UK HOLOCAUST MEMORIAL
Victoria Tower Gardens
London SW1P

City of Westminster

Geoarchaeological evaluation report

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Summary

This document reports on the results of a geoarchaeological evaluation carried out by Museum of London Archaeology (MOLA) on the UK Holocaust Memorial site in Victoria Gardens, London SW1P. The report was commissioned by Atkins on behalf of the client, UK Holocaust Memorial Foundation.

The site is situated on a small parcel of green space (Victoria Gardens) to the south of the Houses of Parliament, at the confluence of one of the former channels of the River Tyburn and the Thames.

Geoarchaeological fieldwork consisted of three targeted boreholes sited to retrieve sedimentary deposits across a range of environments noted during the previous geotechnical investigation monitored by MOLA. The deposits consisted of approximately 4m of made ground, 2 to 3.5m of Holocene (mainly alluvial and peat) deposits lying over undulating Pleistocene river gravel deposits. Previous deposit modelling had indicated the ground targeted by the boreholes dipped southward into what was considered a former channel of the Tyburn.

In order to explore the palaeoenvironmental potential of the site, as recommended in the geoarchaeological watching brief report (MOLA 2019a), subsamples were taken throughout the boreholes for pollen, ostracod and plant macrofossil assessments, as well as for radiocarbon dating. An assessment of the finds from the boreholes was also undertaken. Furthermore, the borehole results allowed the deposit model for the site and vicinity to be updated refining the early Holocene or Mesolithic topography across the site.

Results indicate that the alluvial sediments accreted from the very early Holocene (relatively rare preservation for the London area) in a backwater area associated with the Tyburn channel which suffered at least two erosive episodes, with one clearly associated with river (Tyburn) migration. Whereas the upper part of the pre-channel migration deposits were radiocarbon dated to the early Neolithic when thick Alder woodland predominated, those above were dated to the early Historic period (through radiocarbon dates and finds). The pollen from the upper alluvium was also indicative of anthropogenic activity and waste typical of the Historic period. Artefact retrieval from the overlying made ground deposits appear to date reclamation of the area to the early post medieval period.

If further fieldwork (e.g. archaeological trenches) are undertaken prior to or as part of the construction phase, it is recommended that a watching brief by a geoarchaeologist is undertaken on the works to record and, if possible, sample the deposits and underlying palaeo-topography to nuance the deposit models of this Tyburn/Thames confluence. Notwithstanding further fieldwork however, further analysis work is recommended as the geoarchaeological component of the site thus far is considered worthy of publication. The overall decision if any further work is required rests with the Local Authority however.

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1.1 Site background

1.1.1 The UKHM Victoria Gardens site (VWG19) comprises 0.25 ha, bounded to the east by the River Thames, to the west by Millbank, to the north by Black Rod's Garden and to the south by the Millbank and Lambeth bridge junction. At present, the site is an open public garden, with the Buxton Memorial located in the east of the park. The site is generally level, ranging from 4.5m OD to 4.8m OD. The centre of the site lies at National Grid reference (NGR) 530260 179180 (Fig 1).

1.1.2 A Desk-Based Assessment (DBA) (Atkins, 2018) and a Report on geoarchaeological monitoring of geotechnical work (MOLA, 2019a) were previously prepared for the site. These documents should be referred to for information on the natural geology, archaeological and historical background of the site (including initial deposit modelling of the site).

1.2 Planning background

1.2.1 The planning and legislative background to the site is summarised in the previous Written Scheme of Investigation (WSI) (MOLA, 2019).

1.3 Origin and scope of the report

1.3.1 This report was commissioned by Atkins on behalf of the client and produced by MOLA (Museum of London Archaeology). The report has been prepared within the terms of the relevant standards specified by the Chartered Institute for Archaeologists (CIFA, 2014).

1.3.2 The aim of the present document is to assess the potential of the sediments sampled and recorded within the geoarchaeological site investigation phase with the purpose of reconstructing the site's depositional history and varying past environments as a whole. Thus, the conclusions presented in the previous geoarchaeological report (MOLA 2019a) will be updated and refined and recommendations will be made for further off site analysis work if deemed appropriate.

2 Geoarchaeological background

2.1.1 The site lies on the wider floodplain of the River Thames at the confluence of the Thames and one of its tributaries, the Tyburn, flowing from the west. The British Geological Survey (BGS) indicates the site is positioned on alluvial deposits accumulated within the wider Thames floodplain (http://mapapps.bgs.ac.uk). In general, the deposit sequence within the floodplain area consists of the basal floodplain gravels overlain fine grained minerogenic silt/clays and occasionally peats, all capped by made ground deposits. The site is relatively flat. Ground levels are relatively uniform around 4.5m above Ordnance Datum (AOD).

2.1.2 The floodplain gravel that underlies the site (the Shepperton Gravel) was deposited in a network of braided, ephemeral channels at a time when the Thames (and Tyburn) had similar characteristics to those flowing in arctic regions today. Within the wider floodplain, sand and gravel bars accumulated, forming an irregular surface topography. This gravel aggradation is thought to have ceased by 15 000 BP (Wilkinson et al 2000).

2.1.3 The gravel surface topography was often later modified by sand deposition, which took place as a result of changes in the river regime, as the climate warmed and river flow slackened at the Pleistocene/Holocene interface. The sand, which is typically found to be banked–up against areas of higher gravel or occupying lower-lying braided channel threads, appears to be of Late Glacial to early Holocene date. It frequently ‘fines–up’ and passes laterally into clayey sand to sandy clay and in higher gravel areas forms eyots (small islands) such as Thorney Island, where Westminster Abbey and the Palace of Westminster are now located, just to the north of the site. Along the Lower Thames, Mesolithic flints have been found within and at the surface of bedded sands for example at North Woolwich (Spurr, 2015); with findings of Neolithic ard marks on the Hopton or Bermondsey eyot (Ridgeway, 1999); and the Early Neolithic grave and Bronze Age hearth at Yabsley Street (Coles et al 2008).

2.1.4 The current, general model for the landscape evolution for the Lower Thames floodplain area was proposed by Bates and Whittaker (2004) and furthered by Stafford et al (2012), see Table 1. The model suggests that, following the deposition of the floodplain (Shepperton) gravel and before the impact of rising relative sea level (RSL) was felt in this part of the Lower Thames Valley, a period of landscape stability existed in the early Mesolithic when soils developed in the Shepperton Gravels and other pre-Holocene deposits. As estuarine conditions migrated upstream the silts and clays of marsh environments began to accumulate in the later part of the Mesolithic. Widespread peat subsequently developed during the Neolithic and earlier Bronze Age, with a switch to brackish conditions in the Iron Age and the deposition of minerogenic deposits continuing into the historic period.

2.1.5 The Bates and Whittaker model (2004) suggests that where the topography of the ‘pre- (or early) Holocene template’ lay below –6m OD it was a wetland area at least by the late Mesolithic; by the early Neolithic land around –2m OD was inundated; and by the late Neolithic to early Bronze Age surfaces below 0m OD were inundated (Stafford et al 2012). Such wetland expansion caused islands of higher land to be created such as Thorney Island, as the surrounding lower-lying land turned to marsh and mudflats. These islands may have become targeted for exploitation and are often associated with evidence for prehistoric activity. The remains of timber structures, built to access and/or traverse the wetland are also occasionally found in the surrounding peat deposits.

2.1.6 In the vicinity of the confluence of the Thames and Tyburn, the ancient environment (during the Holocene) is considered to be a mosaic of sandy channels, shallow pools and wetland, which probably existed here from the later prehistoric until subsumed beneath tidal mudflats during the medieval period (Nicholls et al 2018).

2.1.7 Although the site would not have been suitable for habitation at the time, it may have been used for early wetland exploitation as artefacts largely from the Bronze Age or possibly earlier have been found locally (Atkins, 2018). Only from the early Medieval period was the local area developed with the construction of Westminster Abbey (ibid, 2018).

2.1.8 By the 16th Century, reclamation had expanded southwards with early maps showing a water mill (Abbott's mill) and a slaughterhouse and yard in the north of the site. It is also likely that during this period some form of river wall existed.

2.1.9 Evidence of waterfront structures dating to the 17th Century have been recorded to the north of the site in Black Rod's Garden (PLW14) (MOLA, 2015). By the mid-18th Century, historic maps show the site being occupied by various wharves, comprising of large, irregularly planned warehouse buildings, interspersed by lanes and alleys to the river front.

2.1.10 Following the destruction of Westminster Palace by fire in 1834, the land south of Victoria Tower was developed into a public open space.

2.1.11 By the early 20th century, the full extent of the site had been reclaimed from the River Thames.

Table 1: Stages of Lower Thames sedimentation and environment (ka=1000years) (Bates and Whittaker 2004)

Stage	Time period	Characteristics
1 Late Glacial	(1a) 30-15ka BP	Late glacial period; low sea level; reworking of river terraces under periglacial conditions; downcutting by river greatest at Glacial Maximum (height of cold period) 18ka BP.
	(1b) 15ka-10kaBP	Valley infilling and deposition of Shepperton gravels; late glacial braided channel system; high fluvial energy.
2 Early Holocene	10 – 6/7ka BP	Early Period of landscape stability across floodplain; low fluvial energy; complex vegetation mosaics; sedimentation largely sand bodies within river channels and areas of localised peat growth. Mesolithic and early Neolithic occupation.
3 Middle Holocene	6/7 - 5 ka BP	Major landscape instability; sea level rise associated with extensive flooding (initially freshwater then brackish); expansion of wetland environments across previously dryland areas; mainly minerogenic sedimentation (clay/silts); numerous temporary and ephemeral landsurfaces existing within flooded zone. Neolithic period.
4 Late Holocene	5 - 3ka BP	Apparent sea level fall and associated reduction of tidal influence; period of organic sedimentation under brackish conditions (Alder carr peat development) equating with Devoys Tilbury III; expansion of wetland environments inland; topographic variation lost. Neolithic / Bronze Age.
5 Later Holocene	3-1ka BP	Final submergence of floodplain with minerogenic (clay/silt) sedimentation dominating; no organic sedimentation; brackish tidal conditions as tidal head moves up Lower Thames. Late Bronze Age; Iron Age; Roman; early medieval periods.
6 Later Holocene	1ka BP - present	Human manipulation of floodplain (flood defences and drainage channels); sedimentation rates reduce. Medieval post-medieval periods.

3 Geoarchaeological investigation methodology

3.1 On site methodology

3.1.1 The previous geoarchaeological report (MOLA 2019a) identified areas of particular interest including where the sands overlying the Pleistocene deposits are highest (MOLA_BH01) and the lower, conjectured channel areas, where the palaeoenvironmentally rich Holocene alluvial deposits were thickest (MOLA_BH03B). In between these two boreholes a third borehole (MOLA_BH02) was placed to recover material on the slope between the high and low gravel areas.

3.1.2 A team supplied by the client drilled the 3 boreholes with a Terrier rig fitted with a windowless core sampler, under the supervision of a MOLA Senior Geoarchaeologist. The boreholes were drilled to the surface of the Pleistocene sand and gravel deposits or underlying geology in accordance with the WSI (MOLA 2019).

3.1.3 The core columns were drilled through the Holocene sequence and sediments recovered in 1m long plastic tubes. The deposits were preliminarily logged before being labelled and sealed and transported back to the MOLA geoarchaeological laboratory. The deposits were described using standard sedimentary criteria (relating to colour, compaction, texture, structure, bedding, inclusions, and clast-size).

3.1.4 The client's surveyors recorded the location of the boreholes to the OS grid, with m OD obtained for the top of the boreholes.

3.1.5 The locations of the boreholes are illustrated in Fig 2.

3.2 Off-site methodology

3.2.1 The following procedures were carried out on each core sample as appropriate.

Sediments

3.2.2 All the core samples were split, cleaned and described, using standard sedimentary criteria, as outlined in Jones et al (1999). This attempts to characterise the visible properties of each deposit, in particular relating to its colour, compaction, texture, structure, bedding, inclusions and clast-size. For each profile the depth and nature of the contacts between adjacent distinct units was noted.

3.2.3 The geoarchaeological boreholes were correlated with the previous geotechnical data to update the facies model presented in the previous geoarchaeology report (MOLA 2019b). A cross-section was drawn through the data points and correlations were made between key deposits which were then interpreted into facies (a series of site-wide deposits which are representative of certain environments).

3.2.4 The Rockworks data was then transferred to an Arc GIS v.10 and Surfer programmes through which updated topographic plots of the early Holocene surface were created in 2D and 3D. This programme gives an approximation of the topography of the site as it existed at the beginning of the Holocene period (i.e. the early Mesolithic, c 10 000 years ago) and its development over time. The modelled elevation of the early Holocene surface is shown in Fig 4& Fig 5.

Finds

3.2.5 Fragments of finds were found in each borehole and, in this section, they are described and, if possible, provide approximate dates.

Dating

3.2.6 Sub-samples of organic material were taken from the top of the organic strata and the bottom of the overlying silts in borehole MOLA_BH03B in order to extract plant macrofossils for Accelerator Mass Spectrometry (AMS) 14C (radiocarbon) dating (Table 3). The AMS 14C dating was carried out by Beta Analytic, Florida, USA.

Ecological Remains

3.2.7 Natural deposits surviving within different boreholes were sub-sampled (see Table 3) for microfossil (ostracod and pollen) and plant macrofossil remains which were submitted to external and MOLA specialists for assessment, in order to identify the preservation quality, range and abundance of environmental remains and their potential for past environment reconstruction.

Synthesis of Results

3.2.8 The results of the different types of assessment outlined above have been drawn together in this geoarchaeological report. This has produced an outline of the development of the site and an assessment of its potential for further archaeological and palaeoenvironmental investigation.

4 The geoarchaeological investigation

4.1 Introduction

4.1.1 The geoarchaeological investigation comprised of 3 boreholes (MOLA_BH01B, MOLA_BH02 and MOLA_BH03B) placed on a north/south axis through the site, located following the results of the geotechnical work (MOLA 2019a) which identified areas of greatest geoarchaeological interest. The boreholes were designed to both allow detailed characterisation of the stratigraphy and to assess the palaeoenvironments the different layers represented. Indeed, the primary objective of the assessment was to analyse the sediments to assess the quality and potential of any surviving geoarchaeological deposits or remains across the site.

4.2 Lithostratigraphy

4.2.1 The recovery of material in all boreholes was exceptionally good. All the boreholes are shown in the transect (Fig 3) with their locations illustrated in Fig 2. In order to facilitate their description and subsequent assessment and discussion, the sediments have been grouped into 'facies' or sediment types which reflect different depositional environments. The deposit sequence in each borehole is described and the results are presented below.

Table 2: Sediments recorded in the geoarchaeological boreholes, MOLA_BH01B, MOLA_BH02 and MOLA_BH03B.

MOLA_BH01B						
Land surface at: m OD			4.48		NGR: 530260, 179229	
Depth below ground level		**Elevation m OD**		**Thickness**	**Description**	**Interpretation**
0.00	0.15	**4.48**	**4.30**	0.15	Turf over very dark grey gravelly silt with fragments of red brick glazed ceramic pipe and white glazed tile	Made ground
0.15	1.40	**4.30**	**3.05**	1.25	Friable pale greyish brown gravelly sandy silt with flint pebbles, CBM, white and blue glazed pottery, mortar flecks and oyster shell fragments.	
1.40	1.60	**3.05**	**2.85**	0.20	Firm 10YR 5/2 greyish brown silty clay	
1.60	2.40	**2.85**	**2.05**	0.80	Loose fragments of red and yellow brick mortar in a sandy matrix	
2.40	3.00	**2.05**	**1.45**	0.60	Loose becoming compact 10YR 7/3 very pale brown coarse sand and subangular to angular flint gravel (granular to medium)	
3.00	3.40	**1.45**	**1.05**	0.40	Compact 5YR 4/3 reddish brown gritty silt with mortar and yellow and red brick fragments interspersed with bands of crushed yellow and red brick	
3.40	3.95	**1.05**	**0.50**	0.55	Compact bands of 10YR 2.5/1 black organic silt with oyster shell fragments and fine fragments of brick interspersed with a crushed brick layer (3.57 to 3.64m bgl) and loose 10YR 2.5/1 black sand layer with tile fragments and oyster shell at base	
3.95	4.10	**0.50**	**0.35**	0.15	Firm 10YR 3/4 dark yellowish brown fine sandy silt with fragments and oyster shell, pottery and gravel (foreshore deposit?)	Alluvium
4.10	5.15	**0.35**	**-0.70**	1.05	Soft odorous predominantly 10YR 3/1 very dark grey silty clay with occasional snail	

					shell fragments throughout	
5.15	5.86	**-0.70**	**-1.41**	0.71	Soft odorous predominantly 10YR 3/1 very dark grey sandy silty clay with occasional snail shell fragments throughout and occasional defined coarse sand band	
5.86	7.00	**-1.41**	**-2.55**	1.14	Loose 10YR 5/2 greyish brown coarse sand and granular to medium subangular to rounded flint gravel	Pleistocene Gravel

MOLA_BH02						
Land surface at: m OD		4.45			NGR: 530261,179180	
Depth below ground level		**Elevation m AOD**		**Thickness**	**Description**	**Interpretation**
0.00	0.20	**4.45**	**4.25**	0.20	Turf over very dark grey gravelly silt with fragments of red brick, glazed ceramic pipe and white glazed tile.	Made ground
0.20	0.95	**4.25**	**3.50**	0.75	Friable mid brownish grey sandy gravelly silt with cobble sized fragments of CBM, rare glass fragments, rare medium coal fragments and rare cobbles of pale yellow sandstone.	
0.95	1.10	**3.5**	**3.35**	0.15	Loose 10YR 5/1 grey silty sand with concrete and yellow brick fragments	
1.10	1.40	**3.35**	**3.05**	0.30	Firm 10 YR 5/3 brown silty clay	
1.40	1.60	**3.05**	**2.85**	0.20	Loose 10 YR 3/2 very dark greyish brown silty sand with frequent granular to medium slag waste fragments	
1.60	1.95	**2.85**	**2.5**	0.35	Loose mortar and red brick fragments; large cobble sized red brick fragment at base	
1.95	2.00	**2.5**	**2.45**	0.05	Firm 10 YR 5/2 greyish brown silty clay with brick and mortar fragments	
2.00	3.06	**2.45**	**1.39**	1.06	Loose 10 YR 32/2 very dark brown loamy fine to medium sand with burnt tile, fine brick fragments, ash waste.	
3.06	3.25	**1.39**	**1.2**	0.19	Firm 10 YR 5/2 greyish brown silty clay	
3.25	4.37	**1.2**	**0.08**	1.12	Loose 5 YR 4/3 reddish brown gritty sandy silt with frequent red brick, mortar, tile, chalk and oyster fragments. Glazed pot fragment at base.	
4.37	4.43	**0.08**	**0.02**	0.06	Soft 10YR 5/4 yellowish brown silty clay interspersed with laminations of fine sand.	Alluvium
4.43	5.10	**0.02**	**-0.65**	0.67	Soft 10YR3/1 very dark grey odorous silty clay with fine sand element becoming sandier with depth. Occasional mollusc shells.	
5.10	5.68	**-0.65**	**-1.23**	0.58	Moderately compact 10YR 5/2 greyish brown coarse sand and subrounded to rounded gravel becoming compact, fractured 10 YR 2/1 black coarse sand and angular granular to medium gravel.	Channel migration deposit
5.68	5.89	**-1.23**	**-1.44**	0.21	Soft 10YR 4/1 dark grey silt with laminations of fine to medium sands increasing with depth becoming medium sands with angular to subangular gravel; black and greyish brown coarse sand at base.	
5.89	6.00	**-1.44**	**-1.55**	0.11	Soft 10 YR 4/3 brown silt with occasional coarse greyish brown sand laminations (</=1 cm thick)	Alluvium
6.00	7.00	**-1.55**	**-2.55**	1.00	Compact 10YR 3/1 very dark grey medium to coarse sand with frequent medium angular to subrounded gravels becoming fine subangular to angular gravels with depth.	Pleistocene Gravel

MOLA_BH03B						
Land surface at: m OD		4.95			NGR: 530259, 179081	
Depth below ground level		**Elevation m AOD**		**Thickness**	**Description**	**Interpretation**
0.00	0.15	**4.95**	**4.80**	0.15	Topsoil	Made ground
0.15	1.53	**4.80**	**3.42**	1.38	Loose 10YR 5/1 grey sandy silt mortar based material with frequent granular to medium fragments of chalk, fine fragments of CBM, cobble sized fragments of brick and roadstone at base.	
1.53	1.75	**3.42**	**3.20**	0.22	Firm 10 YR 5/3 brown silty clay.	
1.75	2.00	**3.20**	**2.95**	0.25	Crumbly 10YR 4/2 dark greyish brown moist, slightly organic gritty silt with cobble sized fragments of yellow and plum coloured bricks.	
2.00	2.20	**2.95**	**2.75**	0.20	Void.	
2.20	2.85	**2.75**	**2.10**	0.65	Loose cobble sized fragments of yellow coloured brick.	
2.85	3.05	**2.1**	**1.90**	0.20	Loose matrix of 10YR 6/2 light brownish grey sand with frequent gravel and concrete fragments	
3.05	4.00	**1.9**	**0.95**	0.95	Soft 10YR 2/2 very dark brown initially sandy silt becoming silty clay mid unit with occasional fine to cobble sized red brick fragments, occasional tile fragments and moderately frequent oyster shell fragments	
4.00	4.40	**0.95**	**0.55**	0.40	Void.	
4.40	5.00	**0.55**	**-0.05**	0.60	Soft 10YrR 3/3 dark brown gritty silty sand with increasingly frequent shell (winkle and oyster), occasional fragments of pot (including single brown glazed ware), occasional chalk fragments.	
5.00	5.25	**-0.05**	**-0.30**	0.25	Soft 10YR 4/2 greyish brown fine sandy silt with frequent snail shells (Fragments and whole)	Alluvium / foreshore deposit
5.25	5.35	**-0.3**	**-0.40**	0.10	Soft 10YR 2/2 black fine sandy silt with fine fragments of mollusc with tile fragments and possible ash or mortar layer at base	
5.35	7.26	**-0.4**	**-2.31**	1.91	Moderately firm N5/5GY 5/1 greenish grey gleyed silts and fine sand bands with rare decayed wood fragments, occasional snail shells (fragmented and whole) seemingly associated with sand bands. Tile fragment around mid-unit (6.58m bgl).	
7.26	7.45	**-2.31**	**-2.50**	0.19	Rounded medium flint gravel in a matrix of medium to coarse sands with fragments of oyster	Channel migration deposit
7.45	7.55	**-2.5**	**-2.60**	0.10	Firm 10YR 2/2 very dark brown organic silt with singular medium size rounded pebble of flint at base	Alluvium
7.55	7.90	**-2.6**	**-2.95**	0.35	Firm 10YR 2/2 very dark brown woody peat	Marsh/fen deposit
7.90	8.48	**-2.95**	**-3.53**	0.58	Firm 10YR 2/2 very dark brown organic silt becoming sandy from 8m bgl.	
8.48	9.00	**-3.53**	**-4.05**	0.52	10YR 5/2 greyish brown coarse sand and granular to medium angular to rounded flint gravel.	Pleistocene Gravel

4.3 The subsamples

4.3.1 On the basis of the lithological assessment, subsamples were taken in varying degrees from each of the three MOLA boreholes although the sequence from MOLA_BH03B was selected for the most detailed assessment, given the presence of the palaeoenvironmentally rich peat and organic silt layers at depth. The subsamples taken from the cores were as follows (locations of palaeoenvironmental and C14 subsamples can also be seen in Fig 3).

Table 3: Subsamples from Victoria gardens MOLA boreholes

MOLA_BH01B subsamples						
Depth (m BGL)	**Elevation (m OD)**	**Ostracods**	**Pollen**	**C14**	**Plant Macro**	**Finds**
4.05	0.43					
4.20	0.28	O8				
4.60	-0.12					
4.90	-0.42					
4.98	-0.50	O9				
5.25	-0.77					
5.50	-1.02	O10				
5.80	-1.32					

MOLA_BH02 subsamples						
Depth (m BGL)	**Elevation (m OD)**	**Ostracods**	**Pollen**	**C14**	**Plant Macro**	**Finds**
3.90	0.55					Pot glazed
4.60	-0.15					
4.90	-0.45	O6				
5.05	-0.60					
5.75	-1.30					
5.95	-1.50	O7				

MOLA_BH03B subsamples						
Depth (m BGL)	**Elevation (m OD)**	**Ostracods**	**Pollen**	**C14**	**Plant Macro**	**Finds**
4.45	0.50					Pot
5.10	-0.15	O1				
5.32	-0.37					Tile
5.42	-0.47					
5.45	-0.50	O2				
5.62	-0.67					
5.70	-0.75	O3				
5.90	-0.95					
6.05	-1.10					
6.30	-1.35	O4				
6.65	-1.70					Tile
6.95	-2.00		P1			
7.20	-2.25	O5	P2	VWG19-2.25OD		
7.50	-2.55		P3			

7.60	-2.65		P4	VWG19-2.65OD		
7.65	-2.70				PM3	
7.75	-2.80		P5			
7.85	-2.90				PM2	
7.95	-3.00		P6			
8.25	-3.30		P7			
8.45	-3.50		P8		PM1	

4.4 Finds

4.4.1 Finds that were recovered from the borehole cores were washed and given to MOLA specialists (Nigel Jefferies, pottery, and Ian Betts, ceramic building material) to identify and date if possible. See Table 3 for locations.

4.4.2 From MOLA_BH01B a fragment of what was initially thought to be pottery was seen in the top of the alluvial deposit at 4.05m bgl (0.45m AOD) - considered to be part of a foreshore (beach) deposit. This fragment was tentatively described as a degraded piece of a clay tobacco pipe which, if correct, dates to the post medieval period, from the 17th century onward (Higgins, D 2017).

4.4.3 More definitively, a glazed pottery fragment was recovered from the base of the made ground in MOLA_BH02 at 3.90m bgl or 0.55m AOD. This fragment was defined as Rhenish stoneware which dates to between the 15th and 16th centuries.

4.4.4 From MOLA_BH03B, three fragments of brown coloured glaze ware was found at 4.45m bgl (0.50m AOD) near the base of the made ground, which was identified as regionally and locally produced redwares, which again date to post medieval period, specifically the 16th and 17th centuries.

4.4.5 Finally, two pieces of ceramic building material (tile fragments) were recovered from the alluvium / foreshore deposit in MOLA_BH03B. These were identified as Roman tile with the lower fragment (at 6.65m bgl or -1.70m OD) dating to AD120 and 250 and the higher one (at 5.32m bgl or -0.37m OD) paradoxically dating to AD50-160. The inverse dating with respect to the stratigraphic position of the tiles could be explained by the erosive and depositional cycles occurring on the foreshore mixing the finds, as is evident along the Thames today.

4.5 Radiocarbon dating

Introduction

4.5.1 After death, living organisms cease carbon exchange with the biosphere and the naturally occurring radioactive isotope of carbon in the organism (14C) begins to decay to form the stable element 14N. Measuring the ratio of the amount of 12C to the 14C in a sample enables the amount of radioactive decay to be quantified and the age of the death of the organism to be determined.

4.5.2 The radiocarbon determination or conventional radiocarbon age, quoted with a plus or minus error, reflects the number of radiocarbon years before 1950 ('the present' [BP]) based on an assumed constant level of 14C in the atmosphere. The radiocarbon determination is sometimes called the raw radiocarbon age to avoid confusion with a true calendar date. The error (e.g. ± 40) represents the statistical uncertainty or 'precision' of the method (a range of 2 relative standard deviations from the mean [2σ]).

4.5.3 Since the level of 14C in the atmosphere is known to have varied through time radiocarbon ages need to be 'calibrated' in order to convert them to the calendar timescale; this is done using a 'calibration curve' of records of past atmospheric 14C. Calibrated ages are expressed as a 95% confidence date range (i.e. there is a 95% confidence that the true calendar age lies within the range) expressed in years 'cal BC' or 'cal AD'. Since the calibration curve is not a straight line and features several 'wiggles' and 'plateaus', a single radiocarbon age may intercept the curve in several places, and therefore return multiple date ranges

Method

4.5.4 Two samples consisting of the remains of the above-ground parts of terrestrial plants were extracted from the MOLA_BH03B core. The samples extracted from the top of the peats (at -2.65m OD) just below the gravelly layer (lying between -2.30 and -2.50m OD) and from the base of the alluvium, lying over the gravels at -2.25m OD. The samples were radiocarbon dated by Beta Analytic Inc, Florida, USA. All the dates are conventional radiocarbon ages (Stuiver and Polach 1977) and are quoted in accordance with international standards (Stuiver and Kra 1986). The samples were prepared using an acid-alkali-acid pre-treatment to remove carbonates and extraneous humic acids.

4.5.5 Radiocarbon ages were calibrated to the calendar timescale using OxCal 4.3 (Bronk Ramsey 1995, 2001, 2017), and the internationally agreed calibration curve for the northern hemisphere IntCal13 (Reimer et al 2013). The calibrated date ranges cited in Table 4 are quoted in the form recommended by Mook (1986) and have been calculated according to the maximum intercept method (Stuiver and Reimer 1986).

Results and Discussion

4.5.6 The results of the radiocarbon dating are presented in the table below.

Table 4: Radiocarbon dates

MOLA sample reference	Lab code	Depth (m bgl)	Height (m OD)	$\delta^{13}C$ (‰) (IRMS)	Radiocarbon age (BP)	Calibrated age range
VWG19-2.25OD	Beta-535043	7.20	-2.25	-25.2	1200 +/- 30	765 - 940 cal AD (1185 - 1010 cal BP)
VWG19-2.65OD	Beta-535044	7.60	-2.65	-27.6	5070 +/- 30	3956 – 3796 cal BC (5905 – 5745 cal BP)

4.5.7 The results of the radiocarbon dating have demonstrated that the peat in BH03B ceased to accumulate during the early Neolithic period (between 3956 – 3796 BC). In contrast, sandy silts lying over the gravels in BH03B (above the peat) dated to the later Saxon period (765 - 940 AD).

4.5.8 The broad time span across a relatively small gap between the samples (0.40m or so), coupled with the presence of a thin gravelly intervening layer, indicates an erosive event most probably by a migration of the southerly branch of the Tyburn.

4.6 Biostratigraphy: Pollen

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Introduction

4.6.1 A pollen assessment has been carried out to establish if sub-fossil pollen and spores are present and if so to provide preliminary palaeoecological information. The study was successful and palynological data has been obtained from the UKHM Victoria Gardens site. Sediment from three distinct phases has produced information on the past vegetation and environment of deposition of the River Tyburn and its surrounds. These data are compared with other local sites.

Method

4.6.2 Standard pollen extraction techniques were used on sediment sub-samples of 1.5ml. volume (Moore and Webb 1978; Moore et al. 1992). Pollen (assessment) sums ranging from 300 and 500 pollen grains coming from dry land plants plus extant marginal and aquatic taxa were counted. Fern spores and miscellaneous palynomorphs were also identified and counted for each sample level. These chemical preparation procedures were carried out in the Palaeoecology Laboratory of the School of Geography, University of Southampton and identification and counting was carried out using an Olympus biological microscope with Leitz optics at magnifications of x400 and x1000.

4.6.3 A pollen diagram has been constructed (Fig 6 & Fig 7) using Tilia and Tilia Graph. Percentage calculations used for the sum and sub-groups are as follows.

Sum =	% total dry land pollen (tdlp).
Marsh/aquatic =	% tdlp + sum of marsh/aquatics.
Spores =	% tdlp + sum of spores.
Misc. =	% tdlp + misc. pre-Quaternary etc

4.6.4 Pollen taxonomy, in general, follows that of Moore and Webb (1978) in some cases modified according to Bennett et al. (1994). These procedures were carried out in the Palaeoecology Laboratory of the Department of Geography and Environment, University of Southampton. An extensive reference/comparative collection of modern pollen types was available for identification of taxa where necessary.

Results

4.6.5 Three distinct local pollen assemblage zones (l.p.a.z.) have been recognised in this 1.5m profile. These are characterised from the base of the sequence upwards in *Table 5*.

Table 5: Local pollen assemblage zones for MOLA_BH03B.

Pollen zone	Palynological characteristics
l.p.a.z. 3 *7.35m to 6.95m bgl* *(-2.40m to -2m OD)* Quercus-*Poaceae-Cerealia*	This upper zone is delimited by a sharp reduction in *Alnus* from l.p.a.z. 2 to c. 10%. There are also increasing values of Poaceae (to c. 40%) and a range of other herbs/taxonomic diversity. This includes Cereal type, *Centaurea cyanus, Papaver, Cannabis* type, Chenopodiaceae and *Plantago lanceolata*. Trees/shrubs show an increase in Quercus (to 30% max) with Corylus avellana (8%) and small numbers of Betula (to 4%) and *Pinus* (1-2%). Marsh/fen taxa show an expansion of Cyperaceae (c. 10%) with *Potamogeton* type and *Pediastrum*. A single intestinal parasite (Ascaris) cyst is noted at 7.20m.
l.p.a.z. 2 *7.85m to 7.35m bgl* *(-2.90m to -2.40m OD)* Alnus-Quercus	*Alnus* attains high values (80%) with rising values of *Quercus* (10-25%) and *Corylus avellana* type (to 10%). *Betula* and *Pinus* of the preceding zone are much reduced. There are small numbers of *Ulmus* and *Tilia*. There are few herbs contrasting with preceding l.p.a.z. 1. Poaceae and Cyperaceae values are minimal.
l.p.a.z. 1 *8.45m to 7.85m bgl* *(-3.50m to -2.90m OD)* Betula-Pinus-*Poaceae-Cyperaceae*	Herbs are dominant with high values and taxonomic diversity especially in the basal sample. Poaceae (to 60%) and Cyperaceae (50% sum + marsh). Other herbs include *Sanguisorba officinalis, Plantago maritima* and *Saxifraga ssp*. and a diverse range of other taxa. Trees and shrubs comprise declining values of Betula from 15% in the basal level top to <5% in the upper zone. In contrast, *Pinus* value increase to 27%. *Juniperus* (to 4%) is of note. *Salix* (to 3%) is consistent. Pollen of *Alnus* and *Corylus avellana* type is incoming at the upper zone boundary. Freshwater *Pediastrum* is present in low numbers (1-2% Sum + Misc.). There is a peak of reworked pre-Quaternary palynomorphs at the top of the zone (alluvial sediment?).

Discussion

4.6.6 The three pollen assemblage zones represent three contrasting vegetation environments and appear to be from three contrasting periods. That is, with sedimentary hiatuses or phases of erosion between the zone. These suggested depositional phases and their vegetation and environment are described but require radiocarbon dating confirmation and such that the data obtained can be compared with existing data and models of environmental change for Central London.

4.6.7 L.p.a.z. 1: This basal zone is suggested as being late-glacial (Younger Dryas; ZIII; Loch Lomond re-advance spanning into the early Holocene, post glacial (Pre-Boreal; Flandrian Ia). A possible second alternative is transitional from the Older Dryas (Zone 1) into the Allerod (Zone II/ Windermere interstadial) (less likely).

4.6.8 This phase shows a largely open herbaceous habitat, especially in the basal sample which has a greater floral diversity with a range of largely heliophilous herbs referable to a number of different habitats. These include:

- Disturbed ground with Artemisia (mugwort), Plantago major (greater plantain).
- Grassland including Poaceae (grasses), Ranunculus type (buttercups), Rumex (docks), Asteraceae types.
- Tall herbs and damp pasture with Sanguisorba officinalis (greater burnet), Thalictrum (rue), Filipendula (meadowsweet), and Succisa pratensis (meadow scabious).
- Dwarf/Arctic/Alpine. Occasional Saxifraga spp., Wahlenbergia and ?Primulaceae.
- Halophytes. Occasional Plantago maritima (sea plantain) and possibly Chenopodiaceae (goosefoots/oraches).
- Marsh and aquatic: Grass-sedge fen with Cyperaceae (sedges), Alisma plantago-aquatica (water plantain), Typha latifolia (common bulrush); Typha angustifolia (bur reed and/or greater reedmace). Aquatic habitats are evidenced by Nymphaea alba (white water lily), Potamogeton/Triglochin type (pond weed or water milfoil) and algal freshwater Pediastrum.

4.6.9 During this basal phase, Betula (birch) was initially present but declines with Pinus (pine) apparently becoming more important. This suggests that some woodland existed, however, both are high pollen producers and anemophilous such that pollen may be over represented in pollen profiles and, may come from more regional and long distance sources. This fact and the importance of herbs suggest that the habitat, as described, was a diverse and largely open environment. In addition to these trees, Juniperus (juniper), Salix (willow) and occasional dwarf shrubs - Calluna (ericaceous/ling) are noted.

4.6.10 Overall, this pollen zone probably represents a late-glacial into early Holocene transition showing change from open herbaceous vegetation communities to transitional, pioneer birch and pine woodland. Interestingly, juniper remains and is an indication that this phase may in fact be earlier in the late-glacial (e.g. Zone I - II). If the former age is correct, the diverse range of herbs in the basal level may also suggest that this area remained partially open well in to the early Holocene.

4.6.11 L.p.a.z. 2: After a hiatus (or erosional phase), alder (Alnus glutinosa) became dominant on site as floodplain alder carr (Alnetum) woodland. The nature of this woodland being dense will have inhibited the extent of the airborne pollen catchment and as such, the taxa recovered relate to the on, and near site vegetation community. As such, there is a paucity of herbs and a small representation of the other communities. Oak (Quercus) and hazel (Corylus avellana) appear to have been expanding throughout this period. Small numbers of lime (Tilia) indicate some local presence. That is because lime pollen is very poorly represented in pollen spectra being entomophilous and/or the taphonomy of pollen in this closed environment. Here, Alnus is included in the main pollen sum and with its very substantial numbers, the within sum values/percentages have been suppressed. Any further analysis would consider this autochthonous component separately (Janssen 1969). Small numbers of elm (to which the latter argument also applies) are present at the start of this zone and it may be tentatively understood that this middle phase may be transitional from the middle Holocene to late-prehistoric Neolithic at c. 5,500-5,000BP. There is no evidence of human activity in terms of plant taxa or woodland clearance.

4.6.12 In summary, Alder carr woodland was dominant on site. Surrounding woodland comprised oak and hazel (also possibly on drier areas of the floodplain) and lime and initially some elm. Absence of anthropochorous taxa and evidence of woodland disturbance is absent making suggested ages difficult.

4.6.13 L.p.a.z. 3: The upper alluvial sediment is represented by only two samples. The pollen assemblages show that there was a significant shift from the alder woodland of zone 2 to an expanding and wetter, grass-sedge fen. Because of the broad sample interval used in this assessment study, it is not clear whether this was a transitional change or whether there was a further cessation of sedimentation and a hiatus between pollen zones 2 and 3.

4.6.14 The characteristics of this upper unit are typical of the most recent phases of the Thames and its tributaries with floodplain alluviation and sediment accumulation over late-prehistoric (Bronze Age) peat. This was asynchronous from the early historic period onwards often seen as a negative hydrosere with increasing herb fen due to increasing wetness caused by regional rising relative sea level and consequent brackish/marine transgression, ponding back of freshwater systems and rising ground water table. Although there is little palynological detail, this appears to be the case here. Values of Chenopodiaceae (goosefoot, orache and samphire) are higher in these levels and may be attributed to halophytes from salt marsh or mud flat. Diatoms may indicate whether there were incursions of brackish water at this time. The pre-Quaternary palynomorphs attest to reworking, transport and deposition of earlier sediment probably through overbank flooding.

4.6.15 The on-site vegetation, as noted, showed a marked reduction in the alder carr to low levels; probably as it was pushed away from the immediate site by the rising water table. The wetter conditions are shown by freshwater algal Pediastrum cysts and increased fen taxa: grasses (Poaceae), sedges (Cyperaceae), reedmace/bur reed (Typha and/or Sparganium) and Potamogeton. The latter may be pondweed or also Triglochin (arrow grass), If the latter, possibly a salt marsh halophyte or from freshwater fen.

4.6.16 The terrestrial zone will be better represented than for zone 2 with the increased likelihood of fluvially transported pollen from farther afield. Oak and hazel remained the most important woodland components, probably from regional managed woodland. This has been seen in many London profiles spanning the historic period. Increase in pine (Pinus), albeit small, is diagnostic of its over representation in fluvial environments. Spruce (Picea) is an interesting occurrence of this non-native conifer. This appeared not to be reworked from earlier pre-Quaternary of interglacial sediment and is one of an increasing number of records from London which may be attributed to long distance marine transport or from planting of exotics by Roman and later immigrants (Scaife 2000a, 2004).

4.6.17 Whilst the arboreal flora is much reduced in this probably Roman or later phase, the herb pollen flora becomes typically more diverse and includes here, the first evidence of cereal cultivation and associated arable weeds such as blue cornflower (Centaurea cyanus). However, it can be noted that an egg of the intestinal parasite (helminth) Ascaris cf lumbricoides (roundworm) is present and there is, therefore, the strong possibility that the arable component may derive from human or animal faecal remains. Grassland is indicated by a range of herbs including ribwort plantain (Plantago lanceolata) and others including a proportion of the grass pollen also attributed to the on-site fen habitat. Cannabis type pollen comprises both hop (Humulus lupulus) and hemp (Cannabis sativa). Either may be represented here as cultigens, the former obviously for brewing and the latter for hemp fibre. Hop is also a native of lowland alder fen woodland. It can be noted that hemp is more commonly found in Saxon and medieval contexts.

4.6.18 This most recent phase shows a change from floodplain woodland to open herb-dominated floodplain, grass-sedge fen with alluvial sedimentation. There is some tentative evidence that there may have been brackish water/tidal influences. There is also, a possibly a hiatus between local pollen zones 2-3. Additional pollen/stratigraphical detail is required. This upper zone had a wider pollen catchment with fluvially transported pollen. Dating to the historic period, there is evidence of arable cultivation and grassland with a background of remaining oak and hazel woodland. It is probable that some of the cereal pollen may derive from faecal material dumped in the channel and floodplain.

<u>A brief comparison with existing pollen data</u>

4.6.19 Sites within Victoria-Westminster proximity, which may be useful for comparison include; Westminster sites at Joan Street, St Stephens East, Palace Chambers South, Storeys Gate on the Jubilee Extension Line (Scaife 2000a); Thorney Street (Scaife 2001), Westminster Theatre (Scaife 2005); Cromwell Green and New Palace Yard (Greig 1992), Broad Sanctuary (Scaife 1982) and Victoria Station (Scaife 2013a,b, 2014).

4.6.20 Three distinct periods/phases are present in this profile and have been described. Perhaps the most unusual is the basal unit which has been attributed to the late Devensian cold stage and/or the very early post-glacial period. There are few sites in London which provide information on this important glacial/interglacial transition. Existing, and comparable data come only from Bramcote Green, Bermondsey (Thomas and Rackham 1996); Silvertown (Scaife 2000b; Wilkinson et al. 2000), Point Pleasant, Wandsworth (Scaife 1998, 2003). The latter has a date of 9410+/-100 BP and 9620+/-80 BP. These similarly show the dynamic biogeography associated with temperature amelioration at c.10, 000 BP. That is, change from heliophilous, largely herb communities of Arctic-Alpine affinity to colonisation by pioneer woodland (birch and pine).

4.6.21 Sites with the initial local dominance of Betula and/or Pinus woodland in the early Holocene include Peninsula House, City of London (Scaife 1983), Three Ways Wharf, Uxbridge (Lewis et al. 1992), Bramcote Green, Bermondsey (Thomas and Rackham 1996) (see above) and Silvertown (Scaife 1996, 1998; Wilkinson et al. 2000). Unpublished sites include Elizabeth Fry which has peat dated to 9,000-8,500 BP (Scaife 1995; Davis et al. 1995), Ferry Lane, Brentford (Scaife 2000c); Strathfield Road (Scaife 1995b; Giorgi et al. 1995) dated to 9270 +/-60 BP (Beta-76897), Meridian Point (Scaife 1997) and Point Pleasant, Wandsworth (Scaife 1998, 2003).

4.6.22 Change from birch woodland ascribed to the late glacial interstadial (Allerod/Windermere) into the Younger Dryas (Zone III; Loch Lomond Re-advance is noted at Bramcote Green (Thomas and Rackham). Expansion of pine at Victoria Gardens after decline of birch may well be from long distance transport and deposition in a more open environment. Thus, it is not altogether clear whether the profile is wholly late-Devensian/late-glacial age or transitional into the Holocene and radiocarbon dating and possibly additional pollen analysis is needed for this important phase. Whichever the case, this site holds useful palaeo-biogeographical records for this early period (late Palaeolithic/early Mesolithic).

4.6.23 The importance of alder carr floodplain during the middle Holocene (Atlantic; Flandrian II) has been seen at many Thames/tributary sites in the Central London region. At Victoria, such a habitat is seen at Alnus) growing on, or very close to the sample site, also perhaps on the banks of the river channel. At other Westminster sites such a habitat is seen along the Jubilee Line Extension at Storeys Gate, Palace Chambers South, St Stephens East, Union Street (Scaife 2000a) at Rotherhithe (Sidell et al. 1995), Silvertown (Scaife 2000b, 2002), Westminster Theatre (Scaife 2005) and Victoria Circle Line (Scaife 2014).

4.6.24 The most recent phase of alluviation, accompanied by significant palynological changes, is widespread along the Thames and in the lower part of its tributaries (Devoy 1979, 1980, 1982; Scaife 2000a, 2000b). This is commonly accompanied by decline in woodland with oak and hazel the remaining regional elements of managed woodland and on-site evidence of marine/brackish incursion. Increase in cereal pollen and weeds of arable affinity frequently become more important with changing pollen taphonomy and increased pollen catchment through fluvial transport.

4.6.25 As noted values of cereal pollen and associated segetals (weeds of arable ground such as blue cornflower/Centaurea cyanus) may also derive directly from cultivation or from secondary sources. The latter may include domestic waste such as waste food and human and animal ordure and offal that was disposed of in suitable places such as river channels, pits and ditches. This was noted at Victoria Line extension and at the nearby Tudor age sediment at Broad Sanctuary, Westminster. The latter contained high values of cereal pollen from such sources and also numerous eggs of the intestinal parasites. A cyst of the latter was recovered here in zone 3 (also noted at Victoria Circle Line extension; Scaife 2014).

4.7 Biostratigraphy: Plant macrofossils

Anne Davis

Introduction

4.7.1 During geo-archaeological investigations at VWG19, samples were collected from peats contained within a borehole (MOLA_BH03B) for the potential recovery of biological evidence (including macro-plant remains and insects) and information on the character of the local environment and possibly anthropogenic activities during the accumulation of this deposit.

Methods

4.7.2 Three bulk samples were taken from the base, middle and top of a woody peat deposit in borehole MOLA_BH03B, namely (from bottom to top), PM1(at -3.50m OD or 8.45m bgl), PM2 (at -2.90m OD or 7.85m bgl) and PM3 (at -2.70m OD or 7.65m bgl).

4.7.3 The samples were wet sieved through a 0.25 mm sieve, and the resulting residues examined microscopically. The abundance, diversity and general nature of plant macrofossils and any faunal remains were recorded. The waterlogged plant remains and their abundance are shown in Table 6.The samples were divided into fractions using a stack of sieves for ease of scanning and the environmental remains recorded using a binocular microscope (with a magnification of up to x40). Item frequency and species diversity of biological materials were recorded using the following rating system of 1 to 3.

Frequency: 1 = 1-10 items; 2 = 11-50 items; 3 = 50+ items

Diversity: 1 = 1-4 species; 2 = 5-7 species: 3 = 7+ species

Results

4.7.4 The results of the plant macrofossil assessment from MOLA_BH03B are listed below.

Table 6: Plant macrofossils from Victoria Gardens

Latin name	**Common name**	**Depth in borehole BGL (m)**		
		8.45	**7.85**	**7.65**
Bryophyta indet.	moss fragments	x		x
Chara sp.	-	x	x	
Ranunculus acris/repens/bulbosus	buttercups			x
Ranunculus sceleratus L.	celery-leaved crowfoot	x		
Lychnis flos-cuculi L.	ragged robin		x	
Alnus glutinosa (L.) Gaertn.	alder catkins		xx	x
A. glutinosa (L.) Gaertn.	alder seeds		xx	x
Corylus avellana L.	hazel nut shell fragments			x
Rubus spp	blackberry/raspberry			x
Oenanthe aquatica (L.) Poir	fine-leaved water-dropwort		x	x
Apiaceae indet.	-	x		
Urtica dioica L.	stinging nettle		x	
Menyanthes trifoliata L.	bogbean	x	x	
Sambucus nigra L.	elder		x	x
Alisma sp.	water-plantain		x	x
Potamogeton sp.	pondweed	x	x	x
Juncus spp.	rushes	x		
Sparganium erectum L.	branched bur-reed		x	x
Eleocharis palustris/uniglumis	spike-rush	x		
Schoenoplectus lacus./tabernae.	club-rush	xxx	x	
Carex spp.	sedge	x		
indeterminate	monocot stem fragments	xx		
indeterminate	wood fragments		xxx	xxx
item frequency: x = 1-10 items; xx = 11-50 items; xxx = 50+ items				

Discussion

4.7.5 The results are discussed from the basal sample upward.

4.7.6 PM1 (-3.50m OD or 8.45m bgl): The sample residue consisted mainly of laminated peat, with occasional fine pebbles. Stem fragments from monocotyledonous plants such as reed or sedge, were present, as were occasional rootlets and moss. A moderately large assemblage of seeds came mainly from club-rush (Schoenoplectus lacustris/tabernaemontani), which lives in or by shallow water, with smaller numbers from other aquatic and marginal plants. Two of these, pondweed (Potamogeton sp.) and stonewort (Chara sp.), are rooted under water, indicating bodies of standing water, while spike-rush (Eleocharis palustris/uniglumis), bog-bean (Menyanthes trifoliata) and celery-leaved crowfoot (Ranunculus sceleratus) are characteristic of swamps and reed beds. No wood was seen in this sample, and no seeds of dry-ground plants, suggesting that the environment at the time of deposition was open and uniformly waterlogged, probably a reed or sedge swamp.

4.7.7 PM2 (-2.90m OD or 7.85m bgl) : Wood fragments dominated this sample, several of which were identified as alder (Alnus glutinosa). Catkins and a few seeds of alder were also found, along with a moderate number of seeds of other species. These included several of the same species as the previous sample, indicating that the environment continued to contain standing water and marshy areas, but the growth of alder, and also of elder (Sambucus nigra) suggest some drying of the area compared with the lower sample. The presence of still or slow-flowing freshwater was confirmed by the presence of a number of opercula from the common Bithynia snail (Bithynia tentaculata).

4.7.8 PM3 (-2.70m OD or 7.65m bgl): This sample was similar to that immediately below it, being again dominated by wood fragments, with both seeds and catkins of alder. Other seeds recovered, from plants including water dropwort (Oenanthe aquatica), branched bur-reed (Sparganium erectum) and (Alisma sp.) indicate that still or slow-moving water was still present, though perhaps not throughout the year as these plants can tolerate temporary drying. Opercula from the aquatic Bithynia snail were again present. Occasional seeds of elder, bramble (Rubus sp.) and hazel (Corylus avellana) suggest that scrubby woodland, perhaps on areas of relatively dry ground, was increasing by this time.

4.8 Biostratigraphy: Ostracods and Foraminifera

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Introduction

4.8.1 Ten subsamples taken from three boreholes, (BH01B, BH02 and BH03B), were assessed for microfaunal ostracods and foraminifera remains (Table 3). The purpose of this work was to produce a palaeoenvironmental assessment of the borehole sequence.

Methods

4.8.2 Each sediment sample was first broken up into very small pieces by hand, placed in a ceramic bowl and dried in the oven. When dry, hot water was poured over it and with a little sodium carbonate added (to disperse the clay fraction) the sample was left to soak overnight. The sample was then washed through a 75µm sieve with hand-hot water, the remaining residue being decanted back into the bowl for final drying in the oven. Once dry, each residue was stored in a labelled plastic bag before examination. Examination was achieved by placing the residue into a nest of small sieves (>500 µm, >250 µm, >150µm with a pan underneath to capture the

<150µm fraction). A little of each fraction was then sprinkled onto a picking tray and the residue examined under the microscope. A representative fauna of ostracods and foraminifera was picked out into a 3x1" faunal slide for archive purposes.

4.8.3 A representative selection of material from each sample (foraminifera, ostracods and other sub-fossil material of potential environmental value) was picked out into 3x1" plastic faunal slides and recorded on a presence/absence basis (see tables below).

Results

4.8.4 BH01B

The site of this borehole is c. 150m south of Black Rod's Garden, the microfauna of which had formed a previous environmental assessment (Whittaker, 2015). The results from a 1.3m section are shown in Table 7 and show a wide variety of organic remains, most of it freshwater covering what are probably various environments from the Tyburn River itself and associated marshland. There is also a brackish component indicative of mudflats, indicating the Tyburn/Thames was tidal at this point. The scenario is very similar to that found in the sediments examined from Black Rod's Garden.

Table 7: BH01B ostracod and foraminifera assessment

ORGANIC MATERIAL			
SAMPLE NO:	O8	O9	O10
Depth	4.20m bgl/0.28m AOD	4.98m bgl/-0.50m OD	5.50m bgl/-1.02m OD
plant debris + seeds	x	x	x
freshwater molluscs	f	x	x
cladocera	x	x	
freshwater ostracods	x	x	x
brackish foraminifera	x	x	x
brackish ostracods	x	x	
Bithyniaopercula		x	x
testate amoebae		x	
insect remains			x
charophyte stems + oogonia			x
Ecology	*Various freshwater environments marginal to the river, also with low brackish component*		
FRESHWATER OSTRACODS			
Candona neglecta	xx	xx	xx
Limnocythere inopinata	xx	x	x
Ilyocypris bradyi	x	x	x
Pseudocandona rostrata		x	
Cyclocypris ovum		x	
Cypridopsis vidua			x
BRACKISH FORAMINIFERA			
Ammonia(brackish sp.)	x	x	xx
Haynesina germanica	x	o	x
Elphidium williamsoni			x

BRACKISH OSTRACODS			
Leptocythere castanea	**o**		**o**
Leptocythere lacertosa	**o**	**x**	**x**
Contained material is recorded on a presence (x)/absence basis only			
Foraminifera and ostracods are recorded: o – one specimen; x - several specimens; xx – common; xxx – abundant			

4.8.5 BH02

This borehole is located about 60m from BH01. The results of the microfaunal environmental assessment are shown in Table 8. Just two samples were examined here from a 1.05m core section. The upper sample (O6) was very similar to that seen throughout BH01B – a predominately freshwater assemblage (although some of the ostracod species are different) with also a low brackish component (indicative of mudflats). What is really different is sample O7. It is clearly almost entirely freshwater (as also evidenced by freshwater molluscs, bryozoan statoblats and very many small organic spheres, thought to be algal cysts). Only one freshwater ostracod was found, however, and one brackish foraminifer.

Table 8: BH02 ostracod and foraminifera assessment

ORGANIC MATERIAL		
SAMPLE NO:	**O6**	**O7**
Depth	**4.90mbgl/-0.45m OD**	**5.95mbgl /-1.5mOD**
plant debris + seeds	**x**	**x**
insect remains	**x**	**x**
freshwater molluscs	**x**	**x**
freshwater ostracods	**x**	**x**
Bithyniaopercula	**x**	**x**
cladocera + ephippia	**x**	
brackish foraminifera	**x**	**x**
brackish ostracods	**x**	
charcoal		**x**
bryozoan statblasts		**x**
algal cysts		**x**
Ecology	***Marginal to river with low brackish component***	**?**
FRESHWATER OSTRACODS		
Candona neglecta	**xx**	**o**
Limnocythere inopinata	**xx**	
Ilyocypris bradyi	**x**	
Cyclocypris ovum	**x**	
Herpetocypris reptans	**x**	
Darwinula stevensoni	**o**	
BRACKISH FORAMINIFERA		
Ammonia(brackish sp.)	**x**	**o**
Haynesina germanica	**x**	

Elphidium williamsoni	x	
BRACKISH OSTRACODS		
Leptocythere lacertosa	x	
Contained material is recorded on a presence (x)/absence basis only		
Foraminifera and ostracods are recorded: o – one specimen; x - several specimens; xx – common; xxx – abundant		

4.8.6 BH03B

This borehole is situated to the south of BH02, possibly now within the southerly branch of the Tyburn. Here a 2.1m section of core was examined via five samples from -2.25m OD to -0.50m OD (Table 9). Samples O5 up to O2 contained both freshwater and low brackish components, indicating a number of freshwater environments marginal to the Tyburn/Thames, the brackish component suggesting that it was tidal at this point. The uppermost sample at -0.15m OD (O1), on the other hand, was an entirely freshwater habitat with as many as 9 species of ostracod, some of them very abundant (Table 9). Notable is also the occurrence of fish and much stone/brick, in O1. In BH03B, as with the other boreholes, molluscs can be very abundant and diagnostic (bivalves, snails and planorbids).

Table 9: BH03B ostracod and foraminifera assessment

ORGANIC MATERIAL					
SAMPLE NO:	**O1**	**O2**	**O3**	**O4**	**O5**
Depth:	**5.10mbgl/ -0.15m OD**	**5.45mbgl / -0.5mOD**	**5.70mbgl / -0.75mOD**	**6.30mbgl / -1.35mOD**	**7.20mbgl / -2.25mOD**
plant debris + seeds	x	x	x	x	x
charcoal	x	x	x	x	
stone/brick	x				
freshwater molluscs	x	x	x	x	x
Bithyniaopercula	x	x	x	x	x
charophyte stems + oogonia	x	x	x	x	x
fish bone	x			x	
insect remains	x	x	x	x	x
freshwater ostracods	x	x	x	x	x
cladoceran ephippia		x			
brackish foraminifera		x	x	x	x
brackish ostracods		x	x	x	x
testate amoebae				x	
				sandy	
Ecology	***Freshwater habitat***			***Various freshwater environments marginal to the river, also with low brackish component***	
FRESHWATER OSTRACODS					
Candona neglecta	xxx	xx	xx	xx	xx
Pseudocandina rostrata	xxx		xx	x	
Limnocythere inopinata	xx	xx	xx	x	x
Darwinula stevensoni	x	x	x		

Herpetocypris reptans	**x**				
Ilyocypris bradyi	**x**	**x**	**x**	**x**	**x**
Candona angulata	**o**	**o**	**x**		
Potamocyprissp.	**o**				
Cypris ophtalmica	**o**				
Cypridopsis vidua		**x**	**o**		
Cyclocypris ovum			**o**		o
BRACKISH FORAMINIFERA					
Ammonia (brackish sp.)		**xx**	**xx**		**x**
Haynesina germanica		**xx**	**xx**	**x**	**x**
Elphidium williamsoni		**x**	**x**		**x**
BRACKISH OSTRACODS					
Leptocythere lacertosa		**x**	**x**	**o**	**x**
Leptocythere castanea					**o**
Contained material is recorded on a presence (x)/absence basis only					
Foraminifera and ostracods are recorded: o – one specimen; x - several specimens; xx – common; xxx – abundant					

4.9 Synthesis of the results

Introduction

4.9.1 This section discusses the deposits in terms of the identified facies, from the oldest to the most recent, integrating the results of the specialist assessments with the recorded sedimentary characteristics. The facies and lithology recorded within the boreholes are illustrated in the transect drawn across the site (Fig 3). The modelled elevation of the early Holocene surface is shown in Fig 4 & Fig 5.

Facies 1: Pleistocene gravels

4.9.2 The underlying (lowest) sand and gravel deposits seen in the boreholes represent the floodplain gravels ('Shepperton Gravels') of the Thames and its tributaries, which were deposited in the late Pleistocene and are common across the wider floodplain zone. The gravels (facies 1) were dominated by loose greyish brown coarse sand and granular to medium subangular to rounded flint gravel. The importance of this gravel surface topography ('the early Holocene surface' which equates with the early Mesolithic landscape), lies in the fact that it forms a template over and around which the sedimentary architecture of later periods formed during the Holocene, forming the baseline to the geoarchaeological interest across the site.

4.9.3 The modelling indicates the level of the gravels undulates from north to south. To the north of the site, where evidence exists from a previous archaeological study (boreholes with the prefix VTG13, see Fig 2 & Fig 3) and geotechnical boreholes taken during the watching brief (boreholes with the prefix VWG19, see Fig 2 & Fig 3), the Pleistocene gravel surface can be seen dipping northward. Similarly, boreholes from both the watching brief and the current investigation indicate that to the south of the site the gravels dip southward to a maximum of approximately -4m OD before rising up again to approximately -2m OD off site. In contrast, in the middle of the site, the surface of the gravels lie between -2m and -1m OD. The low areas of gravel are thought to define routes of the Tyburn flowing in from the west, dissecting the higher ground (as conjectured by Barton, 2016; see Fig 2).

4.9.4 According to the overall model for the development of the Thames floodplain during the Holocene (Bates and Whittaker 2004), at -4m OD, the lower areas of gravel topography probably became inundated in the later Mesolithic (due to the knock on effect of RSL) with higher areas perhaps remaining high and dry until the Neolithic / Bronze Age periods before being inundated finally in the late prehistoric / early historic periods. The higher areas of gravel could have formed foci for anthropogenic activity and lower areas becoming zones of high palaeoenvironmental potential, infilling with silts, clays and peats.

4.9.5 Indeed, it was the undulating nature of the gravels as seen during the geotechnical works, along with the proposed routes of the Tyburn coupled with the nature of the overlying deposits, which led to the targeting of the southern area of the site by geoarchaeological boreholes that form the basis to this report (MOLA 2019a). The low area around MOLA_BH03B is of particular interest as the Facies 2 deposits (below) reveal. This area probably formed an active, northerly ‘subsidiary’ channel route of the Tyburn which became reactivated in the mid-Holocene (see projected route in Figs 4 and Fig 5).

Facies 2: The Holocene deposits

4.9.6 Facies 2 defines the Holocene sedimentary sequence (Fig 3).

4.9.7 Although facies 2 sediments were successfully retrieved in all boreholes, the deepest and most geoarchaeologically significant Holocene stratigraphic sequence was recovered in MOLA_BH03B to the south of the site (the sands targeted in MOLA_BH01B were not present). Here peats overlying organic silts were recovered lying immediately above the gravels (Table 2 and Fig 3); sediments which were not recovered in any other borehole. These deposits are indicative of low energy, backwater areas, adjacent to a channel, silting up and eventually becoming vegetated. Interestingly, however, the pollen assessment (see lpaz1) indicates the lower organic, slightly sandy silts were laid down in a late-glacial into early Holocene transitional environment showing change from open herbaceous vegetation communities to transitional, pioneer birch and pine woodland. This is a very early and comparatively rare (relative) date for the London area, placing the silts in the late upper Palaeolithic to very early Mesolithic.

4.9.8 The woody peat overlying the silts formed a separate pollen zone (lpaz 2) in MOLA_BH03B. In contrast to the silts below, this environment recorded in both the pollen and the plant macrofossil data indicates the ubiquitous Alder dominated fen / marsh environment (Tilbury III in Devoy, 1979 or Stage 4 in Bates and Whittaker, 2004; Table 1), typical of the middle Holocene Thames. This environment was typically river marginal, drying out in the summer although often underwater at other times, particularly in the winter. The radiocarbon date (Beta- 535044; Table 4) agreed with the relative pollen date placing this environment in the early Neolithic period. It is likely, as mentioned in the pollen assessment, that there was an erosional event between the underlying sandy silts and the peats.

4.9.9 The gravels and sands overlying the peat in MOLA_BH03 most likely represents a migration of the river Tyburn through this area (see the postulated route in Fig 4 & Fig 5) as it reoccupied the previous backwater area. These have been interpreted as 'channel migration deposits' also present in MOLA_BH02, and represent another erosive phase, probably eroding the underlying deposits in both boreholes (Table 2). Although no palaeoenvironmental data was assessed from the sands and gravels, fragments of oyster (MOLA_BH03B, Table 2) tend to indicate a brackish habitat probably as a consequence of being at the confluence with the Thames in the later historic / early historic period (earlier Pleistocene gravels were laid down in a freshwater environment). These deposits probably equate with Stage 5 deposits (Table 1) and possibly formed as the rise in the Thames (due to RSL) altered the flow of the Tyburn. Significantly the date from the alluvial deposits lying directly over the gravels dates to the later Saxon period (Beta-535043; Table 4), substantiating the erosive nature of the gravels and the Stage 5 supposition.

4.9.10 The ostracod assessment of the alluvium overlying the later gravel deposits also indicate brackish (Stage 5) environment in all boreholes. Interestingly, the sample taken from below the channel migration deposit in MOLA_BH02 (O7;Table 8) indicates a wholly freshwater environment prevailing as opposed to O6, above the gravels, although containing predominantly freshwater indicators was also brackish (suggestive of the confluence of the two rivers). The pollen data clearly indicates anthropogenic influences in the upper alluvium from arable weeds, hemp cultivation and intestinal parasites common in Saxon and later contexts. Furthermore, it is of note that the uppermost ostracod subsample, taken just below the made ground in MOLA_BH03B at around Ordnance Datum, is a wholly freshwater environment, indicating the Tyburn provided a freshwater resource well into the historic period.

4.9.11 In terms of the finds recovered from the boreholes in facies 2, two pieces of ceramic building material (tile fragments) were recovered from the alluvium in MOLA_BH03B (between -0.37m OD and -1.70m OD). These were identified as Roman tile dating between AD 50 and 250. Although this apparently conflicts with the Saxon date recovered from plant material at -2.25m OD, the nature of the sediments (silts with sand bands) indicate a foreshore deposit where mixing through erosion and deposition is the norm (which indeed probably accounts for the inverse dating of the tiles with respect to the stratigraphic position although later reuse and discard could also account for this). Nevertheless, the presence of these finds coupled with the radiocarbon dating firmly places these upper silts into the historic period.

Facies 3: Made ground

4.9.12 The three MOLA boreholes and all of the boreholes in the transect (Fig 3) recorded made ground deposits averaging approximately 4.5m thick with the base of made ground at about Ordnance Datum.

4.9.13 Close examination of these deposits in the MOLA boreholes indicates several phases of deposition often mixed with sands or silts, particularly near the contact with the alluvial deposits. At the lower levels this may have just been dumping along or within the doubtless increasingly fetid foreshore / Tyburn channel area, as much of the initial deposits contain food waste (e.g. winkle and oyster shell). Notably, finds material retrieved in at or near the base of the made ground deposits in both MOLA_BH02 and BH03B date from the early post medieval period. This concurs with the information from the DBA (Atkins, 2018) as by the 16th Century, reclamation had expanded southwards with early maps showing a water mill and a slaughterhouse to the north of the site and evidence of waterfront structures dating to the 17th Century recorded further north of the site in Black Rod's Garden (PLW14) (MOLA, 2015).

4.9.14 Further up the profile the made ground deposits become more distinctly brick and mortar, gravel and eventually concrete fragments typical of made ground / demolition deposits. Some of the brick and mortar deposits may relate to the various large, irregularly planned warehouse buildings, interspersed by lanes and alleys to the river front that existed into the mid-18th Century (Atkins, 2018). The concrete fragments relate to the early 20th century and later when the full extent of the site had been reclaimed from the River Thames.

5 Archaeological potential

5.1 Answering original research aims

5.1.1 This section examines the extent to which the original research questions have been answered by the assessment.

- *Confirm the depth of modern disturbance*.

  The previous geoarchaeological report on the geotechnical work (MOLA 2019a) noted that the made ground deposits lay between 0.91m and 4.68m thick which were within the parameters of the thickness of the made ground noted in the MOLA boreholes (approximately 4m in each). There appears little to no geoarchaeological or palaeoenvironmental potential in the made ground deposits although finds extracted from the borehole cores indicated the made ground began to develop from the 16th century.

- *What is the nature and level of the natural topography?*

  Pleistocene floodplain gravels (facies 1) were reached in all the MOLA boreholes. They followed the trend revealed during the watching brief with the surface of the Pleistocene deposits dipping toward the south representing the undulating nature of the early Holocene surface (Mesolithic topography) across the site. The low area of gravels to the south, targeted by the geoarchaeological boreholes, was taken to represent a former channel of the Tyburn running through the site.

- *What is the nature of palaeoenvironmental remains within alluvial deposits from the site?*

  The alluvium (Holocene deposits; facies 2) within the MOLA boreholes was similar to that seen in the geotechnical interventions at the site lying around 3m in thickness. The alluvium and peats were found to have very good palaeoenvironmental preservation. Through the analysis of pollen the Holocene deposits were found to date from the very early Holocene when colder conditions predominated. Radiocarbon dates from the top of the peat in MOLA_BH03B were found to be early Neolithic within a thick Alder carr environment. Interestingly, thin sandy gravel deposits within the Holocene deposits indicated Tyburn channel migration, one of at least two erosive episodes occurring across the site during the prehistoric. Higher silts and clays were found to be historic with pollen and ostracod data indicating a generally brackish, anthropogenically active environment, dated with finds and radiocarbon dating to the Roman and Saxon periods, respectively.

- *Does any evidence for prehistoric or later activity exist within the alluvial sequence?*

  Fragments of ceramic building material were retrieved in the upper alluvial / foreshore deposit in MOLA_BH03B. These were identified as Roman tile dating from AD50 to AD250. Although this apparently conflicts with the Saxon date recovered lower in the alluvium, the nature of the sediments (silts with sand bands) indicate a foreshore deposit where mixing through erosion and deposition is the norm (which indeed probably accounts for the inverse dating of the tiles with respect to the stratigraphic position although later reuse and discard could also account for this

- *What evidence of early exploitation and management of the River Thames and River Tyburn survives on the site?*

The Tyburn migration across the site, although thought more likely to be caused by changes in RSL, could conceivably be due to anthropogenic disturbance or management given the timeframe (historic period).

5.2 General discussion of potential

5.2.1 The recovery of material in all boreholes was exceptionally good. Furthermore the evaluation has shown that the alluvial deposits in particular have high potential for researching environments and environmental change specific to the Tyburn/Thames confluence from the very early Holocene and historic periods.

5.2.2 Post-medieval to modern ground-raising deposits noted across the site are likely to have no palaeoenvironmental potential due to their nature and mode of deposition, although artefactual remains within them have provided a basic chrono-stratigraphy for theses deposits. Post-medieval waterfront structures and associated archaeological remains might still remain within other parts of the site.

5.3 Significance

5.3.1 The geoarchaeological and palaeoenvironmental remains are of considerable local importance, further adding to the current understanding of the River Tyburn and development of the local area.

5.4 Assessment of the evaluation

5.4.1 The three geoarchaeological boreholes taken at Victoria Gardens retrieved excellent core samples which have produced a detailed picture of the confluence area between the Thames and the Tyburn from the very early Holocene through to the modern day.

6 Proposed development impact and recommendations

6.1 Impact of the development

6.1.1 The development proposal for the site is to construct a UK Holocaust memorial in the southern two-thirds of Victoria Tower Gardens. The proposals include the construction of a double basement excavating to at least *c* 10m bgl.

6.1.2 Due to the depth of excavation exceeding the depths of made ground across the site, it is expected that development would impact on the preservation of the Holocene deposits, in places completely removing them.

6.2 Recommendations

6.2.1 If further fieldwork (e.g. archaeological trenches) are undertaken prior to, or as part of the construction phase, it is recommended that a watching brief by a geoarchaeologist is undertaken on the works to record and, if possible, sample the deposits and underlying palaeo-topography to nuance the deposit models of this Tyburn/Thames confluence.

6.2.2 Notwithstanding further fieldwork however, should the opportunity arise, further analysis work is recommended as the geoarchaeological component of the site thus far is considered worthy of publication.

6.2.3 The overall decision if any further work is required rests with the Local Authority however.

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8 OASIS ID: molas1-373159

Project details

Project name	UK Holocaust Memorial, Victoria Tower Gardens
Short description of the project	Geoarchaeological fieldwork consisted of three targeted boreholes sited to retrieve sedimentary deposits across a range of environments noted during the previous geotechnical investigation monitored by MOLA. The deposits consisted of approximately 4m of made ground, 2 to 3.5m of Holocene (mainly alluvial and peat) deposits lying over undulating Pleistocene river gravel deposits dipping into a previous channel of the Tyburn to the south..
Project dates	Start: 29-07-2019 End: 05-08-2019
Previous/future work	Yes / Not known
Any associated project reference codes	VWG19 - Sitecode
Any associated project reference codes	molas1-353452 - OASIS form ID
Type of project	Environmental assessment
Site status	Area of Archaeological Importance (AAI)
Current Land use	Other 15 - Other
Monument type	WATERFRONT Early Mesolithic

Project location

Country	England
Site location	GREATER LONDON CITY OF WESTMINSTER WESTMINSTER UK Holocaust Memorial, Victoria Tower Gardens
Postcode	SW1P
Study area	15000 Square metres
Site coordinates	TQ 30254 79230 51.496486244162 -0.123373556941 51 29 47 N 000 07 24 W Point

Project creators

Name of Organisation	MOLA
Project brief originator	Local Planning Authority (with/without advice from County/District Archaeologist)
Project design originator	MOLA
Project	David Divers

director/manager	
Project supervisor	Graham Spurr
Name of sponsor/funding body	Atkins

Project archives

Physical Archive Exists?	No
Digital Archive Exists?	No
Paper Archive Exists?	No

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	UK Holocaust Memorial, Victoria Tower Gardens, Westminster SW1P. Geoarchaeological evaluation report
Author(s)/Editor(s)	Spurr, G.
Date	2019
Issuer or publisher	MOLA
Place of issue or publication	London
Description	A4 client report

Entered by	G Spurr (gspurr@mola.org.uk)
Entered on	7 November 2019

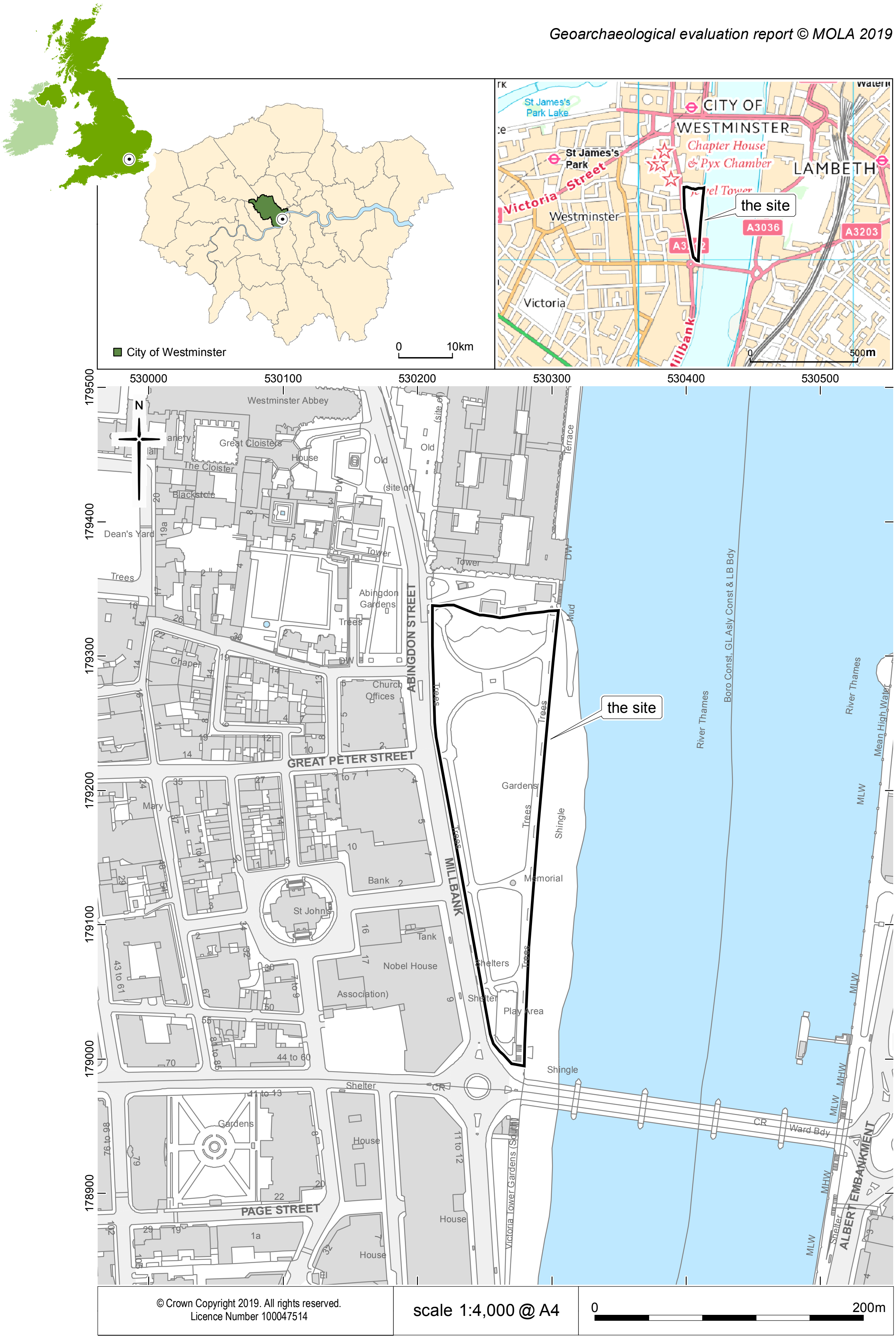

Fig 1 Site location

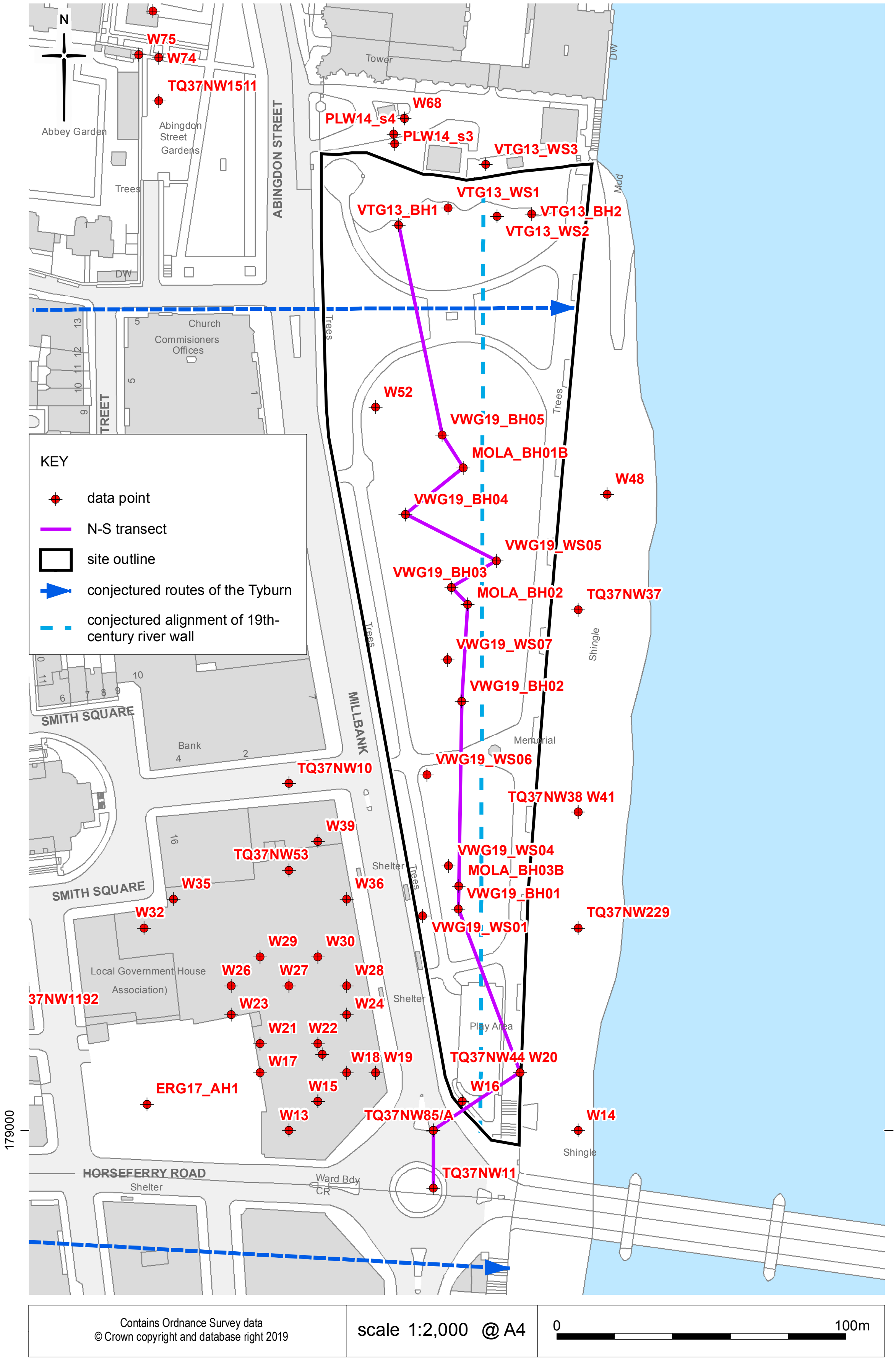

Fig 2 MOLA boreholes, geotechnical interventions and line of transect

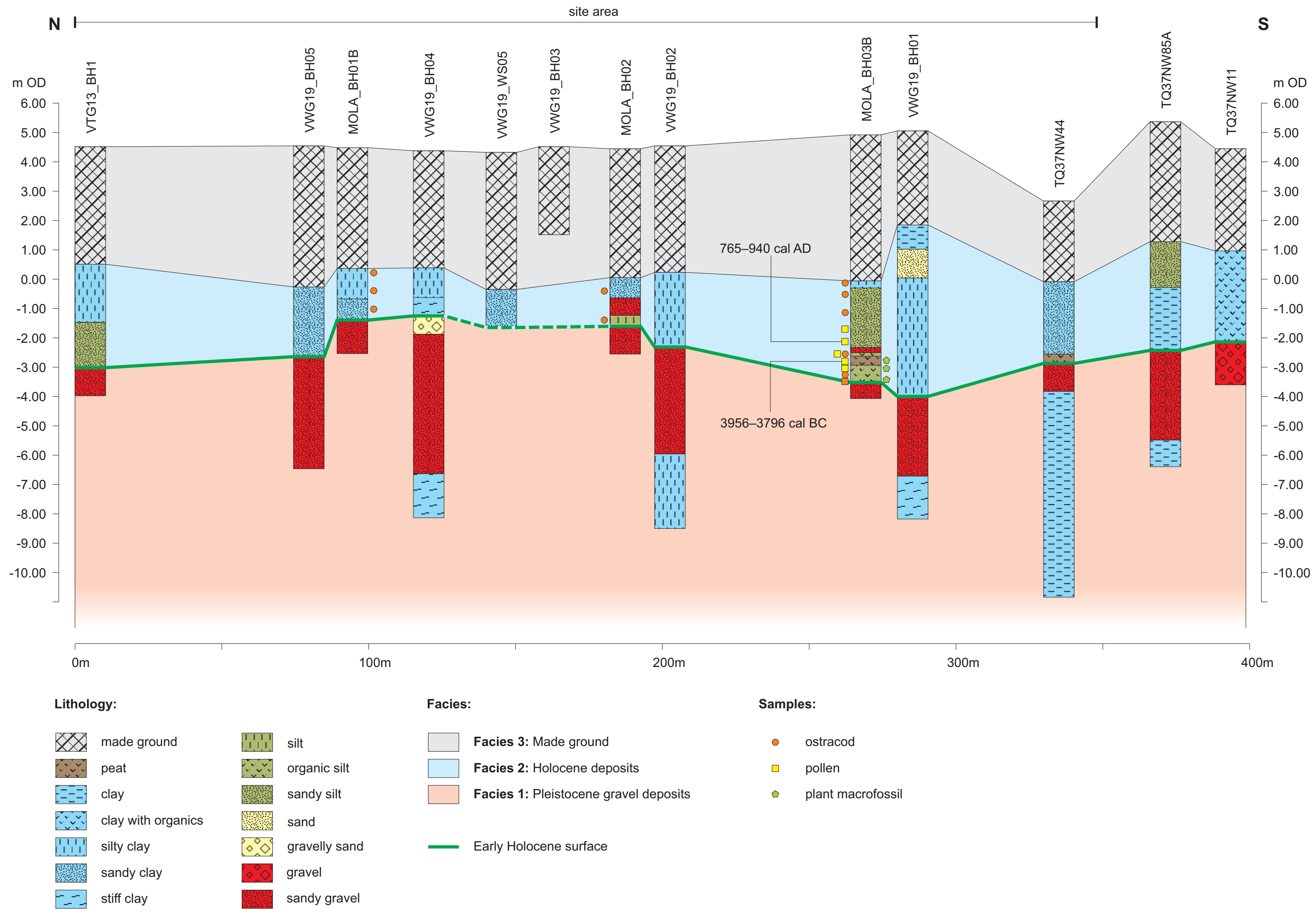

Fig 3 North to south transect across the site showing sample points within MOLA boreholes

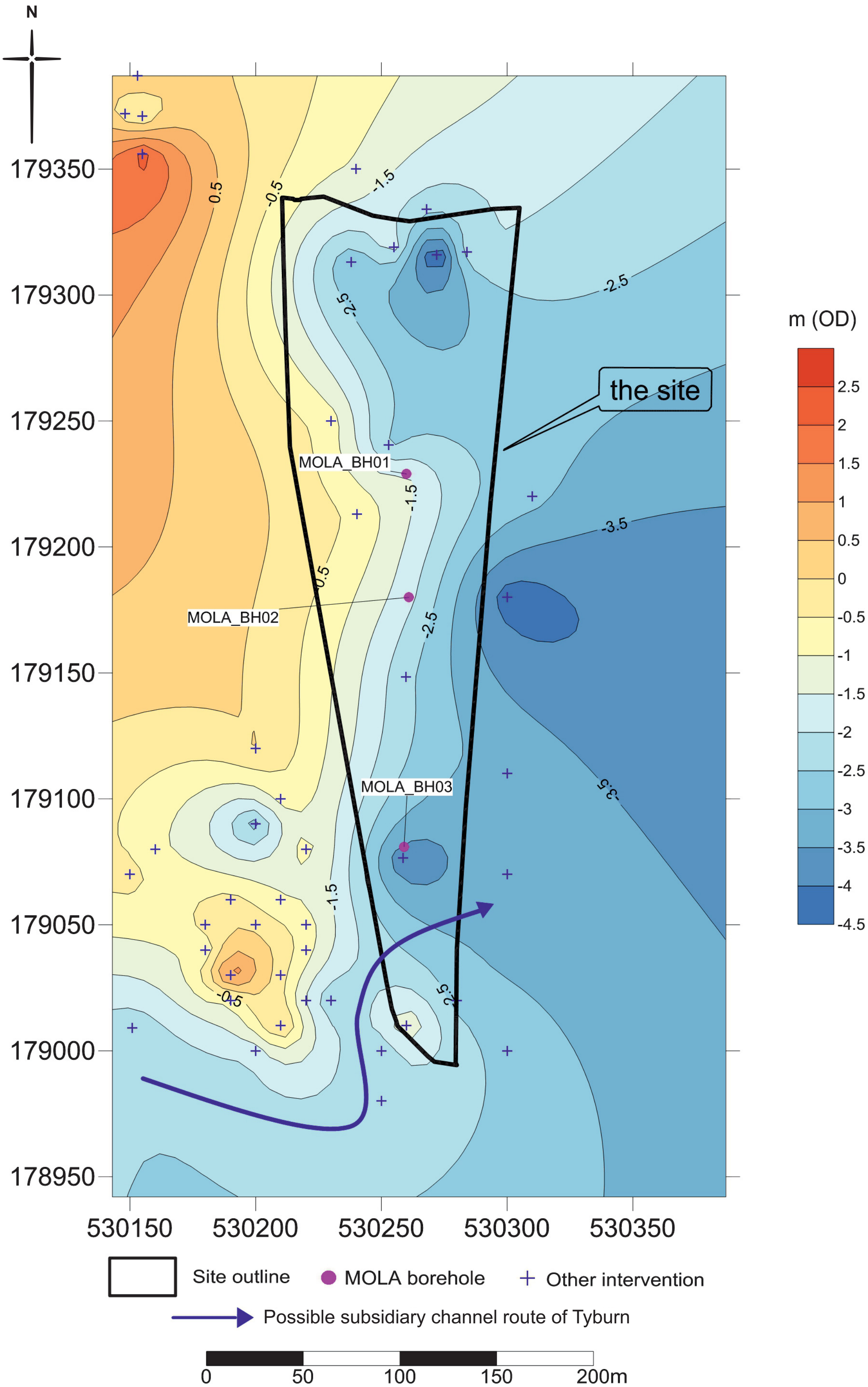

Fig 4 Early Holocene (facies 1) surface 2D

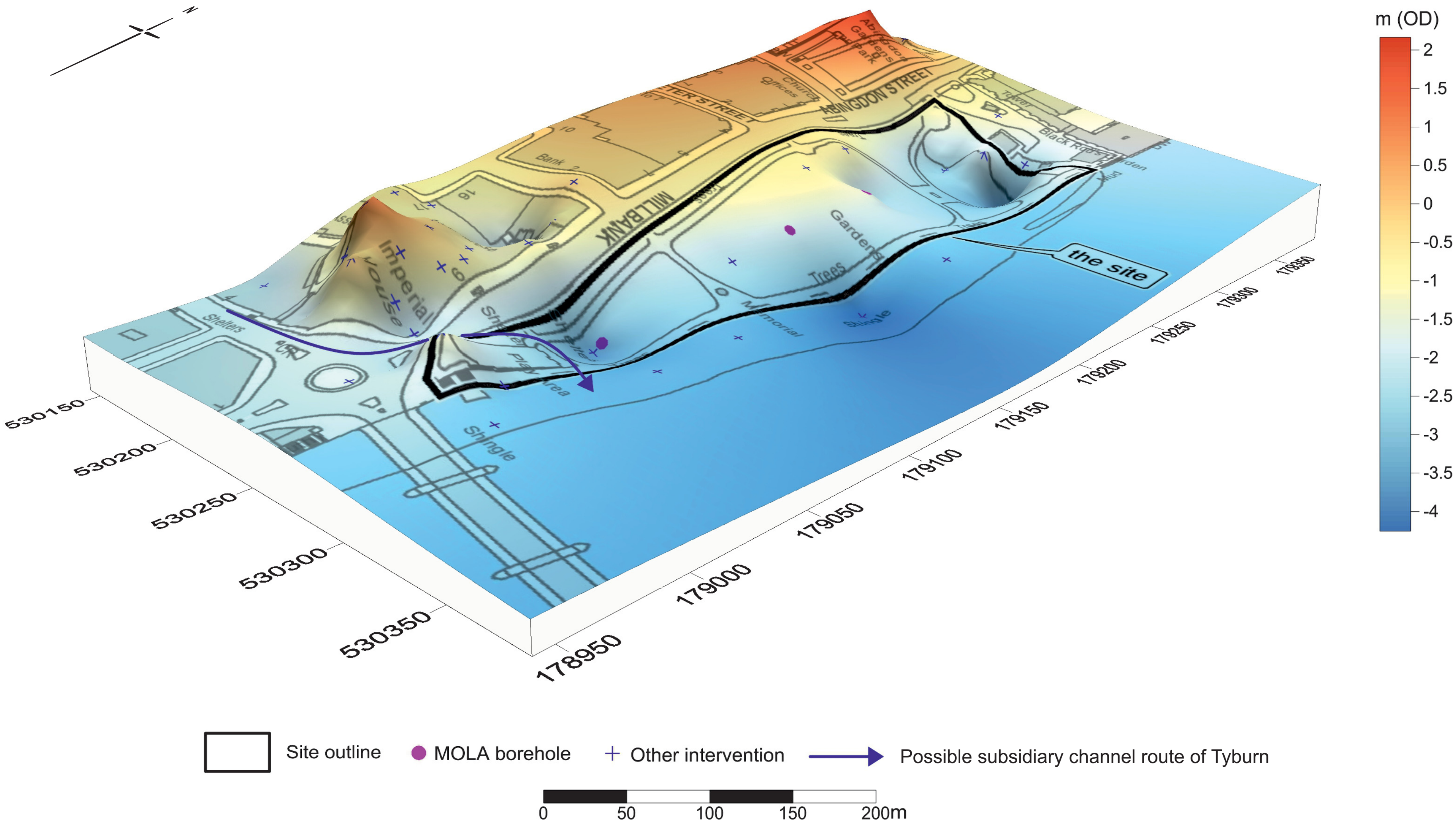

Fig 5 Early Holocene (facies 1) surface 3D

Victoria Gardens

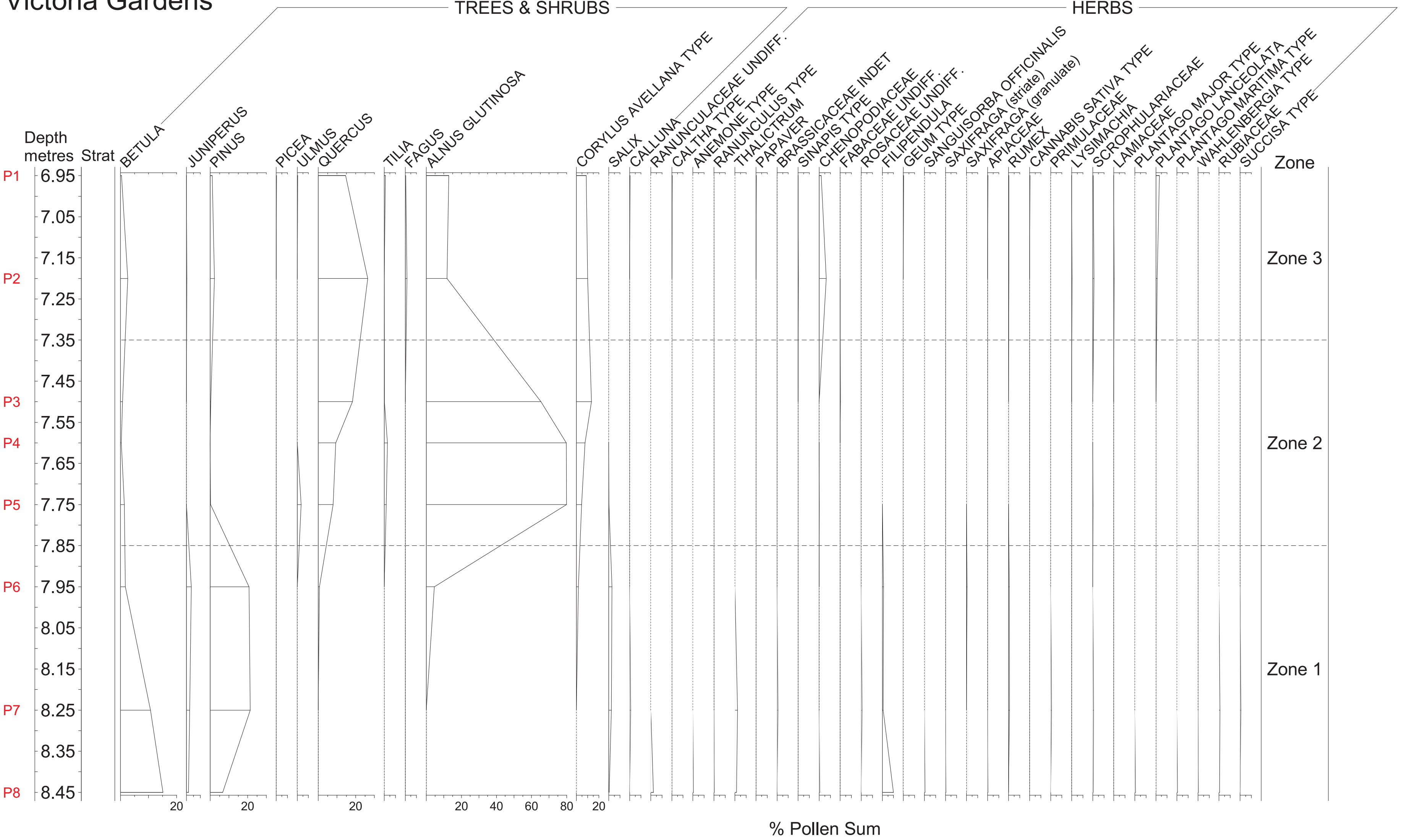

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Fig 6 Pollen diagram

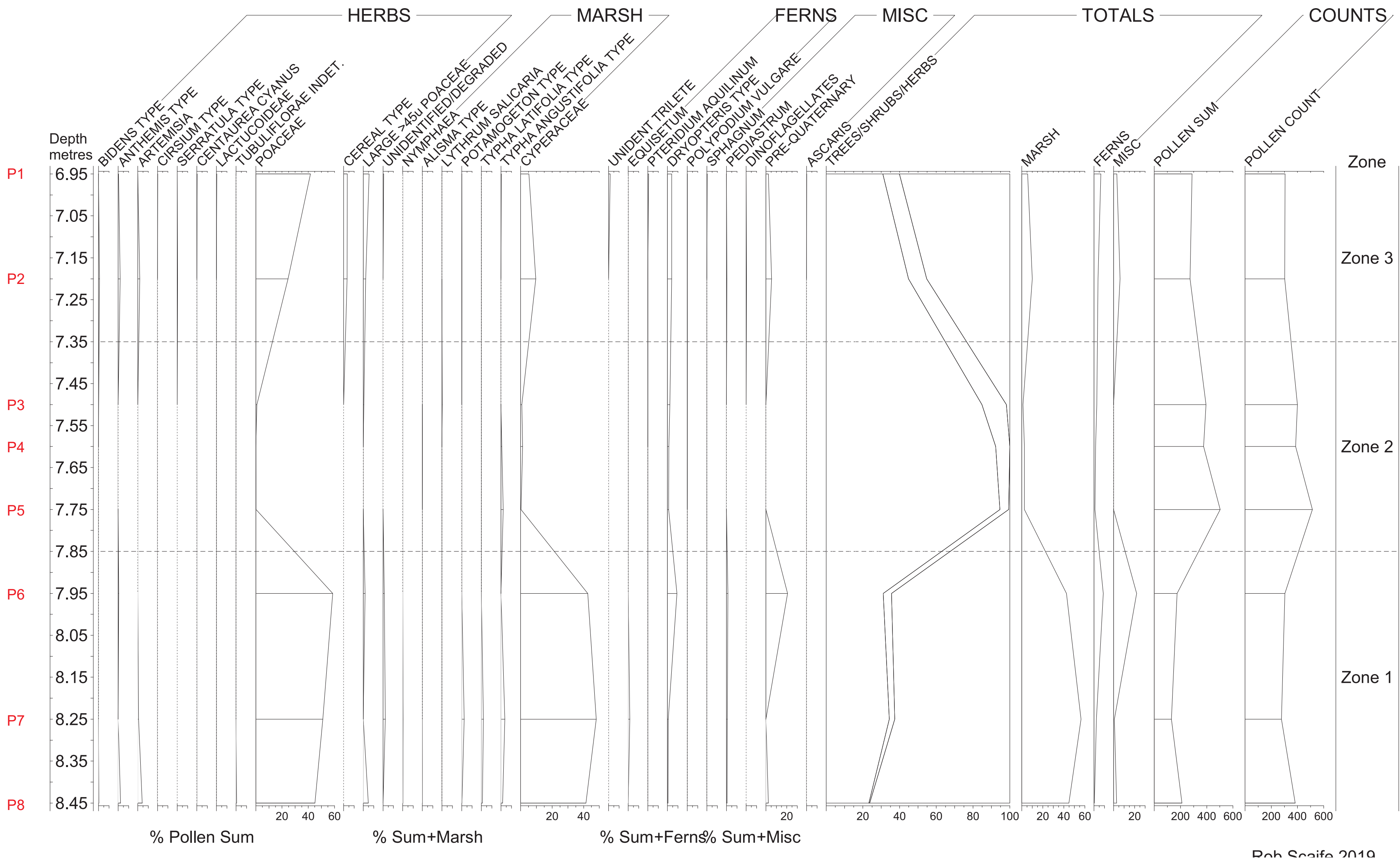

Fig 7 Pollen diagram (cont)

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