus sanguinea* (dogwood) and cf. *Rubus* sp. (bramble). Herbaceous taxa were present, and included *Ranunculus* cf. *repens* (creeping buttercup). Aquatic or damp ground vegetation including *Sparganium erectum* (bur-reed) and *Apium nodiflorum* (fool's watercress) were present in the uppermost sample in the sequence (-2.21 to -2.31m OD). The assemblage in borehole <BH4> is thus indicative of wet conditions below -3.93m OD, with more terrestrial conditions (indicated by the growth of vegetation typical of fen woodland) above -3.93m OD.

Table 11: Results of the macrofossil assessment of borehole BH4, Surrey House, London Borough of Southwark (site code: LVI11)

			Charred					Waterlogged		Mollusca		Bone			Insects	
Depth (m OD)	Volume sampled (ml)	Volume processed (ml)	Charcoal (>4mm)	Charcoal (2-4mm)	Charcoal (<2mm)	Seeds	Chaff	Wood	Seeds	Whole	Fragments	Large	Small	Fragments	Whole	Fragments
-2.21 to -2.31	50	50	-	-	-	-	-	4	1	2	2	-	-	-	-	-
-2.50 to -2.55	25	25	-	-	-	-	-	1	1	-	-	-	-	-	-	-
-2.55 to -2.60	25	25	-	-	-	-	-	1	1	-	-	-	-	-	-	-
-2.60 to -2.70	50	50	-	-	-	-	-	2	1	-	-	-	-	-	-	2
-3.08 to -3.18	50	50	-	-	-	-	-	5	-	-	-	-	-	-	-	-
-3.88 to -3.93	50	50	-	-	-	-	-	3	-	-	-	-	-	-	-	-
-3.93 to -3.98	25	25	-	-	-	-	-	1	1	-	-	-	-	-	-	-
-3.98 to -4.03	25	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-4.03 to -4.08	25	25	-	-	-	-	-	-	1	-	-	-	-	-	-	-
-4.08 to -4.13	25	25	-	-	-	-	-	-	1	-	-	-	-	-	-	-
-4.13 to -4.18	25	25	-	-	-	-	-	-	2	-	-	-	-	-	-	-

Key: 0 = Estimated Minimum Number of Specimens (MNS) = 0; 1 = 1 to 25; 2 = 26 to 50; 3 = 51 to 75; 4 = 76 to 100; 5 = 101+

Table 12: Results of the waterlogged plant macrofossil (seeds and wood) assessment of borehole BH4, Surrey House, London Borough of Southwark (site code: LVI11)

Depth (m OD)	Waterlogged seeds		
	Latin name	**Common name**	**Number**
-2.21 to -2.31	*Cornus sanguinea* *Alnus glutinosa* catkin *Apium nodiflorum* *Sparganium erectum* cf. *Rubus* sp. Unidentified	dogwood alder fool's watercress bur-reed e.g. bramble -	1 1 2 1 1 1
-2.50 to -2.55	*Ranunculus* cf. *repens*	creeping buttercup	1
-2.55 to -2.60	*Alnus glutinosa* catkin *Ranunculus* cf. *repens*	alder creeping buttercup	1 2
-2.60 to -2.70	*Alnus glutinosa* catkin *Ranunculus* cf. *repens*	alder creeping buttercup	2 2
-3.08 to -3.18	-	-	-
-3.88 to -3.93	-	-	-
-3.93 to -3.98	*Scirpus* sp.	bulrush	1
-3.98 to -4.03	-	-	-
-4.03 to -4.08	*Scirpus* sp.	bulrush	2
-4.08 to -4.13	*Ranunculus* cf. *fluitans*/*aquatilis* *Scirpus* sp. *Potamogeton* sp.	water crowfoot bulrush pondweed	1 8 1
-4.13 to -4.18	*Scirpus* sp. *Potamogeton* sp.	bulrush pondweed	44 1

DISCUSSION & CONCLUSIONS

The aim of this environmental archaeological assessment was to assess the borehole BH4 sequence in order to: (1) elucidate the age of the thickest and deepest alluvial sequence recorded on the site, and (2) evaluate the potential for reconstructing the past environmental conditions of the site and its environs. The results of the environmental archaeological assessment have revealed that the main period of peat formation at Surrey House dates from 10,130-9690 cal BP (Early Mesolithic) to 4840-4640 cal BP (Late Neolithic). Significantly, this sequence mainly predates that from the neighbouring 65 Southwark Street, which dated from 5610-5480 to 4290-4090 cal BP (Early to Late Neolithic; Batchelor *et al*., 2011b). As outlined above, there are some uncertainties with the radiocarbon dating as a consequence of being unable to date identifiable terrestrial plant macrofossils. However, both the taxa identified within the pollen and plant macrofossil assessment suggest an open and cold environment probably representative of Late Glacial/Early Holocene climate, and thus provide supporting evidence for the results of the radiocarbon dating. Furthermore, additional dates from the base of the sequence during a stage of further work should enhance this result.

The results of the pollen and plant macrofossil assessment indicate a mainly moderate to high concentration of remains, in a good state of preservation. Within the lower half of the borehole (below *ca*. -3.90m OD), the pollen and plant macrofossil (seeds and wood) records indicate that the local environment was dominated by herbaceous and aquatic vegetation including sedges, grasses, bur-reed and bulrush, whilst pine and birch woodland probably grew nearby on the dryland. As stated above, these conditions are suggestive of tundra conditions during the Late Glacial/Early Holocene. Above *ca*. -3.90m OD, the same records indicate a transition towards the development of alder-willow dominated carr woodland on the wetland, with mixed deciduous woodland growing on the dryland. Due to the age of these deposits, and the taxa recorded, there is the potential to quantify and date this transition, as well as to record the well documented elm decline, which is approximately dated to the Mesolithic/Neolithic transition around 6700 cal BP, and possibly the colonisation of yew (*Taxus*) which is recorded further east along the Lower Thames Valley. The results of the organic matter content determinations suggest that throughout the period of peat formation, the site was subject to periodic or even frequent flooding. At the transition into Unit 5 (above -2.33m OD), the results of the pollen assessment indicate a gradual transition towards more open and wetter conditions, as would be expected during the inundation of the peat. No indications of anthropogenic activity were recorded during the assessment.

No diatom, Mollusca, Ostracoda or Foraminifera remains were recorded within the lower parts of the sequence, but some were recorded (sometimes in abundance) within the alluvium of unit 5. These remains have the potential to provide information on the palaeohydrology of the site (i.e. marine, brackish or freshwater conditions).

RECOMMENDATIONS

Following the results of the assessment, it is recommended that detailed analysis is carried out on the borehole BH4 sequence from Surrey House. The sequence has good potential to provide a quantified reconstruction of the environmental history of the site and its surroundings, during the Mesolithic and Neolithic cultural periods. It is recommended that this analysis comprises high resolution pollen analysis, further radiocarbon dating, and analysis of select diatom, waterlogged wood, seed, insect and Mollusca remains.

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