QUEST
QUATERNARY SCIENTIFIC

University of Reading

THE REACH, THAMES REACH, ROYAL BOROUGH OF GREENWICH

Geoarchaeological & Palaeoenvironmental Analysis Report

NGR: TQ 45203 79791

Site Code: TMR16

Date: 11th April 2017

Written by: C.R. Batchelor
D.S. Young
T. Hill
C.P. Green

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

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

DOCUMENT HISTORY

REVISION	DATE	PREPARED BY	SIGNED	APPROVED BY	SIGNED	REASON FOR ISSUE
v1	11/04/17	C.R. Batchelor		C.R. Batchelor		First edition

CONTENTS

1 NON-TECHNICAL SUMMARY

Geoarchaeological and palaeoenvironmental analysis was instigated at The Reach, Thames Reach, Royal Borough of Greenwich following the findings of previous field- and assessment work. The aim of the analysis was to fully address the seven original project aims outlined in the Written Scheme of Investigation for the site (Batchelor, 2016) with a specific focus on the environmental conditions during the medieval period.

The results of the investigation have revealed a sequence of Gravels overlain by Alluvium capped by Made Ground. The sequence however, is unique within the Lower Thames Valley for two reasons:

1. Towards the south of the site, peat deposits recorded within the Gravels date to the Bronze Age and Iron Age demonstrating that they cannot be correlated with the Late Devensian Shepperton Gravel as recorded elsewhere across the Lower Thames Valley. Two alternative hypotheses are proposed for its accumulation: (1) that the deposits originated from the erosion of nearby deposits during one or more high-energy flood events during the Late Holocene; or (2) that slope-wash processes led to the redeposition of nearby gravel and peat deposits, perhaps associated with an unusual depression in the surface of the bedrock. It is not possible to state which of these hypotheses is most likely to be correct, nor is it possible to unequivocally ascertain where this Gravel deposit is replaced by the 'usual' Shepperton Gravel.

2. Towards the top of the Alluvium, a clayey peat dating to the medieval period is recorded, isolated to the centre of the northern part of the site. Despite its later age, it occurs at a similar elevation to older and thicker peat horizons recorded more frequently within the alluvial sequence in this area. The peat most likely accumulated in an abandoned saltmarsh creek/channel or similar environment. Such an environment would have encouraged the accumulation of organic material, resulting in the formation of a thin peat unit, spatially restricted to a small area. The feature was probably relatively shallow and eventually became infilled, after which, the transition to mineral-rich alluvium took place as a result of repeated tidal inundation. During its infilling, the saltmarsh creek/channel was probably bordered by reed swamp with limited sedge fen and possibly saltmarsh taxa. As it became infilled however, the local vegetation changed to become more strongly dominated by saltmarsh communities. The surrounding environment was apparently very open with limited trees/shrubs as might be expected during this period. A marginal expansion of woodland is recorded as the feature became infilled, most likely representing pollen influx from a wider area.

No definitive evidence of human activity was recorded within the sequences analysed. The aims and objectives of the project are considered to have been successfully achieved, providing a unique record from this area of the Lower Thames Valley. The results whilst significant, are not considered worth publishing in isolation, but instead should be held for a wider-ranging paper on the depositional history of the Plumstead Marshes.

2 INTRODUCTION

2.1 Site context

This report summarises the findings arising out of the geoarchaeological and palaeoenvironmental analysis undertaken by Quaternary Scientific (University of Reading) in connection with the proposed development of land at The Reach, Thames Reach, Royal Borough of Greenwich (site code: TMR16; NGR centred on: TQ 45203 79791; Figures 1 & 2). Quaternary Scientific were commissioned by CgMs Consulting to undertake the investigations. The site is located *ca*. 300m to the south-east of the current course of the River Thames and approximately 1km north of the margin between the floodplain and dryland edge. The ground across the area originally formed part of the natural floodplain of the Thames, and is underlain by river alluvium (British Geological Survey 1:50,000 sheets 256 North London 1993, 257 Romford 1996, 270 South London 1998, 271 Dartford 1998). This alluvium consists of fine-grained mineral-rich deposits and peat, and is mapped to the south to approximately the position of the A206 where it meets higher, drier ground. Beneath the alluvium, sand and gravel is present representing either the Pleistocene Kempton Park (above *ca*. -2m OD) or Shepperton Gravel (below *ca*. -2m OD) terraces. The bedrock beneath this is mapped as the Palaeogene Lambeth Group – Clay, Silt and Sand.

Formerly, the area encompassed by the site was modelled as part of a geoarchaeological exercise focussed on the Gallions Reach Urban Village by MoLA (1996, 1997). This revealed the presence of six landscape zones (LZ1 to 6), which were determined on the basis of variations in the sub-surface deposits. The current site is located within LZ2, in which the River Terrace Gravels were recorded between -3.1 and -3.4m OD, a relatively high surface when compared to the rest of the modelled area (*ca*. -4 to -6m OD). The overlying sequence was mineral-rich with no distinct peat horizons.

Recent geoarchaeological investigation of the site however, has recorded a stratigraphic sequence that is different to that indicated by the MoLA model (Young *et al*., 2016), and is unique within the Lower Thames Valley. Resting above the bedrock is a sequence of Gravel, overlain by Holocene alluvial deposits capped by variable thicknesses of Made Ground. Significantly, thin peat horizons dating to the Bronze Age/Iron Age are recorded within the Gravel on the southern part of the site, and medieval peat is intermittently present towards the top of the overlying alluvium. The results therefore suggest that the deposits on at least the southern part of the site have been heavily disturbed (probably during the later prehistoric period) and redeposited by processes associated with either: (1) over-deepening of the underlying bedrock, or (2) the erosion and redistribution of nearby sediments during high-energy flood events. The Gravels recorded on at least the southern part of the site therefore cannot be *in situ* Shepperton Gravel. Palaeobotanical assessment of the peat horizons are indicative of different floodplain environments; the assemblages from the peat within the gravel are dominated by tree and shrub taxa, indicative of an alder-dominated fen woodland, whilst the assemblages from the peat within the alluvium are dominated by grasses, sedges and other herbaceous taxa, indicative of a reed swamp or sedge fen. No unequivocal evidence for human activity was recorded in either of the sequences, although the very open environment and cereal-type pollen noted in the uppermost peat is consistent with a medieval age for this part of the sequence.

Several geoarchaeological and palaeoenvironmental investigations have taken place in the local area, including at the Gallions Reach Urban Village site (MoLA, 1996, 1997; Sidell, 2003), Belmarsh West & East (Hart *et al*., 2009), Thamesmead 8J (Branch *et al*., unpublished) Woolwich Trade Park / Pettman Crescent (Batchelor & Young, 2008; Batchelor, 2009), 2-6 Griffin Manor Way (Batchelor, 2012b), Collingtree Park (Branch *et al*., unpublished) and Nathan Way (Batchelor, 2012c). These investigations have revealed considerable variation in the nature and thickness of the major sedimentary units across the local area, with peat deposits of up to 2m thick dating from the late Mesolithic through to the Bronze Age. The new record from the Reach is important as it indicates peat formation also took place intermittently during the medieval period (see section 2.2; Young *et al*., 2016).

2.2 Geoarchaeological, archaeological and palaeoenvironmental significance

The different deposits and thicknesses recorded are important as they represent different environmental conditions that would have existed in a given location. For example: (1) the varying surface of the Shepperton Gravel may represent the location of former channels and bars; (2) the presence of peat represents former terrestrial or semi-terrestrial land-surfaces, and (3) the alluvium represent periods of changing hydrological conditions. Thus by studying the sub-surface stratigraphy across the site in greater detail, it will be possible to build an understanding of the former landscapes and environmental changes that took place across space and time. As above, the new records from the Reach are particularly significant, as they indicate gravels apparently redoposited during the later prehistoric period and the intermittent presence of medieval peats; a combined occurrence which is thus far unique in the Lower Thames Valley.

The deposits also have high potential to provide a detailed reconstruction of prehistoric environments on both the wetland and dryland. In particular, there is the potential to increase knowledge and understanding of the interactions between hydrological change, human activity, vegetation succession and climate in this area of the Lower Thames Valley. In this case, the medieval peat is of particular interest as there are so few occurrences of it in the area. Such investigations are carried out through the assessment/analysis of palaeoecological remains (e.g. pollen, plant macrofossils & insects) and radiocarbon dating. So called palaeoenvironmental reconstructions have been carried out on the sedimentary sequences from Gallions Reach Urban Village site (MoLA, 1996, 1997; Sidell, 2003), Belmarsh West & East (Hart *et al*., 2009), and Woolwich Trade Park / Pettman Crescent (Batchelor & Young, 2008; Batchelor, 2009).

Finally, areas of high gravel topography, soils and peat represent potential areas that might have been utilised or even occupied by prehistoric people, evidence of which may be preserved in the archaeological (e.g. features and structure) and palaeoenvironmental record (e.g. changes in vegetation composition). Whilst apparently predating the deposits recorded on the Reach site, significant nearby findings include, a possible Early Neolithic trackway and associated structures were discovered within the peat at Belmarsh West, *ca*. 500m to the south of the present site (Hart *et al*., 2009).

2.3 Aims and objectives

The Geoarchaeological Written Scheme of Investigation originally outlined the following research aims for the site (Batchelor, 2016a):

1. To clarify the nature of the sub-surface stratigraphy across the site
2. To clarify the nature, depth, extent and date of any former land surfaces, alluvial and peat deposits;
3. To clarify the presence of peat deposits within the River Terrace Gravels.
   NB this aim may not be possible to achieve due to the difficulties of drilling through and retaining gravel deposits.
4. To compare the results of the investigation to the Gallions Reach Urban Village model, and those of nearby sites.
5. To investigate whether the sequences contain any artefact or ecofact evidence for prehistoric or historic human activity;
6. To investigate whether the sequences contain any evidence for natural and/or anthropogenic changes to the landscape (wetland and dryland);
7. To integrate the new geoarchaeological record with other recent work in the local area for publication in an academic journal.

The preceding geoarchaeological fieldwork and assessment reports have either in part or fully addressed aims 1 to 6; aim 7 is yet to be considered.

The investigations have therefore identified an apparently unique sequence with no known parallels in this area of the Lower Thames Valley. However, it is unlikely that further investigation of the samples retained from the site can provide any more information on the processes of disturbance in the southern area of the site. Due to the redeposited nature of the sequence, no further palaeoenvironmental investigation of the peat horizons within the gravel will therefore be carried out. However, further analysis aimed at ascertaining the processes that led to the formation/cessation of the medieval peat and the hydrological conditions under which the encompassing alluvium was deposited is certainly warranted. Furthermore, the importance of enhancing our knowledge and understanding of environmental conditions during the medieval period is emphasised in the Research Framework for London (2002) as an M2 framework objective.

The following report therefore aims to fully address the seven original project aims and consider the environmental conditions of the site during the medieval period.

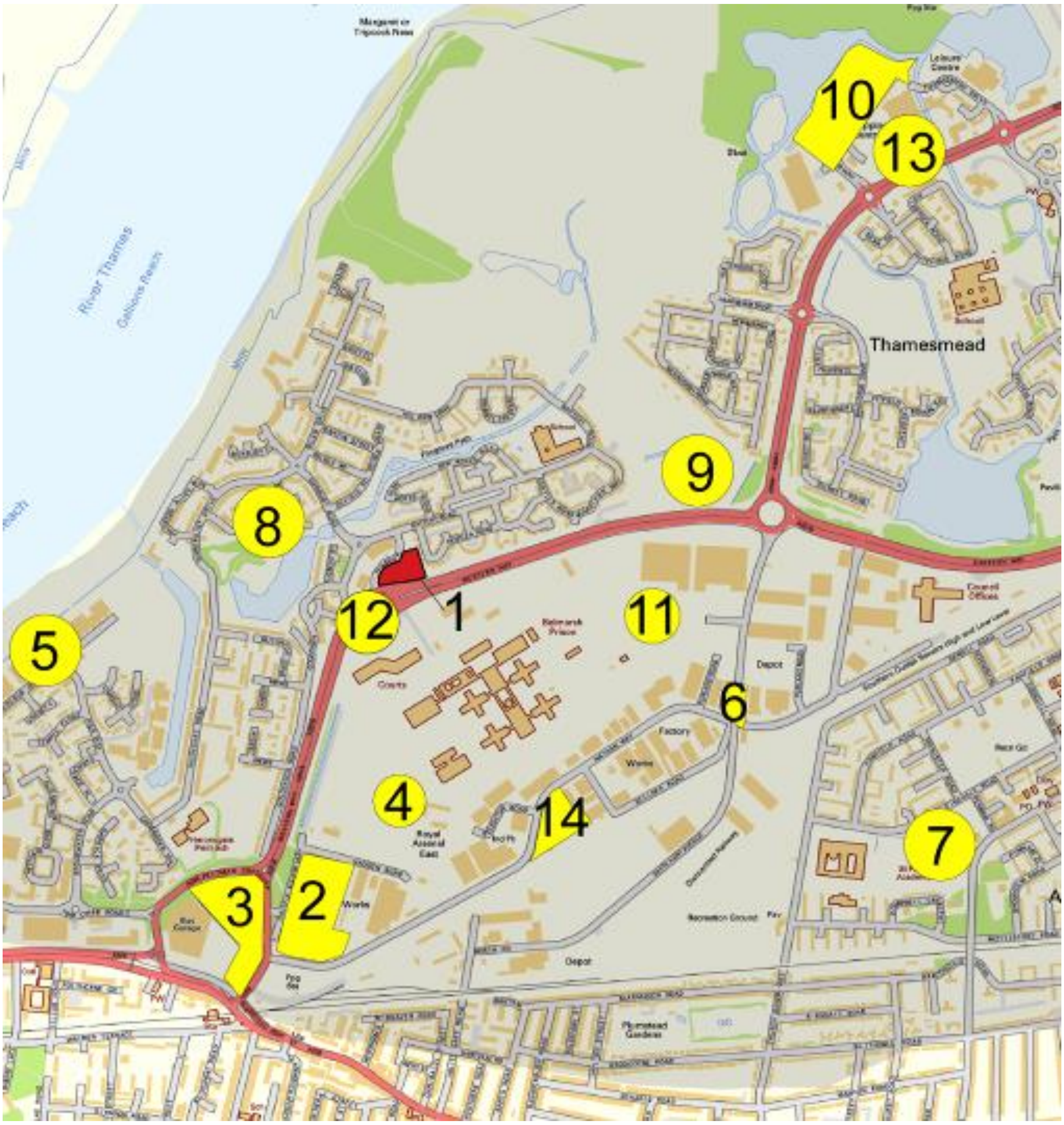

Figure 1: Location of (1) The Reach, Thames Road, Royal Borough of Greenwich and other local sites recording prehistoric archaeology or deposits: (2) 2-6 Griffin Manor Way (GMW12; Batchelor, 2012b); (3) Pettman Crescent (POW08; Batchelor & Young, 2008) / Woolwich Trade Park (WTP03; Batchelor, 2009) (4) Belmarsh West (BWQ09; Hart et al., 2009); (5) Thamesmead 8J (no site code; Branch et al., unpublished); (6) White Hart Triangle (WHT03; Spurr, 2003); (7) St Pauls Academy (AWS05; Batchelor et al., 2008); (8) Gallions Reach Urban Village (GAH96; Sidell, 2003; MoLA, 1996, 1997); (9) Collingtree Park (no site code; Branch et al., unpublished); (10) Safeway Store Extension (TUM03; Sankey and Spurr, 2004); (11) Belmarsh East (Archaeology South East, 2008, unpublished); (12) Battery Road (Pine et al., 1994, unpublished); (13) Aldi Foodstore (Sidell, 1998, unpublished); (14) 82-86 Nathan Way (Batchelor, 2012b). Grey shaded area represents the recorded extent of alluvium. ***Contains Ordnance Survey data © Crown copyright and database right [2017]***

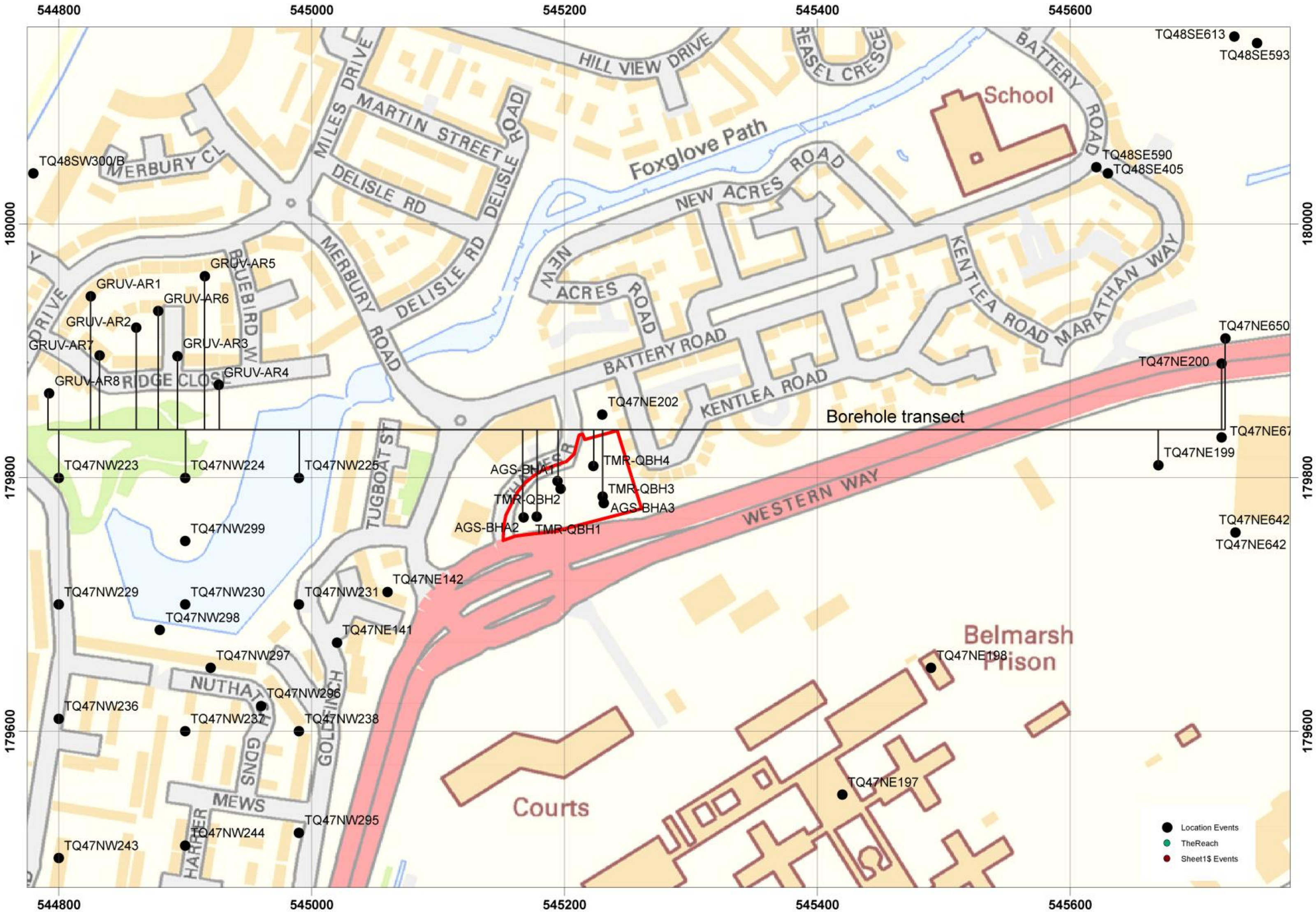

Figure 2: Location of the geotechnical and geoarchaeological boreholes on and nearby The Reach, Thames Reach, Royal Borough of Greenwich. ***Contains Ordnance Survey data © Crown copyright and database right [2017].***

3 METHODS

3.1 Previous investigations (Field investigations, lithostratigraphic descriptions and deposit modelling)

During the previous investigations at the site (Young *et al*., 2016), four geoarchaeological boreholes (boreholes TMR-QBH1 to QBH4) were put down in September 2016 by Quaternary Scientific (Figure 2). The borehole core samples were recovered using an Eijkelkamp window sampler and gouge set using an Atlas Copco TT 2-stroke percussion engine. This coring techniques provide a suitable method for the recovery of continuous, undisturbed core samples and provides sub-samples suitable for not only sedimentary and microfossil assessment and analysis, but also macrofossil analysis. The new and historic borehole locations were obtained with reference to site maps and recent topographic surveys (Table 1). Laboratory-based lithostratigraphic descriptions of the new borehole samples was carried out 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 to 5.

The deposit model for the site itself was based on a review of 10 borehole records, incorporating the four new geoarchaeological boreholes, three existing geotechnical boreholes and three BGS archive boreholes (Young *et al*., 2016; see Figure 2, Table 1). Sedimentary units from the boreholes were classified into five groupings: (1) Gravel, (2) Alluvium; (3) Peat, and (5) Made Ground. The classified data for groups 1-5 were then input into a database with the RockWorks geological utilities software. Models of surface height were generated for the Gravel and Alluvium (Figures 4, 5 and 7). Thickness of the Alluvium, Peat and Made Ground (Figures 6, 8 and 9) were also modelled. Because the boreholes are not uniformly distributed over the area of investigation, the reliability of the models generated using RockWorks is variable. In general, reliability improves from outlying areas where the models are largely supported by scattered archival records towards the core area of commissioned boreholes. Because of the 'smoothing' effect of the modelling procedure, the modelled levels of stratigraphic contacts may differ slightly from the levels recorded in borehole logs and section drawings. As a consequence of this the modelling procedure has been manually adjusted so that only those areas for which sufficient stratigraphic data is present will be modelled. In order to achieve this, a maximum distance cut-off filter equivalent to a 50m radius around each record is applied to all deposit models, with the exception of the more locally present peat (25m). In addition, it is important to recognise that multiple sets of boreholes are represented, put down at different times and recorded using different descriptive terms and subject to differing technical constraints in terms of recorded detail including the exact levels of the stratigraphic boundaries.

3.2 Radiocarbon dating

A total of five samples were extracted for radiocarbon dating: one from the lower peat within the gravel in TMR-QBH3 (-5.81 to -5.87m OD); two samples from the base (-4.12 to -4.17m OD) and top (-4.22 to -4.27m OD) of the middle peat within the gravel in TMR-QBH3; and two samples from the base (-1.41 to -1.46m OD) & top (-1.11 to -1.16m OD) of the peat in TMR-QBH1. The samples were submitted for AMS radiocarbon dating to the BETA Analytic Radiocarbon Dating Facility, Miami, Florida. The results have been calibrated using OxCal v4.2 (Bronk Ramsey, 1995; 2001 and 2007) and the IntCal13 atmospheric curve (Reimer *et al.*, 2013). The results are displayed in Figure 3 and Table 6.

3.3 Diatom analysis

0.5g of sediment was required for the diatom sample preparation. Samples were first treated with hydrogen peroxide (30% solution) and/or weak ammonia (1% solution) depending on organic and/or calcium carbonate content, respectively. Due to the high silt and clay content of most samples, all samples chosen for analysis were then treated with sodium hexametaphosphate and left overnight, to assist in minerogenic deflocculation. Samples were finally sieved using a 10µm mesh to remove fine minerogenic sediments. The residue was transferred to a plastic vial from which a slide was prepared for subsequent assessment. Upon visual inspection of the samples, the uppermost two samples were silt and clay rich but reacted with hydrogen peroxide to indicate organic content. Similarly, the lowermost samples were found to have a higher organic content and hence required prolonged hydrogen peroxide pretreatment to remove the majority of organic material from the sample in advance of analysis.

A minimum of 400 diatoms were identified for each sample depth. Diatom species were identified with reference to van der Werff and Huls (1958-74), Hendy (1964) and Krammer & Lange-Bertalot (1986-1991). Ecological classifications for the observed taxa were then achieved with reference to van der Werff and Huls (1958-74), Vos and deWolf (1988; 1993), Van Dam *et al.*, (1994), Denys (1991-92; 1994) and Round *et al*. (2007). The computer software Tilia was used to plot the diatom results to aid subsequent analysis and interpretation. The results are displayed in Figures 9-13 & Tables 6-7.

3.4 Pollen analysis

Seven sub-samples from the peat in borehole TMR-QBH1 were extracted for pollen analysis. 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. The analysis procedure consists of counting the pollen and spores present until a count of 300 total land pollen is (TLP) was reached. This consists of tree, shrub and herb taxa; aquatics and spores are counted as a percentage of total land pollen. 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 concentration of microscopic charred particles is also recorded. The results are displayed in Figure 14.

3.5 Macrofossil assessment

Seven small bulk samples were extracted and processed for the recovery of macrofossil remains, including waterlogged plant macrofossils, wood, insects and Mollusca from the peat within borehole TMR-QBH1 (Table 9). The extraction process involved the following procedures: (1) removing a sample of 5cm 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. Preliminary identifications of the waterlogged seeds have been made using modern comparative material and reference atlases (e.g. Martin & Barkley, 2000; NIAB, 2004; Cappers *et al.* 2006). Nomenclature used follows Stace (2005).

4 RESULTS, INTERPRETATION AND DISCUSSION OF THE GEOARCHAEOLOGICAL ANALYSIS

The results of the lithostratigraphic descriptions and deposit modelling have been reporting previously (Young *et al.*, 2016), and are summarised and updated below, based upon the results of the most recent radiocarbon dating (Table 6), and feedback from the Regional Science Advisor. A summary of the geoarchaeological and geotechnical data used in the deposit models is shown in Table 1, with the lithostratigraphic descriptions shown in Tables 2 to 5. The results of the deposit modelling are displayed in Figures 3 to 8: Figure 3 is a 2-dimensional west-east transect, and Figures 4 to 8 are surface elevation and thickness models for each of the main stratigraphic units. The results of the deposit modelling indicate that the number and spread of sedimentary logs is sufficient to permit modelling with a high level of reliability across the entire area of the site. The full sequence of sediments recorded in the boreholes comprises:

Made Ground – widely present
Peat – sporadically present within the Alluvium
Alluvium – widely present
Gravel – widely present

4.1 Gravel

The lowermost sediments recorded in each of the boreholes consisted of sands and gravels, indicative of deposition within a high energy river system. The surface of the gravel is variable across the site, generally falling from east to west towards the modern channel of River Thames, recorded at between -2.81 (TMR-QBH3) and -4.76m OD (TMR-QBH1) (Figures 3-4; Tables 1-4). Ordinarily at this location and elevation on the River Thames floodplain, these deposits would be representative of the Shepperton Gravel, which was deposited during the late Glacial, 15,000 to 10,000 years before present. This may still be the case towards the north of the site, however, within three boreholes on the southern part of the site peat was recorded within these gravel deposits at varying levels as follows:

AGS-BHA2: -8.2 to -8.5m OD
AGS-BHA3: -4.7 to -5.1m OD
TMR-QBH3: -5.81 to -5.87 and -4.07 to -4.37m OD

When first noted within geotechnical boreholes AGS-BHA2 & AGS-BHA3, it was hypothesised that these units might represent peat horizons that accumulated before the Holocene, either during accumulation of the Shepperton Gravel, or the earlier Kempton Park Gravel (Batchelor, 2012a). Such deposits are rare and of some significance, and thus were targeted with the aim of collecting material for further investigation. TMR-QBH3 was successfully put down adjacent to AGS-BHA3, and recorded two peat horizons at approximately the same depth as previously found. Subsequent radiocarbon dating of these peats provided age determinations of 2855-2755 cal BP (-5.81 to -5.87m OD), 3580-3450 cal BP (-4.27 to -4.22m OD) and 3560-3400 cal BP (-4.17 to -4.12m OD).

These results therefore confirm that the hypotheses proposed for the deposition and age of these peat units can be discounted: they date to the late prehistoric period and are not contemporary with the Late Devensian Shepperton Gravel, and do not represent a remnant of the organic units occasionally recorded within the Late Ipswichian-Middle Devensian Kempton Park Gravel. Furthermore, the determinations are inversed with the lower of these peat horizons (-5.81 to -5.87m OD) appearing to be younger than that at -4.22 to -4.12m OD.

On the basis of their age, the peat deposits indicate that the processes of deposition that led to the formation of the combined gravel-peat sediments were active during the Bronze Age. It is highly unlikely that a channel of sufficient energy to deposit this thickness of gravel was active at this time in the Late Holocene, so fluvial processes associated with a channel can effectively be ruled out. Two alternative hypotheses are thus proposed: (1) that the deposits are associated with the erosion of nearby gravel and peat deposits during one or more high-energy flood events during the Late Holocene; or (2) that colluvial (slope-wash) processes led to the redeposition of nearby gravel and peat deposits, perhaps associated with an anomalous depression in the surface of the bedrock. Unfortunately, on the basis of the borehole data available, it is not possible to confirm which of these processes is more likely to have led to the deposition of the sequence at The Reach site. We know from this site and investigations nearby that Bronze Age peat deposits and earlier, higher gravel units that could have been redeposited by such processes. In addition, such over-deepening of the bedrock has been recorded at several locations elsewhere in London, associated with pingos (Hutchinson, 1980), scours as a consequence of fluvial or glacio-fluvial processes (Berry, 1979), and alternatively geological faults, chalk dissolution, thermokast features, ice wedges or frost heaved diapirs (Collins *et al*., 2014). Interestingly, a geological fault is recorded by the BGS not far from the present site (*ca*. 2km to the northeast (see http://mapapps2.bgs.ac.uk/geoindex/home.html).

In either case, such processes could also explain the age reversal recorded in the peat deposits in TMR-QBH3, potentially resulting in the reworking and redeposition of sediments within the body of the gravel. It is important to note at this stage that the entire sequence in the southern area of the site, including in boreholes TMR-QBH3, AGS-BHA2 and AGS-BHA3 may have been influenced by the processes described above, and thus cannot be considered to represent the Shepperton Gravel (as such the probable reworked nature of the peat deposits in TMR-QBH3 do not warrant further investigation). However, distinguishing the boundary between these deposits and normally distributed Shepperton Gravel across the site is not possible on the basis of the existing borehole evidence alone. As a consequence, the gravel deposits across The Reach site are not allocated to a particular Gravel terrace.

More widely (Figure 5), the Gravel surface at the present site lies at similar or lower elevations to the Shepperton Gravel recorded at sites to the south, but higher than those at Gallions Reach Urban Village to the west (MoLA, 1996; 1997; Sidell, 2003) (see Figures 3 and 11). Shepperton Gravel surfaces of between *ca*. -2 and -2.5m OD were recorded across much of the 2-6 Griffin Way site (Batchelor, 2012), rising both southwards and westwards towards Woolwich Trade Park (Batchelor and Young, 2008) and Pettman Crescent (Batchelor, 2009), where it was recorded at between *ca*. 0 and -1m OD (and more likely to represent the earlier Kempton Park Gravel terrace). At Belmarsh West (Hart *et al*., 2009) *ca*. 400m to the south it was recorded at between -2.33m and -2.70m OD, whilst at Gallions Reach Urban Village (MoLA, 1996, 1997; Sidell, 2003), *ca*. 200m to the west, the gravel surface drops to between *ca*. -4 and -6m OD.

4.2 Alluvium

Alluvial deposits were recorded in all boreholes, resting directly on the Gravel. Initially, these deposits are predominantly silty and sandy, tending to become increasingly sandy downward in most sequences. Detrital wood, plant remains, organic material and occasional Mollusca remains are also noted. Further up the sequence, the deposits become finer grained, consisting of silt and clay with minimal organic-inclusions. Ordinarily within the Lower Thames Valley, these deposits would be representative of the Lower and Upper Alluvium respectively, deposited during the early to late Holocene. However, the apparent age of the gravel deposits clearly indicates that this is not the case on the present site; and certainly not on the southern part. As such, they are simply referred to as representing alluvium, deposited within a generally low energy fluvial or estuarine environment. The higher mineral content recorded towards the surface may reflect increased sediment loads resulting from intensification of agricultural land use from the later prehistoric period onward, combined with the effects of rising sea level.

The thickness of the alluvial units are recorded at between 2.4 and 4.7m in thickness across the site, and tend to reflect the shape of the underlying Gravel deposits (Figure 6). The surface of the Alluvium (Figure 7) is variable, recorded at between -1.3 (AGS-BHA1) and 0.95m OD (TMR-QBH2).

4.3 Peat

Peat was recorded within the alluvium in two of seven records within the site (AGS-BHA2 and TMR-QBH1), indicative of a transition towards semi-terrestrial (marshy) conditions. In both cases it was recorded around the transition from silty sand to silty clay. The peat is described as 0.4m thick in borehole AGS-BHA2 and 0.36m thick in TMR-QBH1 (Figure 8), with an upper surface resting between -1.1 and -1.5m OD (Figure 5). Radiocarbon dating of the peat unit in TMR-QBH1 reveals that it accumulated between 660-545 and 485-305 cal BP, indicative of accumulation during the medieval period.

Thicker peat horizons dating to the late Mesolithic through to the Bronze Age have been recorded at the sites to the south, west and northwest (see Figure 1). At 2-6 Griffin Way (Batchelor, 2012b) thicknesses of between *ca*. 0.5 and 1.5m were recorded at elevations between *ca*. -2.5 and 0.5m OD, either resting directly on the Gravel or the Lower Alluvium. Similar results were recorded at Belmarsh West where the peat accumulated between *ca*. -2.70 to -0.60m OD and was dated from 6180-5950 to 2150-1990 cal BP (late Mesolithic to late Iron Age; Hart *et al*., 2009). At Greenwich Reach Urban Village (MoLA, 1997) to the northwest (Figure 3), the peat recorded at elevations between *ca*. -6 and -1m OD was radiocarbon dated to between 7250-6860 and 2760-2380 cal BP (late Mesolithic to early Iron Age).

Significantly therefore, no peat deposits equivalent in age to the medieval horizon at the Reach have been recorded in this general area of the floodplain, and are rare elsewhere in the Lower Thames Valley (e.g. at Rawalpindi House, Newham; Young & Batchelor, 2014). Although the peat within the alluvium at The Reach site is recorded at a similar elevation, it is clearly later than the peat deposits from neighbouring sites. It is therefore possible that that an episode of erosion (perhaps associated with channel activity) may have occurred at this location, enabling a later peat horizon to accumulate at similar elevations to the older peat elsewhere. Alternatively, such a phenomenon may reflect localised peat accumulation during the medieval period, perhaps within a floodplain hollow.

4.5 Made Ground

Between 1.5 and 3.7m of Made Ground caps the Holocene alluvial sequence (Figure 9).

Table 1: Borehole attributes for records across The Reach, Thames Reach, Royal Borough of Greenwich.

Name	Easting	Northing	Elevation (m OD)	Total Depth (m)	Top of Alluvium (m OD)	Top of Peat (m OD)	Top of Lower Alluvium (m OD)	Top of Gravel (m OD)	Notes
Existing geotechnical boreholes (Provectus, 2016)									
AGS-BHA1	545194.51	179797.36	2.40	12.00	-1.30	Not present	-3.10	-3.70	
AGS-BHA2	545167.67	179768.60	2.10	12.00	-0.70	-1.50	-1.90	Unknown	Peat within Gravel at 10.3-10.6m bgl
AGS-BHA3	545231.05	179780.17	2.10	12.00	-0.40	Not present	-1.50	Unknown	Peat within Gravel at 6.8-7.2m bgl
New geoarchaeological boreholes									
TMR-QBH1	545178.20	179769.45	2.14	9.00	-0.81	-1.10	-1.46	-4.76	
TMR-QBH2	545197.12	179791.22	2.45	7.00	0.95	Not present	-1.75	-3.45	
TMR-QBH3	545230.33	179785.07	2.33	9.00	-0.07	Not present	-0.67	-2.81	Peat within Gravel at 6.4-6.7 and 8.14-8.20m bgl
TMR-QBH4	545223.03	179809.24	2.37	7.00	0.87	Not present	-0.63	-3.83	

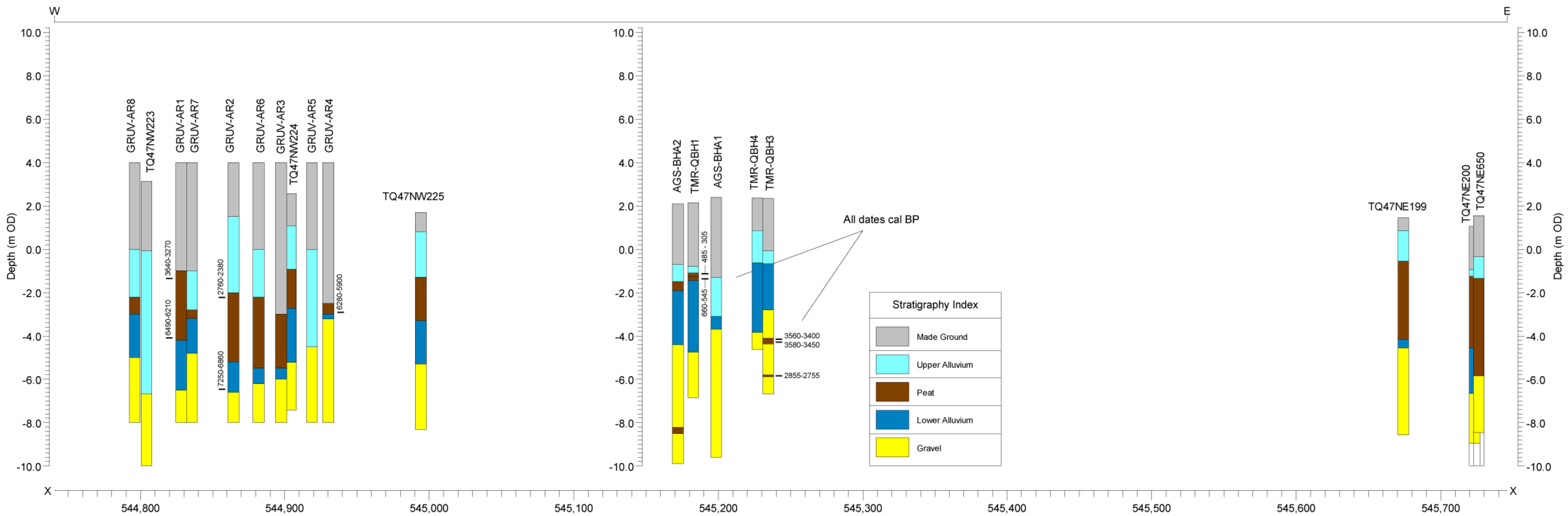

Figure 3: West to east transect of boreholes across The Reach site and the wider area, incorporating boreholes from the Greenwich Reach Urban Village (GRUV; MoLA, 1997) site and BGS archive boreholes (see Figure 2). Results of the radiocarbon dating also shown (see Table 6)

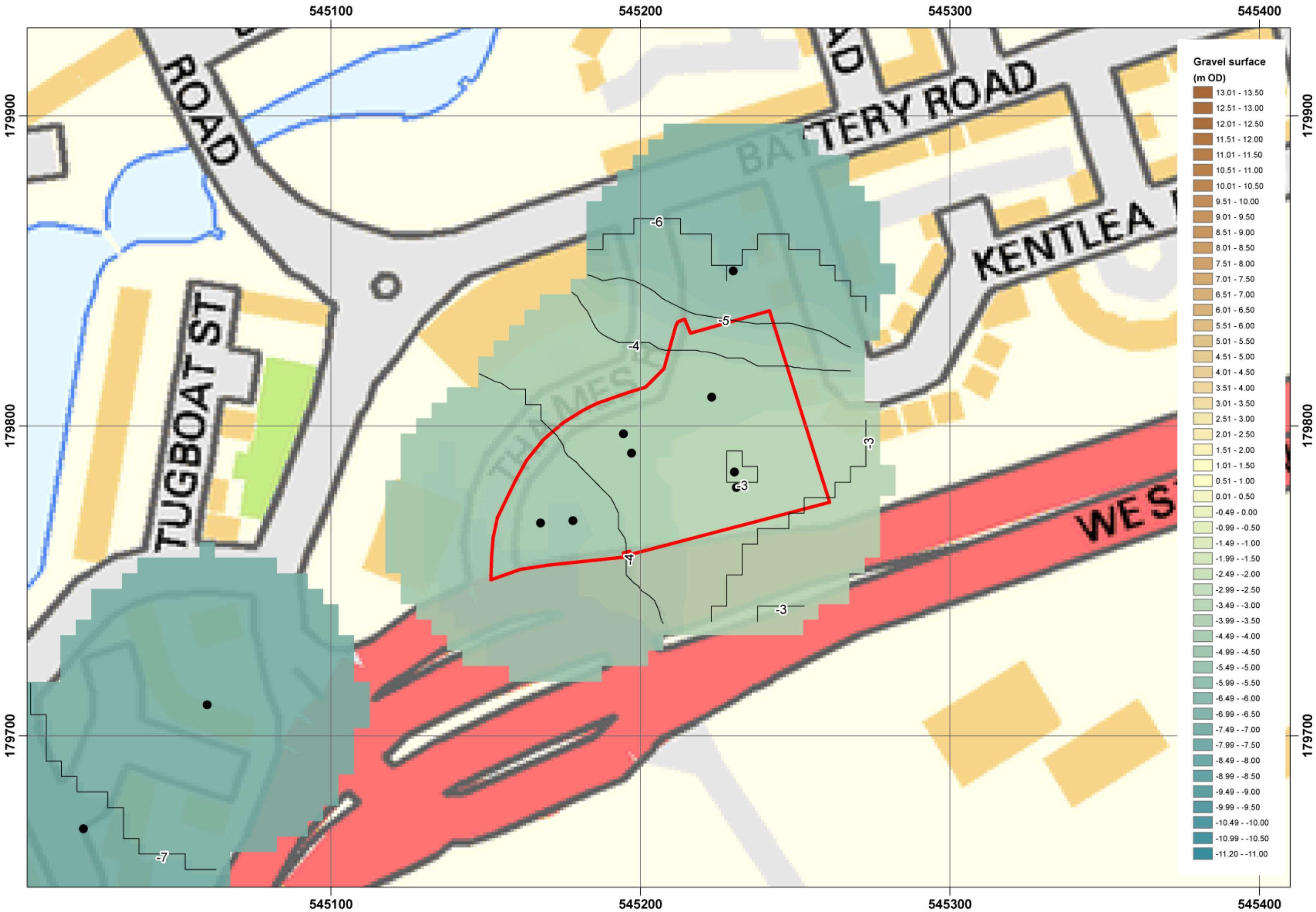

Figure 4: Top of the Gravel (m OD) (site outline in red). ***Contains Ordnance Survey data © Crown copyright and database right [2017].***

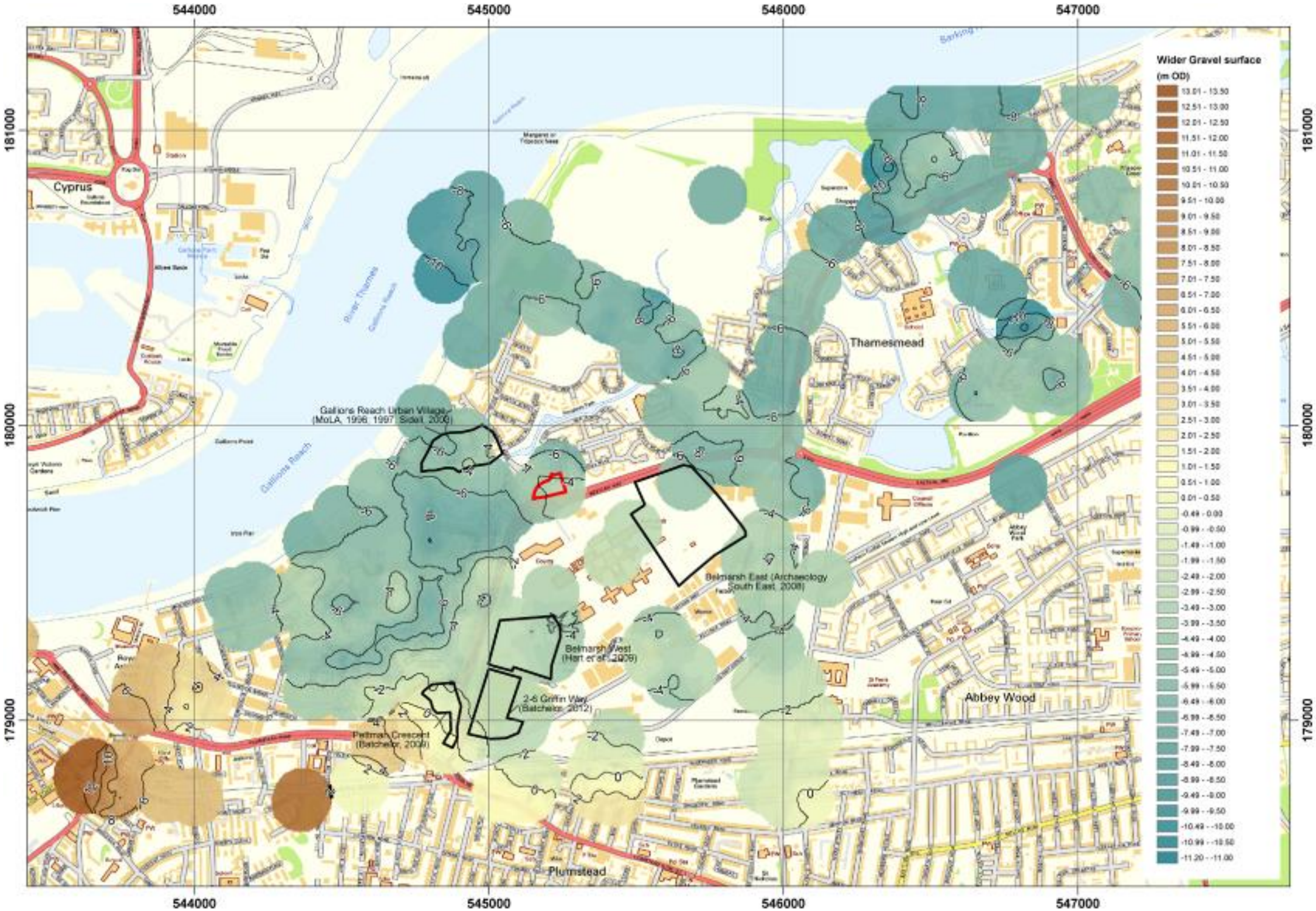

Figure 5: Wider Shepperton Gravel surface (contour heights m OD) in the wider area, including sites mentioned in the text.

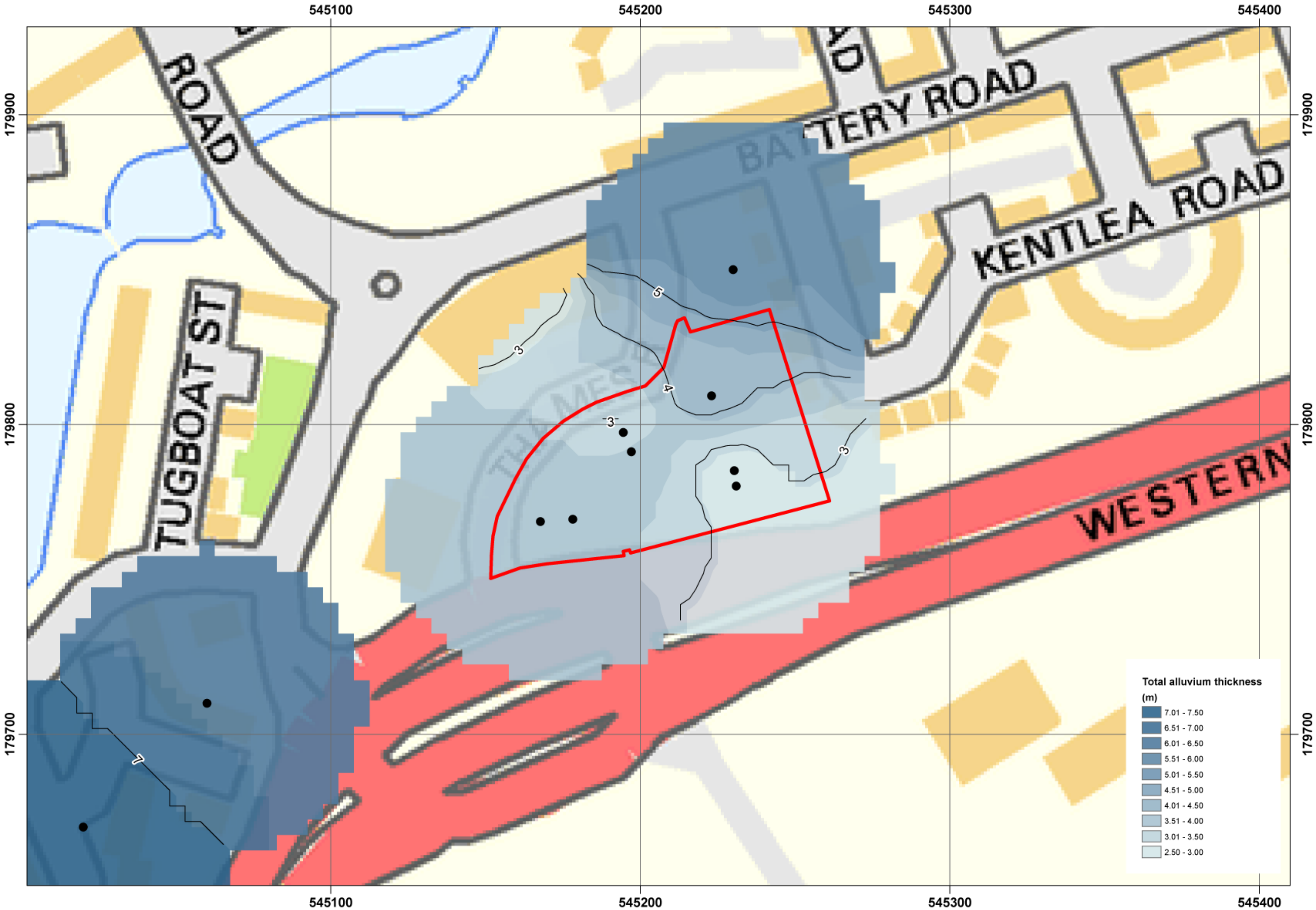

Figure 6: Thickness of the Alluvium (m) (site outline in red). ***Contains Ordnance Survey data © Crown copyright and database right [2017].***

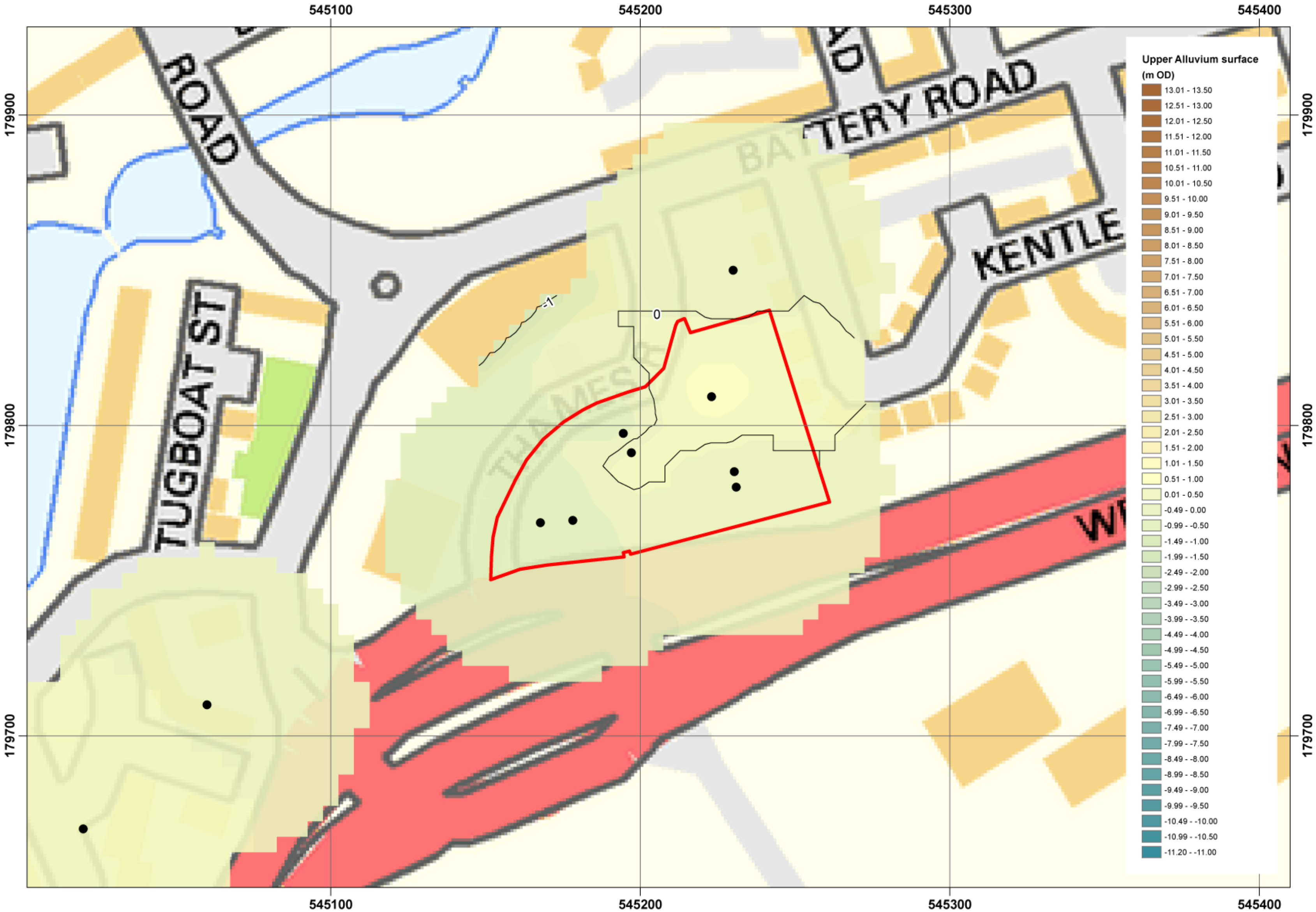

Figure 7: Top of the Alluvium (m OD) (site outline in red). ***Contains Ordnance Survey data © Crown copyright and database right [2017].***

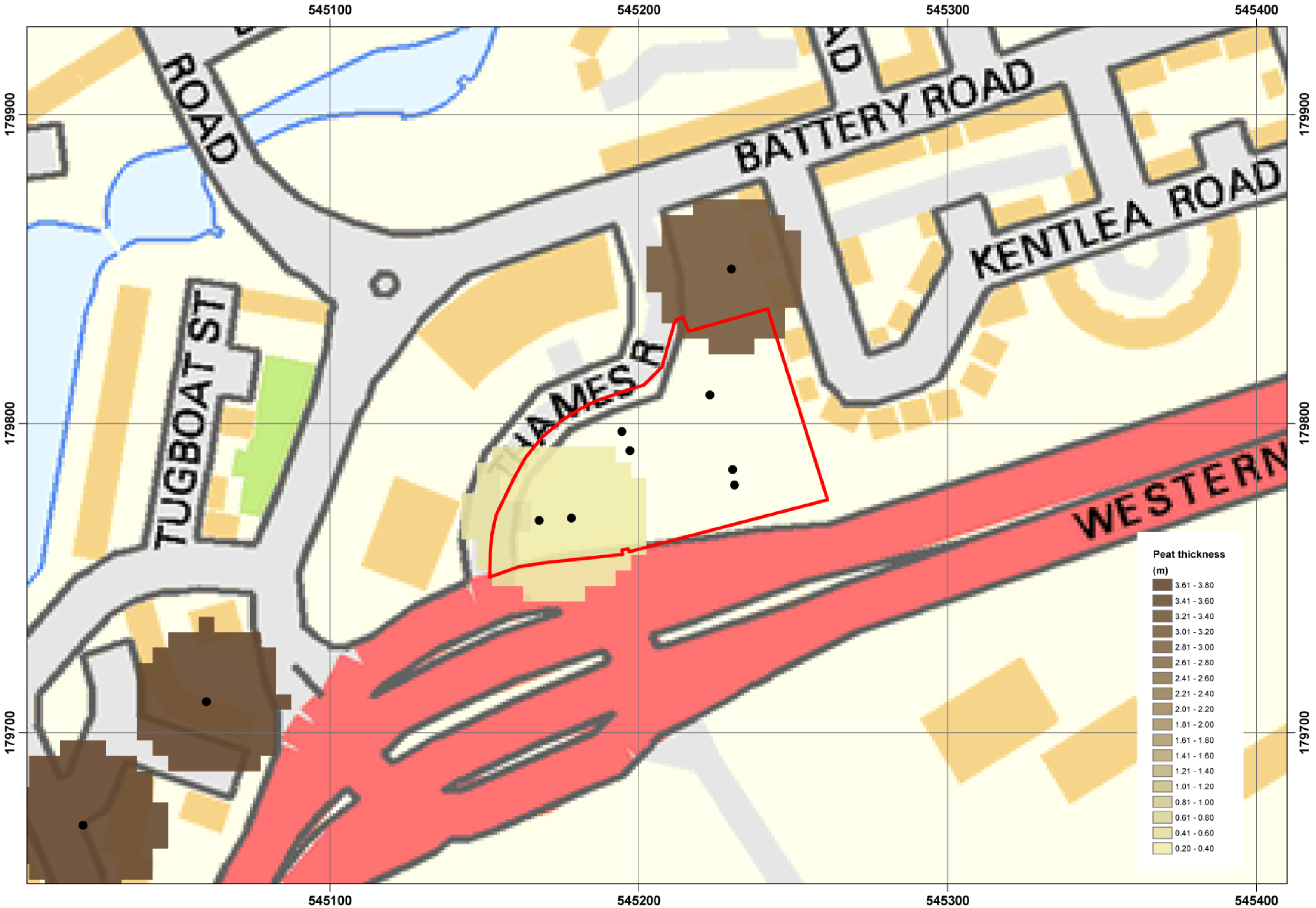

Figure 8: Thickness of Peat (m) (site outline in red) (25m radius). ***Contains Ordnance Survey data © Crown copyright and database right [2017].***

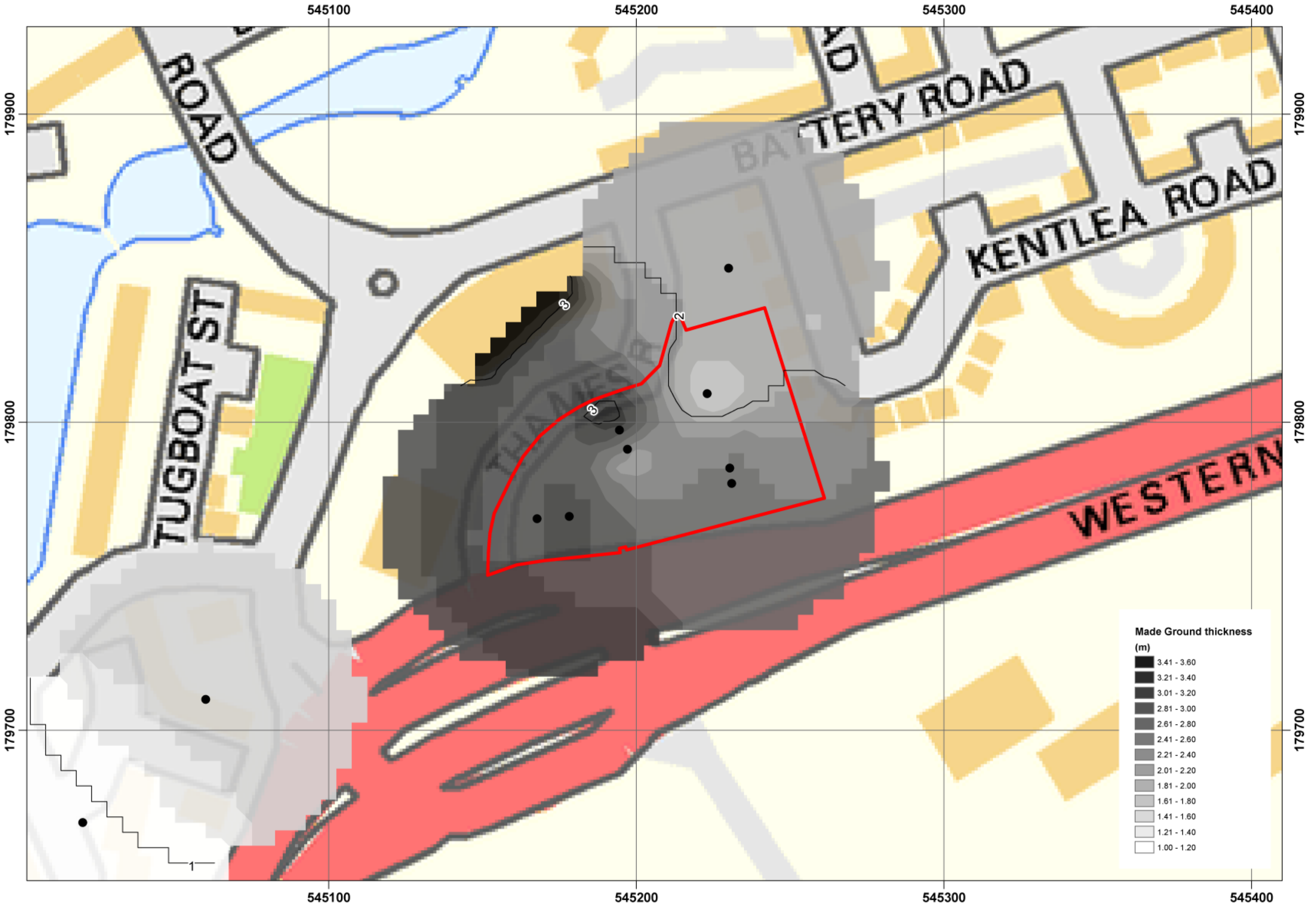

Figure 9: Thickness of Made Ground (m) (site outline in red). ***Contains Ordnance Survey data © Crown copyright and database right [2017].***

Table 2: Lithostratigraphic description of borehole TMR-QBH1, The Reach, Thames Reach, Royal Borough of Greenwich

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic group
2.14 to -0.81	0.00 to 2.95	Made Ground of sand, gravel, ash and occasional brick/concrete fragments.	MADE GROUND
-0.81 to -1.10	2.95 to 3.24	As3 Ag1; grey silty clay. Very sharp contact in to:	UPPER ALLUVIUM
-1.10 to -1.46	3.24 to 3.40	Sh3 As1 Th+; humo. 3; reddish black well humified clayey peat with a trace of herbaceous material. Diffuse contact in to:	PEAT
-1.46 to -1.56	3.40 to 3.70	Dh2 Ag1 As1 Sh+; dark grey detrital herbaceous material in a matrix of clay and silt. Dh is predominantly *Phragmites australis* (common reed). Diffuse contact in to:	LOWER ALLUVIUM
-1.56 to -2.86	3.70 to 5.00	Ag2 As2 Dh+ Sh+; dark grey clay and silt with horizontal beds including traces of detrital herbaceous material and organic matter.	
-2.86 to -4.76	5.00 to 6.90	Ag3 As1 Ga+; dark blueish grey clayey silt with a trace of sand. Some fine (1-2mm) horizontal bedding, mainly of Ga3 Ag1 (silty sand) units. Sharp contact in to:	
-4.76 to -4.86	6.90 to 7.00	Gg2 Ga2; orange sand and gravel. Clasts are flint, up to 40mm in diameter, sub-angular to well-rounded.	GRAVEL

Table 3: Lithostratigraphic description of borehole TMR-QBH2, The Reach, Thames Reach, Royal Borough of Greenwich

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic group
2.45 to 0.95	0.00 to 1.50	Made Ground of sand, gravel, ash and occasional brick/concrete fragments	MADE GROUND
0.95 to -1.05	1.50 to 3.50	As3 Ag1; greyish brown silty clay with some iron staining. Diffuse contact in to:	UPPER ALLUVIUM
-1.05 to -1.55	3.50 to 4.00	Ag2 As2; greyish brown silt and clay with some iron staining. Diffuse contact in to:	
-1.55 to -1.75	4.00 to 4.20	Ag2 As2; blue grey silt and clay. Sharp contact in to:	
-1.75 to -3.45	4.20 to 5.90	Ag2 Ga2; blueish grey horizontally bedded silt and sand. Beds 2-5mm in thickness. Contact with lower unit obscured.	LOWER ALLUVIUM
-3.45 to -4.55	5.90 to 7.00	Gg2 Ga2; orange sand and gravel. Clasts are flint, up to 40mm in diameter, sub-angular to well-rounded.	GRAVEL

Table 4: Lithostratigraphic description of borehole TMR-QBH3, The Reach, Thames Reach, Royal Borough of Greenwich

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic group
2.33 to 0.53	0.00 to 1.80	Made Ground of sand, gravel, ash and occasional brick/concrete fragments.	MADE GROUND
0.53 to -0.07	1.80 to 2.40	Made Ground (redeposited alluvium).	
-0.07 to -0.67	2.40 to 3.00	As2 Ag2 Ga+; blueish grey silt and clay with a trace of sand. Diffuse contact in to:	UPPER ALLUVIUM
-0.67 to -2.67	3.00 to 5.00	Ga2 Ag2; blueish grey horizontally bedded silt and sand. Beds 2-5mm in thickness. Diffuse contact in to:	LOWER ALLUVIUM

-2.67 to -2.81	5.00 to 5.14	Ag3 As1; blue grey clayey silt. Sharp contact in to:	
-2.81 to -3.87	5.14 to 6.20	Gg3 Ga1; orange sandy gravel. Clasts are flint, up to 40mm in diameter, sub-angular to well-rounded. Sharp contact in to:	GRAVEL
-3.87 to -3.99	6.20 to 6.32	Ag2 As1 Dh1; grey clayey silt with frequent detrital herbaceous material. Sharp contact in to:	
-3.99 to -4.07	6.32 to 6.40	Ga4 Gg+; yellowish brown sand with occasional gravel clasts. Sharp contact in to:	
-4.07 to -4.37	6.40 to 6.70	Sh2 Ag2; humo. 3/4; dark greyish brown well humified very silty peat. Sharp contact in to:	PEAT
-4.37 to -5.81	6.70 to 8.14	Ga2 Gg2 Ag+; dark greyish brown sand and gravel with a trace of silt. Sharp contact in to:	GRAVEL
-5.81 to -5.87	8.14 to 8.20	Sh4 Th+; humo. 4; dark reddish black very well humified peat with a trace of herbaceous material. Sharp contact in to:	PEAT
-5.87 to -6.07	8.20 to 8.40	Ga3 Gg1; orange gravelly sand. Clasts are flint, up to 10mm in diameter, sub-angular to well-rounded. Diffuse contact in to:	GRAVEL
-6.07 to -6.67	8.40 to 9.00	Gg3 Ga1; orange sandy gravel. Clasts are flint, up to 40mm in diameter, sub-angular to well-rounded.	

Table 5: Lithostratigraphic description of borehole TMR-QBH4, The Reach, Thames Reach, Royal Borough of Greenwich

Depth (m OD)	Depth (m bgl)	Description	Stratigraphic group
2.37 to 0.87	0.00 to 1.50	Made Ground of sand, gravel, ash and occasional brick/concrete fragments.	MADE GROUND
0.87 to 0.57	1.50 to 1.80	As3 Ag1; dark blueish grey silty clay with some woody root material. Diffuse contact in to:	UPPER ALLUVIUM
0.57 to -0.43	1.80 to 2.80	As3 Ag1; dark blueish grey silty clay. Some iron staining. Diffuse contact in to:	
-0.43 to -0.63	2.80 to 3.00	Ag2 As2 Ga+; dark blueish grey silt and clay with a trace of sand. Diffuse contact in to:	
-0.63 to -2.63	3.00 to 5.00	Ag2 Ga2 As+ Dl+; blueish grey horizontally bedded silt and sand with a trace of clay and detrital wood. Beds 2-5mm in thickness. Occasional fine Mollusca fragments. Diffuse contact in to:	LOWER ALLUVIUM
-2.63 to -3.83	5.00 to 6.20	Ag3 Ga1 Dh+; blueish grey sandy silt with a trace of detrital herbaceous material. Horizontally bedded, but less frequently than unit above. Sharp contact in to:	
-3.83 to -4.63	6.20 to 7.00	Gg3 Ga1 Ag+; orange sandy gravel with a trace of silt. Clasts are flint, up to 40mm in diameter, sub-angular to well-rounded.	GRAVEL

Table 6: Results of the radiocarbon dating, The Reach, Thames Reach, Royal Borough of Greenwich

Laboratory code / Method	Material and location	Depth (m OD)	Uncalibrated radiocarbon years before present (yr BP)	Calibrated age BC/AD (BP) (2-sigma, 95.4% probability)	δ13C (‰)
BETA-456688	*Phragmites australis* stem; top of peat in alluvium in TMR-QBH1	-1.11 to -1.16	330 ± 30	1465-1645 cal AD (485-305 cal BP)	-25.2
BETA-449567 AMS	*Phragmites australis* stem; base peat in alluvium in TMR-QBH1	-1.41 to -1.46	620 ± 30	1290 to 1405 cal AD (660 to 545 cal BP)	-26.0
BETA-449565 AMS	Twig wood; top of upper peat in gravel in TMR-QBH3	-4.12 to -4.17	3250 ± 30	1610 to 1450 cal BC (3560 to 3400 cal BP)	-26.7
BETA-449566 AMS	*Alnus* fruits; base of upper peat in gravel in TMR-QBH3	-4.22 to -4.27	3290 ± 30	1630 to 1500 cal BC (3580 to 3450 cal BP)	-27.7
BETA-449564 AMS	Twig wood; lowest peat in gravel in TMR-QBH3	-5.81 to -5.87	2700 ± 30	905 to 805 cal BC (2855 to 2755 cal BP)	-29.3

5 RESULTS AND INTERPRETATION OF THE DIATOM ANALYSIS

Diatom analysis was targeted on the contact between the medieval peat and encompassing alluvium in TMR-QBH1. A summary of the diatom results are provided in Table 7 and Figures 10-13. In the majority of cases, taxa were identifiable to species level, but in some instances, identifications were only possible to genera level. Only taxa with presence above 2% Total Diatom Valves (TDV) are displayed for ease of subsequent interpretation.

Table 7 displays the diatom species present within each sample. In Figure 10, the diatoms encountered have been displayed according to their broad salinity and life form classifications, for example: 'marine planktonic' species are those encountered in open marine waters with salinities typically >20-30‰, found floating in the water column; 'brackish benthic' species are encountered in waters more typically associated with shallow estuarine settings with salinities of 1-9‰. In addition, their benthic status indicates that these species live attached to, or within the sediment substrate under investigation. Benthic taxa can be further divided, based on substrate preference:

- Epiphytic taxa - found attached to organic material (plants and decomposing organic debris),
- Epipelic taxa - attach themselves for muddy deposits,
- Epipsammic taxa - associated with sandy substrates,
- Aerophilous taxa - require a period of both aquatic submergence and emergence, and in the case of coastal sequences are strongly associated with the intertidal zone.

In addition, benthic taxa are considered to provide a more reliable indicator of palaeoenvironmental conditions. This is because they are likely to have lived *in-situ* within the sediment under analysis. This is in contrast to the planktonic taxa which live suspended in the water column and hence have *the potential* to be transported after death.

Figure 11 provides greater focus on the salinity requirements of the diatom taxa encountered, dividing the species into the following categories: Polyhalobous (>30‰; fully marine), Mesohalobous (0.2-30‰; brackish water), Oligohalobous (<0.2‰; salt tolerant) and Halophobous (0‰; exclusively freshwater).The Oligohalobous category can be further subdivided into Oligohalobous halophilous (salt-tolerant freshwater) and Oligohalobous indifferent (tolerant of slightly saline water). This classification enables the overall salinity of the depositional environment to be taken considered, incorporating both planktonic and benthic taxa together.

Due to the dominance of marine and brackish taxa, the dataset has the potential to be incorporated into the palaeoenvironmental scheme of Vos and de Wolf (1993). This scheme enables the likely position of the sediment sample within the palaeo-tidal frame to be determined. Table 8 therefore summarises the diatom assemblage compositions that are associated with differing elevations within the littoral zone and Figure 12 summarises the categories when applied to the diatom sequence.

4.1 Results of the diatom analysis

Diatom preservation was excellent in all samples and full counts were achieved. Abundance was greatest in the two uppermost samples (-1.06m and -1.09m O.D.), which were taken from the alluvium overlying the medieval peat. Diatoms are regularly encountered in peat, especially when a minerogenic component is encountered, such as that recorded in TMR-QBH1. The assumed 'semi-terrestrial' nature of these deposits means that post-depositional fluctuations in the water table can result in silica dissolution by redox and the associated presence of humic acids. Whilst this may explain the slightly lower diatom concentrations encountered during visible inspections, diatom diversity was actually found to be higher in the lower samples.

The diatom assemblages display a clear dominance of marine, marine brackish and brackish taxa, with both planktonic and benthic species contributing to the floral diversity. Of the benthic taxa present, most are typically associated with muddy and organic-rich substrates, and some are aerophilous taxa (hence requiring periods of sub-aerial exposure). Such groupings indicate a tidal setting. The continued presence of a mixture of marine, brackish and freshwater planktonic taxa, present throughout the samples (but decreasing in overall abundance through time) further supports this, and infers that deposition of the entire sedimentary sequence took place within the intertidal zone. Taking into account the stratigraphic context, the vertical shift from a clayey peat into alluvium is suggestive of a rise in relative sea level.

Figure 10 shows a distinct shift in the dominant lifeform of the diatoms through the profile. The assemblages from the underlying peat (-1.25m and -1.28m OD) contain *ca*. 55% TDV planktonic taxa and 45% TDV benthic taxa. This trend reverses through the profile, with benthic taxa becoming the dominant lifeform group within the upper alluvium (*ca*. 60% TDV). The reduction in planktonic taxa is primarily reflected by the decrease in brackish plankton, specifically *Cyclotella striata*. The benthic assemblages increase primarily through the increased influence of marine-brackish and brackish benthic taxa, including *Surirella ovata*, *Synedra pulchella* and *Navicula avenacea*. There are also subtle fluctuations in the abundance of benthic taxa that require less saline conditions (e.g. *Cocconeis placentula*, *Synedra ulna*).

In terms of salinity preferences, Figure 11 confirms the absence of any halophobous (freshwater) taxa, with salt tolerant species dominating the profile. A similar trend is displayed with the planktonic vs benthic picture, with a reduction in the dominance of polyhalobous and mesohalobous taxa, and increase of oligohalobous halophilous and oligohalobous indifferent taxa. Figure 11 displays the ecological groupings of key taxa in accordance with the scheme of Vos and de Wolf (1993), which provides a greater insight into both the ecological and lifeform affiliations of the species, specifically describing the variations in benthic groups. With the increase in benthic taxa through the profile, this shift in diatom assemblage is reflected through a number of trends, including the increase in epiphytic and epipelic taxa, and an associated drop in aerophilous taxa.

4.2 Interpretation of the diatom analysis

The diatom assemblages present within borehole TMR-QBH1 reveal an interesting palaeoenvironmental story. On face value, the diatoms encountered don't necessarily mirror the stratigraphic record. Within coastal lowland wetland environments, organic-rich peat deposits ordinarily tend to reflect a freshwater signal, whilst alluvial deposits reflect more estuarine conditions. Thus, a shift from peat to alluvium would normally record an increase in taxa tolerant of higher salinity conditions. However, in the TMR-QBH1 record, the opposite is recorded, with greater numbers of marine plankton and tychoplanktonic species present within the peat unit than the overlying estuarine alluvium. Similarly, there is an apparent overall increase in benthic taxa associated with lower salinities through the profile.

As outlined above, the Vos and deWolf (1993) classification enables the altitude at which the sample developed on the coastal zone to be inferred (i.e. subtidal, intertidal, supratidal) which, when applied to multiple samples within a sequence, can be used to infer changes in palaeo-depositional altitude over time. This can in turn be used to provide a semi-quantitative indicator of changes in relative sea level. For example, a gradual shift from assemblages indicating deposition in supratidal settings, to those more associated with subtidal conditions, would be interpreted as indicating a progressive increase in the influence of relative sea level. Such a shift is suggested by the stratigraphy consisting of peat overlain by alluvium. This apparent marine 'transgression' can be caused by a number and/or combination of factors. These include (but are not restricted to) an increase in eustatic (global) sea-level, a decrease in the rate of terrestrial sedimentation along the coastal zone (to effectively lower the coastline above that of rising sea level) or crustal movements often resulting from glacio-istostasy (an artefact of the impact previous glacial episodes in the UK). Such interpretations are only possible (and useful) if placed within a chronological framework.

The benefit of the Vos and deWolf (1993) scheme is that, whilst it does take into account the presence of planktonic taxa, it also provides substantial windows in which planktonic species can be present. For example, marine planktonic species can contribute anywhere between 10-70% TDV in any of the diatom assemblage associated with deposition in the supratidal realm. This approach is however necessary due to the potential for large amounts of planktonic diatoms to 'flood' into sediments due to their derived nature, biasing salinity classes allocated to each sample. This bias is evident on initial visual inspection of the TMR-QBH1 assemblages, but can be modified when considering the depositional realms allocated to each of the samples by the Vos and deWolf (1993) scheme.

The abundance of taxa other than those affiliated with freshwater conditions clearly indicates that deposition was taking place below Highest Astronomical Tide (HAT), in a depositional setting in which tidal submergence was a regular and influential occurrence. In the case of the two lowermost peat samples, they are suggested to have been deposited within the supratidal realm, in the setting typified by 'pools in saltmarshes'. These samples are allocated into this depositional category primarily based on the overall dominance of marine brackish epipelon species (*Nitzschia navicularis*, *Surirella ovata*) and brackish epipelon species (*Navicula avenacea*, *Gyrosigma acuminata*), in addition to the underlying presence of low (but consistent) percentages of other key benthic groups such as brackish fresh aerophilous (e.g. *Pinnularia viridis*), brackish fresh epiphytic (*Cocconeis placentula*), fresh epipelon (*Pinnularia maior*) and fresh epiphytic (*Synedra ulna*) taxa. When considering the uppermost samples, derived from the overlying alluvium, there is a subtle but distinct shift in taxa to suggest deposition having moved further down the tidal frame, closer to Mean High Water (MHW), primarily resulting from the increased influence of the combination of marine-brackish epipelon (*Surirella ovata*, *Nitzschia litoralis*, *Nitzschia sigma*) and brackish epipelon taxa (*Navicula avenacea*), supported by consistent low levels of marine brackish, brackish fresh and freshwater epiphytic communities (represented by *Synedra pulchella*, *Cocconeis placentula* and *Synedra ulna* respectively), commonly associated with saltmarsh vegetation. These interpretations take into account the planktonic taxa, especially those associated with the lower salinity groupings. For example, the abundance of brackish planktonic taxa throughout (typified by *Cyclotella striata*), in combination with low values of both marine and freshwater plankton, indicates varying water inputs are influencing the depositional setting throughout the site's depositional history. This is to be expected due to the mixing of both terrestrially-derived freshwaters and those marine waters from offshore.

The interpretation based on Vos and de Wolf (1993) must however be treated with caution. The scheme requires the grouping of diatom taxa into ecological categories (marine-brackish epipelon, brackish aerophilous etc) and unfortunately not all species have been allocated such groupings. This requires some assumptions to be made, for example, the ecological classification of *Navicula avenacea* is somewhat poorly understood; it has been referred to both as a brackish and fresh-brackish water taxa and is also cited as both epipelic and epilithic. It is often found to be present in coastal diatom sequences, but always as a subordinate taxa (<5% TDV) and hence its importance is rarely discussed further, yielding limited palaoenvironmental information. Within the TMR-QBH1 samples, *N. avenacea* contributes *ca*. 10-20% TDV in in the overlying alluvial samples, and so applying the correct ecological classification has the potential to dictate subsequent interpretations. As the majority of coastal literature encountered cites this as being a brackish taxa, and considering the associated stratigraphy, the species is herein referred to as a brackish epipelon species. Shennan *et a*l (1996) and Zong (1997) refers to it as being an Oligohalobous halophile species (and so more often a freshwater taxa capable of tolerating saline conditions), but no reference is made to this source of information. Another issue associated with the approach of Vos and deWolf (1993) is that some of the ecological categories require grouping together to implement the scheme. For example, the scheme highlighted in Table 8 doesn't include a brackish epipelon category, and so said taxa defined as brackish epipelon must be incorporated into the marine brackish epipelon group. The present diatom sequence could be questioned, as there are strong similarities between all four samples, and hence the subtle variations in subordinate taxa are responsible for allocating the different depositional settings to the peat and alluvial sediments (Figure 13). Based on the diatom assemblages however, in addition to the spatial distribution and sedimentary composition of the peat, a depositional setting can be suggested that takes into account these findings.

The peat was encountered in only two of the boreholes located *ca*. 20m apart from each other. Whilst some level of post-depositional autocompaction is likely, the unit is only *ca*. 30-40cm thick. It has been assumed that the peat encountered in both boreholes represents the same unit. AGS BHA2 was described as peat, by the geotechnical engineer, and it is unclear whether this included a minerogenic component. The peat in TMR-QBH1 however, was described as clay-rich, and based on the abundance of epipelon (mud-loving) diatoms, the floral assemblage, that this mineral content derived from an estuarine source. Furthermore, since these marine-brackish assemblages originated from samples taken from the centre of peat rather than the upper/lower boundary, it suggests that saline conditions are likely to have been present for much/all of the unit's depositional history. Due to the large planktonic component, and mixture of benthic taxa affiliated with (i) muddy substrates, (ii) organic remains and (iii) regular aerial exposure, a 'salt-marsh pool' environment is inferred for the peat unit.

However the combination of stratigraphy and diatoms indicates deposition was likely taking place in a setting similar to an abandoned saltmarsh creek/channel, positioned at a high relative elevation on the tidal frame. This feature would have remained ponded up with water for much of the time, whilst also being open to regular (daily) tidal inundation to explain the introduction of marine planktonic flora. Such a stagnant aquatic basin would have encouraged the accumulation of organic material, resulting in the formation of a thin peat unit, spatially restricted to a small area (thus explaining its presence in only a few boreholes). The abundance of mineral material within the peat indicates the continued input of marine waters, bringing with it the diverse range of marine/brackish planktonic and benthic flora recorded. It is suggested that the feature would have been relatively shallow and eventually became infilled with organic material. The infilling of the basin and associated loss of accommodation space would lead to a shift from organic to minerogenic deposition, as a lack of waterlogged conditions would lead to the poor preservation of remains. Mineral-rich deposition would continue as a result of repeated tidal inundation. This is evidenced through slight increases in aerophilous, epiphytic and epipelic taxa encountered within the overlying alluvium, along with an overall reduction in planktonic taxa. Ironically the proposed shift to more typical estuarine conditions may also account for the slight increases in taxa affiliated with lower salinity tolerances. Figure 10 indicates that close to 60% of the diatoms within the alluvium are Oligohalobous halophilous or Oligohalobous indifferent. The loss of planktonic influence partly explains this, but the benthic shift is also likely to be a reflection of the mixing of freshwater and brackish waters more generally during high tides. Freshwater run off from the terrestrial realm is likely to have mixed more freely in a minerogenic saltmarsh setting, in contrast to the somewhat isolated 'microenvironment' encountered within an abandoned creek/channel (or similar).

Radiocarbon dating of the upper and lower boundaries of the peat unit have revealed that organic sedimentation took place between 660-545 and 485-305 cal BP. Whilst peat-alluvium boundaries are widely used to quantify the elevation of relative sea level in prehistory, based on the diatom assemblages, it appears likely that such an attempt is not viable in this instance. Traditionally, the peat-alluvium boundary is used to create a stratigraphic Sea-Level Index Point (SLIP), which is constructed based on the assumption that the peat-alluvium boundary formed at a known elevation on the site's former shoreline. This elevation is normally quantified *relative* to MHW (the specific relationship varying between sites), based on the known altitudinal elevation at which mineral-rich sedimentation ends and freshwater terrestrial peat deposition commences. In this instance however, the floral assemblages indicate that the organic rich material was forming lower down in the tidal frame, and therefore rather than being a 'true peat' (in the sense of defining a SLIP), this organic unit is a result of organic sedimentation within the saltmarsh setting. Consequently, any attempt at deriving a SLIP from this stratigraphic boundary would not be viable, and indeed would likely underestimate the true position of sea-level at the time of deposition. This is unfortunate due to the overall lack of any peat units associated with this age/elevation in the region.

Peat units at a similar elevation do exist in the nearby area, but tend to be much thicker. These however date to earlier periods of peat accumulation, often associated with the interbedded estuarine sequence (Tilbury I-V) first proposed by Devoy (1979). Indeed, those peat units within the Thames valley encountered at a similar elevation to that present here (-1.0 to -1.5m OD) are often found to be much older (*ca*. 2,500 BP) and associated with earlier marine regressive phases (such as Tilbury IV; Devoy, 2979). Consequently, without radiocarbon dates and suitable palaeoenvironmental interpretations, it is not possible to compare these deposits with those from TMR-QBH1. There is only one sea level index point from the post-Roman period and this comes from Silvertown and dates to *ca*. 1100-1400 cal BP, with sea level believed to have been positioned around OD at the time (cited in Sidell, 2003). The lack of peat units dating to this period is a likely reflection of not only relatively stable sea levels, but also due to the active and somewhat intensive land use of the coastal lowlands throughout much of the last millennia. Land management, lowland reclamation and farming practices would have also been responsible for substantially reducing/restricting terrestrial sediment input into the coastal lowlands which, when superimposed onto the relative sea-level stability, has resulted in only small changes in the sedimentation (biogenic vs minerogenic), with erosion of the coastal lowlands more common.

Table 7: Diatom flora encountered during analysis of Borehole TMR-QBH1, The Reach, Thames Reach, Royal Borough of Greenwich

	Species		Sample Depth (m O.D.)			
			-1.06	-1.09	-1.25	-1.28
Planktonic	*Actinoptychus senarius*	M Plank	8	3	4	15
	Auliscus scupltus	M Plank	0	0	0	0
	Paralia sulcata	M Plank	13	0	6	0
	Pseudomelorira westii	M Plank	1	0	2	5
	Pseudopodosira stelligera	M Plank	0	0	0	1
	Thalassiosira sp.	M Plank	2	0	0	3
	Delphineis surirella	M Tych	2	0	1	1
	Odontella aurita	M Tych	2	2	33	14
	Rhaphoneis amphiceros	M Tych	8	3	10	5
	Cyclotella striata	B Plank	72	112	136	132
	Coscinodiscus lacustris	B Plank	8	1	17	2
	Cyclotella meneghianina	BF Plank	18	3	15	24
	Melosira varians	F Plank	24	3	12	21
Benthic	*Navicula distans*	M Epipel	2	0	0	1
	Diploneis weissflogii	M Epipel	2	1	4	9
	Diploneis ovalis	MB Aero	0	1	1	3
	Campylodiscus echeneis	MB Epipel	1	0	0	1
	Diploneis didyma	MB Epipel	0	0	0	3
	Nitzschia hungarica	MB Epipel	7	8	1	0
	Nitzschia litoralis	MB Epipel	8	20	2	0
	Nitzschia navicularis	MB Epipel	4	1	47	41
	Nitzschia punctata	MB Epipel	7	0	10	6
	Nitzschia sigma	MB Epipel	6	14	0	0
	Nitzschia trybionella	MB Epipel	10	2	4	5
	Surirella ovata	MB Epipel	45	67	60	21
	Cocconeis scutellum	MB Epiphyt	3	0	2	0
	Synedra pulchella	MB Epiphyt	35	30	1	6
	Gyrosigma acuminata	B epipel	8	6	4	9
	Navicula avenacea	B epipel	93	46	8	12
	Hantzschia amphioxys	BF Aero	0	1	8	0
	Navicula pusilla	BF Aero	1	0	0	1
	Pinnularia viridis	BF Aero	0	1	12	9
	Surirella brebissonii	BF Epipel	0	0	0	0
	Gomphonema gracile	BF Epiphyt	0	6	0	0
	Cocconeis placentula	BF Epiphyt	37	60	33	44
	Amphora ovalis	F Epipel	4	5	4	0
	Pinnularia maior	F Epipel	0	0	5	12
	Diatoma vulgare	F Epiphyt	6	11	1	0
	Epithemia adnata	F Epiphyt	0	1	3	0
	Synedra ulna	F Epiphyt	45	20	2	12
	Epithemia sp.	unknown	1	0	0	0
	Pinnularia sp.	unknown	2	0	0	0
	Total		485	428	448	418

Table 8: Relation between the relative abundance (%TDV) of the ecological groups and the sedimentary environments, modified from Vos & de Wolf (1993)

Ecological groups	Macro- and mesotidal environments							Microtidal and non-tidal environments		
	Subtidal area		Intertidal area		Supratidal area			Marine/brackish		non-marine (fresh)
	open marine tidal channels	estuarine tidal conditions	sand-flats	mud-flats	salt-marshes, around MHW	salt-marshes, above MHW	pools in the salt-marshes	tidal lagoons, small tidal inlet	lagoons, no tides	rivers, ditches, lakes
Marine plankton	10-80	10-60	1-25	10-70	10-70	10-70	10-50	10-60	0-10	0-5
Marine tychoplankton	20-90	15-60	1-25	10-70	10-70	10-70	10-50	10-60	0-10	0-5
Brackish plankton	1-10	20-70	1-10	1-30	1-30	1-30	1-15	1-15	0-10	0-5
Marine/brackish epipsammon	1-40	1-45	50-95	1-45	0-15	0-15	0-15	0-25	0-5	0-1
Marine/brackish epipelon	0-5	0-5	1-30	15-50	1-40	0-5	5-30	5-50	5-60	0-1
Marine/brackish aerophilous	0-1	0-1	0-1	0-1	10-40	15-95	10-40	0-1	0-1	0-1
Brackish/freshwater aerophilous	0-1	0-1	0-1	0-1	10-40	15-95	10-40	0-1	0-1	0-10
Marine/brackish epiphytes	0-1	0-1	0-5	0-5	0-5	0-5	10-60	10-75	10-90	0-5
Brackish/freshwater plankton	0-1	0-25	0-1	0-1	0-1	0-1	0-1	0-20	0-25	0-5
Brackish/freshwater tychoplankton	0-1	0-1	0-5	0-5	0-5	0-5	5-50	5-50	5-80	0-10
Brackish/freshwater epiphytes	0-1	0-1	0-5	0-5	0-5	0-5	1-50	1-50	1-80	0-10
Freshwater epiphytes	0-1	0-1	0-1	0-1	0-5	0-5	0-10	0-10	0-10	1-75
Freshwater epipelon	0-1	0-1	0-1	0-1	0-1	0-1	0-10	0-5	0-10	1-75
Freshwater plankton	0-1	0-1	0-1	0-1	0-1	0-1	0-5	0-15	0-20	10-95

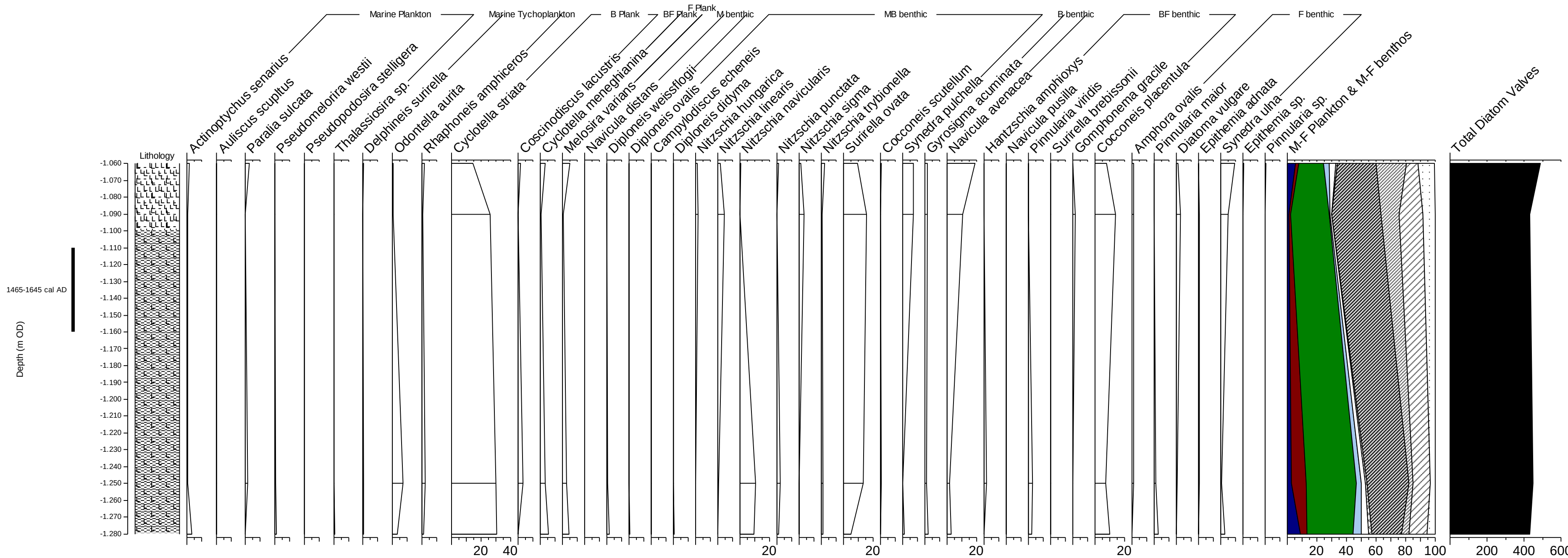

Figure 10: Summary of diatom salinity & lifeform classifications associated with assemblages encountered in The Reach Borehole TMR-QBH1.

The cumulative percentage chart displays the planktonic species in solid colour; dark blue is marine planktonic, red is marine tychoplanktonic, green is brackish planktonic, light blue is brackish-fresh planktonic, and white being freshwater planktonic. The hatched cumulative plots display benthic taxa, going from left to right with decreasing salinity (marine-freshwater)

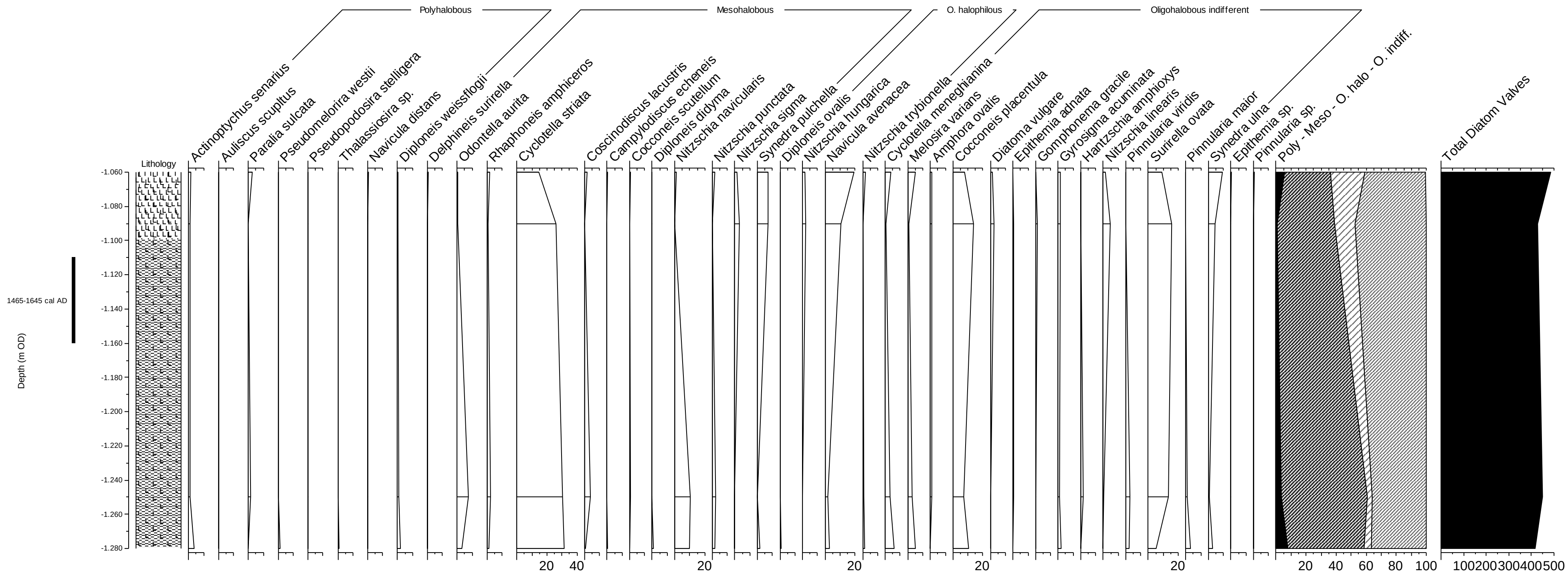

Figure 11: Summary of diatom salinity requirements of assemblages encountered in The Reach Borehole TMR-QBH1. Species are divided into the following categories: Polyhalobous (>30‰), Mesohalobous (0.2-30‰), Oligohalobous (<0.2‰)

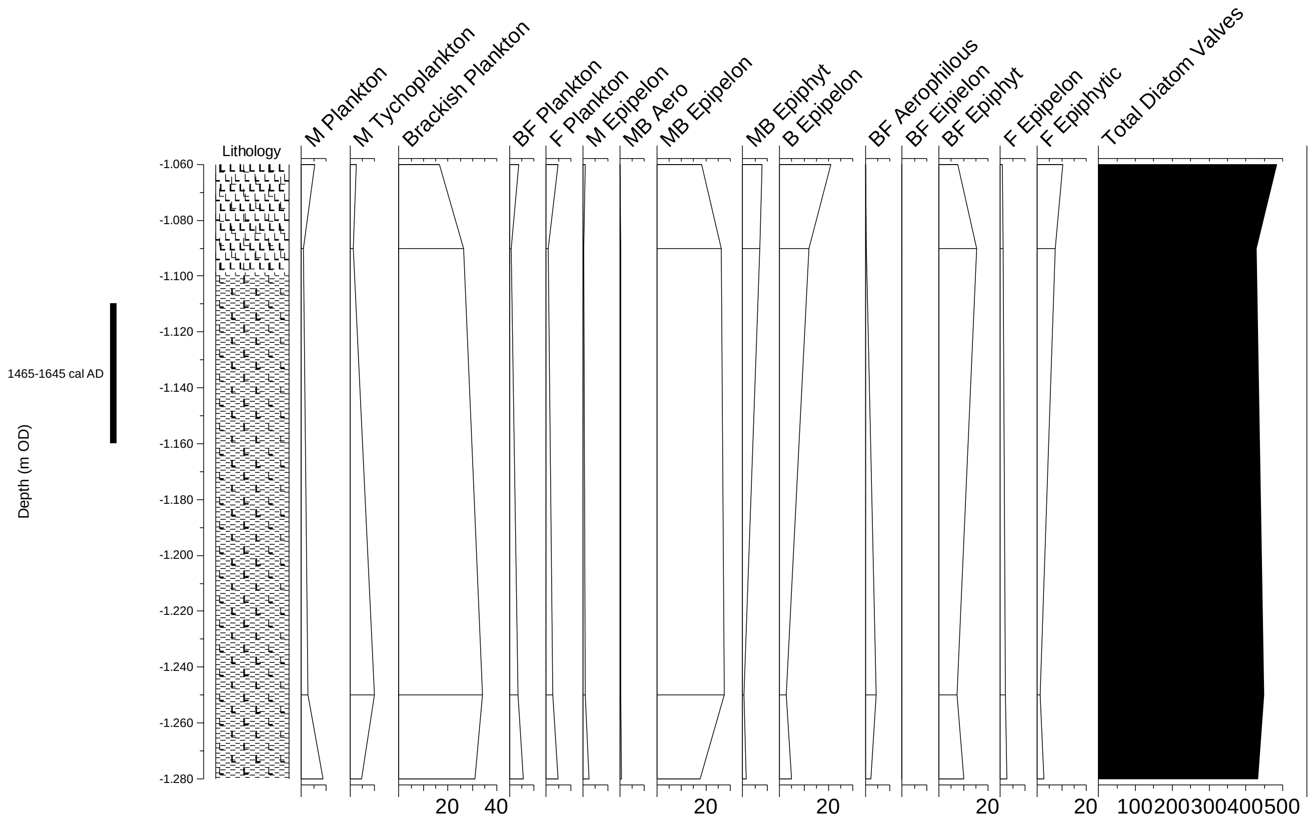

Figure 12: Summary of diatom salinity & lifeform classifications in accordance with the classification scheme of Vos & deWolf (1993), associated with assemblages encountered in The Reach Borehole TMR-QBH1.

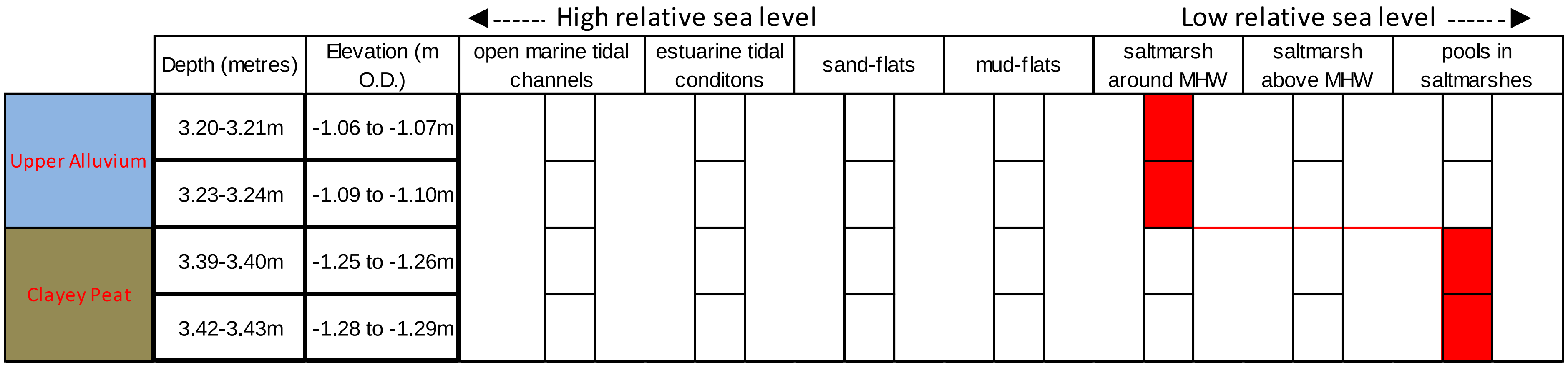

Figure 13: Summary of the costal conditions that prevailed at The Reach, based on Vos & deWolf (1993)

6 RESULTS & INTEPRETATION OF THE POLLEN ANALYSIS

Samples were prepared for pollen analysis from the peat horizons of TMR-QBH1. The samples were focussed on part of the sedimentary sequence most likely to represent semi-terrestrial or terrestrial environments; i.e. the peat. Whilst this prevents a reconstruction of vegetation history through the complete sedimentary sequence (as carried out and advocated by Allen and Scaife, 2000), it does permit higher resolution inspection of these horizons. Furthermore, and as outlined in detail by Allen and Scaife, there are a number of taphonomic issues that complicate the interpretation of palynological data from the mineral-rich sediments of low-energy fluvial and estuarine environments, including: (1) the long distance travel of pollen by fluvial or aeolian means (e.g. Moore *et al*., 1991; Scaife & Burrin, 1992), and (2) the reworking and redeposition of pollen from older sediments (e.g. Cushing, 1967; Waller, 1993; Campbell, 1999). Concentration of the palaeoenvironmental analysis on the semi-terrestrial and terrestrial deposits reduces the impact of these particular taphonomic issues. However, another issue specific to pollen-analytical studies in coastal lowland wetlands is that of taxonomic precision and distinguishing the environment of origin. The identification of pollen grains (in particular herb taxa) is frequently limited by morphological similarities between grains of different species, and often only the genus can be established. In addition, the herbs found in one wetland habitat are often palynologically indistinguishable from other members of their genera/family that may have originated from different wetland or dryland environments (Waller, 1993, 1998; Waller *et al*., 2005; see for example Wheeler, 1980a, b). These issues are taken into account in the following assessment & interpretation.

6.1 Results of the pollen analysis

The percentage pollen diagram from TMR-QBH1 is displayed in Figure 14 and has been divided into two local pollen assemblage zones (LPAZ's TMR-1 & 2).

LPAZ TMR-1 -1.42 to -1.24m OD Poaceae – *Quercus* - Cyperaceae

This zone is characterised by very high values of herbaceous (>95%) pollen. Poaceae dominates (>90%) with Cyperaceae, *Cereale* type, *Plantago* lanceolata, *Chenopodium* type, *Rumex* undifferentiated & *Sinapis* type (all <2%). Trees and shrubs (<10%) include *Quercus*, *Alnus*, *Ulmus* and *Corylus* type (all <2%). Aquatics are represented by *Sparganium* type (<2%). Spores are largely absent with only sporadic occurrences of *Filicales* & *Sphagnum*. Total pollen concentration generally range between 100,000 and 220,000 grains/cm^3. Microcharcoal charcoal concentrations are 50,000 fragments/cm^3 at the base of the zone, decreasing to <5000 fragments/cm^3.

LPAZ TMR-2 -1.24 to -1.06m OD Poaceae – Chenopodium type - Asteraceae

This zone is characterised by very high values of herbaceous (>60%) pollen. Poaceae dominates (40-15%) with *Chenopodium* type (>10%), Asteraceae (20-1%), *Rumex* undifferentiated (15% at -1.16m OD), Lactuceae, Cyperaceae, *Cereale* type & *Sinapis* type (all <5%). Trees and shrubs increased through the zone to include *Quercus*, *Alnus* and *Corylus* type (all >10%) with *Salix*, *Calluna* *vulgaris*, *Ulmus*, *Betula* (all <5%) and one occurrence of *Juglans*. Aquatics are represented by *Sparganium* type with *Potamogeton* type & *Typha latifolia* (all <3%). Spores increase through the zone (to >15%), dominated by *Filicales* with *Pteridium aquilinum*, *Sphagnum* & *Polypodium* vulgare. Total pollen concentration is around 30,000 grains/cm^3. Microcharcoal charcoal concentrations are <20,000 fragments/cm^3, with the exception of a spike of 200,000 fragments/cm^3 at -1.16m OD.

6.2 Interpretation of the pollen-stratigraphic analysis

LPAZ TMR-1 -1.42 to -1.24m OD Poaceae – *Quercus* - Cyperaceae

This assemblage is indicative of a very open environment and damp environment. The dominance of reed swamp with limited sedge fen is indicated by the very high values of grasses (Poaceae – most likely reeds – *Phragmites australis*), with sedges (Cyperaceae) and bur-reed (*Sparganium* type); a marine influence is also suggested by the possible presence of sea plantain (*Plantago maritima*) at the very base of the zone. Given the saline influence in this part of the sequence, it is possible that the presence of *Cereale*-type pollen might represent either cereal cultivation, but are more likely to represent the growth of coastal grasses, which produce pollen with a similar morphology and size to that of cereal pollen grains (e.g. Andersen, 1979). The sporadic occurrence of tree and shrub taxa is suggestive of a very open environment beyond the margins of the floodplain.

LPAZ TMR-2 -1.24 to -1.06m OD Poaceae – *Chenopodium* type - Asteraceae

The transition to LPAZ TMR-2 is characterised by a change in the herbaceous assemblage. An increasing saline influence is suggested by reducing grass pollen percentage values and high values of *Chenopodium* type (e.g. *Suaeda maritima* – annual seablite) and Asteraceae (e.g. sea aster), most likely representing the growth of saltmarsh communities. This interpretation is enhanced by findings of the stratigraphic and diatom analysis (see above). Dinoflagellate cysts were also noted which can also be indicative of brackish/marine environments. It is likely that the *Calluna vulgaris* and Ericaceae recorded during this zone represent the localised growth of saline tolerant coastal heathers on the peat surface.

During this period, an increase of tree / shrub pollen is also recorded. The expansion of alder (*Alnus*) and willow (*Salix*) most likely represents the growth of floodplain woodland at distance either on more stable areas of the floodplain or towards the floodplain / dryland edge. Hazel (*Corylus* type) and oak (*Quercus*) may also have grown with alder and willow on the margins of the wetland forming fen carr woodland on drier peat surfaces. The presence of *Juglans* (walnut) is also of note; since it was introduced during the Roman period, it indicates that the sequence must post-date this period.

Finally, a spike in microcharcoal was recorded at -1.16m OD. Some of these fragments are likely to have derived from a distal source, and have become concentrated due to the nature of the environment. However, the concentrations of microcharcoal are high, and whilst the majority of the fragments are undiagnostic some have a morphology analogous to charred grasses (e.g.

Brown, 2006). At least some of these fragments are therefore considered to represent the autochonous or nearby burning of sedge fen/reed swamp/saltmarsh.

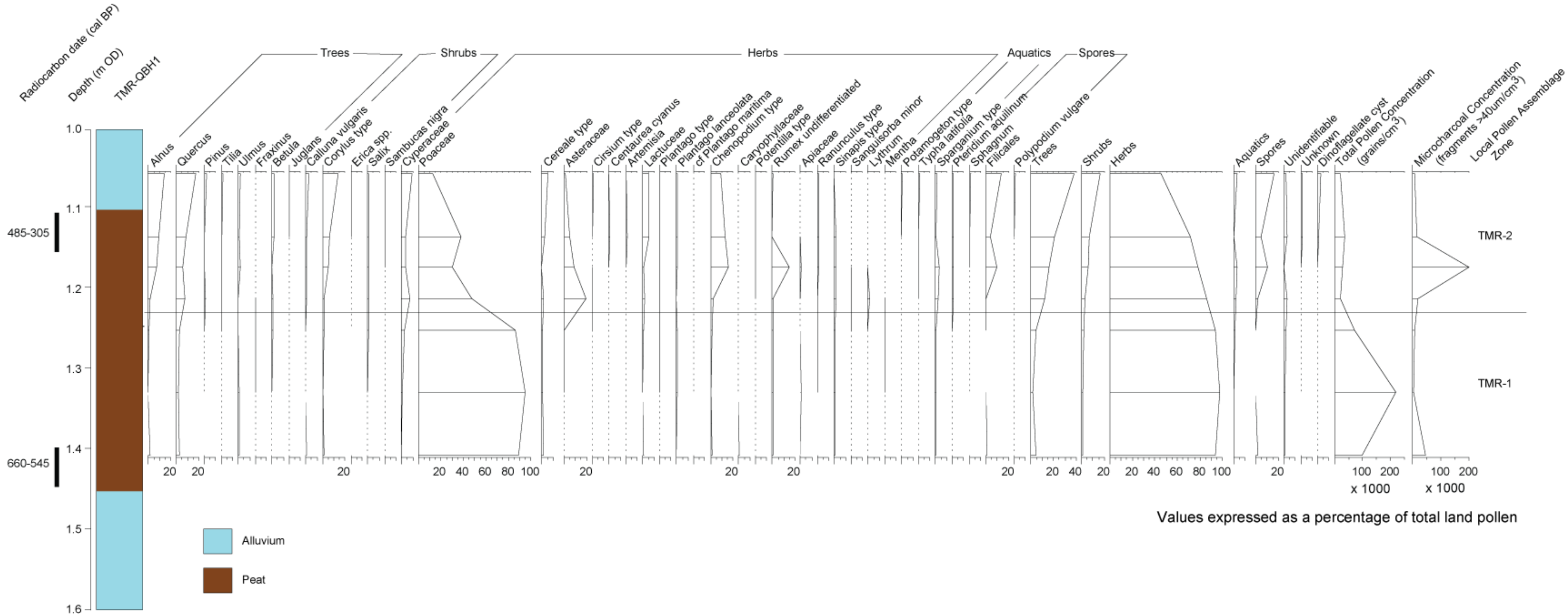

Figure 14: Pollen percentage diagram from TMR-QBH1, The Reach, Thames Reach, Royal Borough of Greenwich.

7 RESULTS & INTEPRETATION OF THE MACROFOSSIL ASSESSMENT

Seven small bulk samples were extracted and processed for the recovery of macrofossil remains, including waterlogged plant macrofossils, wood, insects and Mollusca from the peat within borehole TMR-QBH1 (Table 9).

7.1 Results of the macrofossil assessment

The results of the macrofossil rapid assessment of the samples from TMR-QBH1 indicate that waterlogged wood was present in low concentrations in two samples, one from the peat (-1.11 to -1.16m OD) and one from the underlying alluvium (-1.31 to -1.36m OD). Waterlogged seeds were present in only one sample from the peat (-1.11 to -1.16m OD), including four seeds of *Chenopodium sp.*. Waterlogged sedge remains were present in moderate to high quantities in all seven samples, whilst insect remains were present in low to moderate quantities in all but one sample (-1.16 to -1.21m OD). No charred remains, Mollusca or bone were recorded within any of the samples.

7.2 Interpretation of the macrofossil assessment

The seed assemblage in the samples from TMR-QBH1 is too small to attempt a full environmental interpretation; however, the presence of Chenopodium sp. in the uppermost sample may represent saltmarsh or open communities.

Table 9: Results of the macrofossil assessment of borehole TMR-QBH1, The Reach, Thames Reach, Royal Borough of Greenwich

			Charred					Waterlogged				Mollusca		Bone			
Depth (m OD)	Volume processed (ml)	Fraction	Charcoal (>4mm)	Charcoal (2-4mm)	Charcoal (<2mm)	Seeds	Chaff	Wood	Seeds		Sedge remains (e.g. stems/roots)	Whole	Fragments	Large	Small	Fragments	Insects
-1.11 to -1.16	50	>300µm	-	-	-	-	-	1	1	*Chenopodium* sp.	2	-	-	-	-	-	2
-1.16 to -1.21	50	>300µm	-	-	-	-	-	-	-		3	-	-	-	-	-	-
-1.21 to -1.26	50	>300µm	-	-	-	-	-	-	-		4	-	-	-	-	-	1
-1.26 to -1.31	50	>300µm	-	-	-	-	-	-	-		3	-	-	-	-	-	2
-1.31 to -1.36	50	>300µm	-	-	-	-	-	1	-		5	-	-	-	-	-	2
-1.36 to -1.41	50	>300µm	-	-	-	-	-	-	-		5	-	-	-	-	-	1
-1.41 to -1.46	50	>300µm	-	-	-	-	-	-	-		5	-	-	-	-	-	1

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+

8 CONCLUSIONS

The geoarchaeological and palaeoenvironmental analysis report was aimed at fully addressing the following seven original project aims, with a specific focus on the environmental conditions during the medieval period:

1. To clarify the nature of the sub-surface stratigraphy across the site
2. To clarify the nature, depth, extent and date of any former land surfaces, alluvial and peat deposits;
3. To clarify the presence of peat deposits within the River Terrace Gravels.
   NB this aim may not be possible to achieve due to the difficulties of drilling through and retaining gravel deposits.
4. To compare the results of the investigation to the Gallions Reach Urban Village model, and those of nearby sites.
5. To investigate whether the sequences contain any artefact or ecofact evidence for prehistoric or historic human activity;
6. To investigate whether the sequences contain any evidence for natural and/or anthropogenic changes to the landscape (wetland and dryland);
7. To integrate the new geoarchaeological record with other recent work in the local area for publication in an academic journal.

The results of the investigation have revealed a sequence of Gravels overlain by Alluvium capped by Made Ground. The sequence however, is unique within the Lower Thames Valley for two reasons:

9 Towards the south of the site, peat deposits recorded within the Gravels date to the Bronze Age and Iron Age demonstrating that they cannot be correlated with the Late Devensian Shepperton Gravel as recorded elsewhere across the Lower Thames Valley (e.g. Gallions Reach Urban Village). It further follows that the peat deposits recorded within the Gravel are not of Pleistocene age as previously hypothesised. It is highly unlikely that a channel of sufficient energy to deposit this thickness of gravel was active at this time in the Late Holocene, so fluvial processes associated with a channel can effectively be ruled out. Instead, two alternative hypotheses are proposed: (1) that the deposits are associated with the erosion of nearby gravel and peat deposits during one or more high-energy flood events during the Late Holocene; or (2) that colluvial (slope-wash) processes led to the redeposition of nearby gravel and peat deposits, perhaps associated with an anomalous depression in the surface of the bedrock. Unfortunately, on the basis of the data available, it is not possible to confirm which of these processes is more likely to have led to the deposition of the mixed gravel-peat deposits at The Reach site. It is also not possible from the available evidence to ascertain where this Gravel deposit is replaced by the 'usual' Shepperton Gravel. The absence of peat within the Gravel to the north of the site may represent this transition, but this is not unequivocal.

10 Towards the top of the Alluvium, a clayey peat dating to the medieval period is recorded. It appears to be isolated to the centre of the northern part of the site, being recorded in AGS-BHA2 & TMR-QBH1. Despite its late age, it occurs at a similar elevation to older and thicker peat horizons recorded more frequently within the alluvial sequence in this area (such as at Gallions Reach Urban Village). Diatom analysis indicates that the medieval peat most likely accumulated in a setting similar to an abandoned saltmarsh creek/channel, positioned at a high relative elevation on the tidal frame. It remained filled with water, whilst also being open to regular (daily) tidal inundation. Such a stagnant aquatic basin would have encouraged the accumulation of organic material, resulting in the formation of a thin peat unit, spatially restricted to a small area (thus explaining its presence in only a few boreholes). The abundance of mineral material within the peat indicates the continued input of marine waters, bringing with it the diverse range of marine/brackish planktonic and benthic flora recorded. The feature was probably relatively shallow and eventually became infilled, after which, the transition to mineral-rich alluvium took place as a result of repeated tidal inundation.

During its infilling, the saltmarsh creek/channel was probably bordered by reed swamp with limited sedge fen and possibly saltmarsh taxa. As it became infilled however, the local vegetation changed to become more strongly dominated by saltmarsh communities. The surrounding environment was apparently very open with limited trees/shrubs as might be expected during this period. A marginal expansion of woodland is recorded as the feature became infilled, most likely representing pollen influx from a wider area.

There is no definitive evidence of human activity within the sequences analysed. Potential cereal pollen grains were encountered within the medieval peat, but these most likely represent coastal grasses which have a similar morphology. In addition, high levels of microcharcoal were recorded in certain samples, but it is not possible to state whether these originate from are an in situ or allocthonous source. Nor is it possible to ascertain whether they are of natural or anthropogenic origin.

The aims and objectives of the project are considered to have been successfully achieved, as above, providing a unique record from this area of the Lower Thames Valley. The results whilst significant, are not considered worth publishing in isolation, but instead should be held for a wider-ranging paper on the depositional history of the Plumstead Marshes.

9 REFERENCES

Allen, M.J. & Scaife, R.G. (2010) The physical evolution of the North Avon Levels: A review and summary of the archaeological implications. Wessex Archaeology Internet Reports.

Archaeology South East (2008) *An archaeological excavation at Belmarsh East, a post-excavation assessment and updated project design*. Unpublished Report 2008.

Batchelor, C.R. (2009) *Middle Holocene environmental changes and the history of yew (Taxus baccata L.) woodland in the Lower Thames Valley.* Royal Holloway, University of London unpublished PhD thesis.

Batchelor, C.R. (2012a) *2-6 Griffin Manor Way Phase 2, London Borough of Greenwich (Site Code: GMW12): Geoarchaeological Deposit Model.* Quaternary Scientific (QUEST) Unpublished Report August 2012; Project Number 038/12.

Batchelor, C.R. (2012b) 2-6 *Griffin Manor Way, London Borough of Greenwich: Geoarchaeological Deposit Model*. Quaternary Scientific (QUEST) Unpublished Report March 2012; Project Number 038/12

Batchelor, C.R. (2012c) *82-86 Nathan Way, London Borough of Greenwich: Geoarchaeological Deposit Model.* Quaternary Scientific (QUEST) Unpublished Report March 2012; Project Number 060/12.

Batchelor, C.R. (2016) *The Reach, Thames Road, Royal Borough of Greenwich Geoarchaeological and Palaeoenvironmental Written Scheme of Investigation*. Quaternary Scientific (QUEST) Unpublished Report August 2016; Project Number 099/16.

Batchelor, C.R. & Young, D.S. (2008) *Pettman Crescent, London Borough of Greenwich (PWO08): Radiocarbon dating and geoarchaeological deposit modelling*. Quaternary Scientific (QUEST) Unpublished Report November 2008; Project Number 003/08.

Batchelor, C.R., Elias, S., Young, D., Branch, N.P., Green, C.P., Swindle, G. (2008) *St Paul's Academy, Abbey Wood School, Eynsham Drive, Abbey Wood, London Borough of Greenwich (site code: AWS05): environmental archaeological analysis. ArchaeoScape* Unpublished Report.

Berry, F.G. (1979) Late Quaternary scour hollows and related features in central London. *Quarterly Journal of Engineering Geology*, 12, 9-29.

Branch, N.P., Williams, A. & Swindle, G.E. (no date(a)) *Thamesmead 8J: an environmental archaeological assessment. ArchaeoScape* Unpublished data.

Branch, N.P., Williams, A. & Swindle, G.E. (no date(b)) *Collingtree Park: an environmental archaeological assessment. ArchaeoScape* Unpublished data.

Bronk Ramsey C. (1995) Radiocarbon Calibration and Analysis of Stratigraphy: The OxCal Program, *Radiocarbon* 37 (2), 425-430.

Bronk Ramsey C. (2001) Development of the Radiocarbon Program OxCal, *Radiocarbon* 43 (2a), 355-363.

Bronk Ramsey, C. (2007) Deposition models for chronological records. *Quaternary Science Reviews* (INTIMATE special issue; 27(1-2), 42-60.

Campbell, I.D. (1999) Quaternary pollen taphonomy: examples of differential redeposition and differential preservation. Palaeogeography, Palaeoclimatology, Palaeoecology, 149, 245-256.

Cappers, R.T.J., Bekker R.M. & Jans J.E.A. (2006) Digital Seed Atlas of the Netherlands. Groningen Archaeological Series 4. Barkhuis, Netherlands

CgMs Consulting (2016) Archaeological Desk-Based Assessment: The Reach, Thames Reach, London. *CgMs Consulting Unpublished Report.*

Collins, P.E.F., Banks, V.J.,Royse, K.R. and Bricker, S.H. (2014) Superficial Hollows and Rockhead Anomalies in the London Basin, UK: Origins, Distribution and Risk Implications for Subsurface Infrastructure and Water Resources. *Engineering Geology for Society and Territory* 6: 663-666.

Cushing, E.J. (1967) Evidence for differential pollen preservation in late Quaternary sediments in Minnesota. Review of Palaeobotany and Palynology, 4, 87-101.

Denys, L. (1991-92). A check-list of the diatoms in the Holocene deposits of the western Belgian coastal plain with a survey of their apparent ecological requirements: I. Introduction, ecological code and complete list. *Service Geologique de Belgique, professional paper* 246.

Denys, L. (1994). Diatom assemblages along a former intertidal gradient: a palaeoecological study of a subboreal clay layer (western coastal plain, Belgium). Netherlands *Journal of Aquatic Ecology*. 28, 1, 85-96.

Devoy, R.J.N. (1979) Flandrian sea-level changes and vegetational history of the lower Thames estuary. *Philosophical Transactions of the Royal Society of London*, B285, 355-410.

Gibbard, P.L. (1994) *Pleistocene History of the Lower Thames Valley*. Cambridge University Press, Cambridge.

Hart, D., Allott, L., Bamforth, M., Bates, M., Davies, S., Driver, G., Jones, S., Marshall, P., Whittaker, J. (2009). Archaeological investigations at Belmarsh West, London Borough of Greenwich: post-excavation assessment and project design for publication. Archaeology South-East unpublished report.

Hendy, N.I. (1964). *An introductory account of the smaller algae of the British coastal waters. Part V: Bacillariophyceae (Diatoms)*. Fisheries Investigation Series, I, H.M.S.O., London.

Hutchinson, J.N. (1980) Possible Late Quaternary pingo remnants in central London. *Nature*, 284, 253-255.

Krammer, K. & Lange-Bertalot, H. (1986-1991). *Subwasserflora von Mitteleuropa. Bacciliarophyceae: 2 (1) Naviculaceae; 2 (2) Bacillariacceae, Epithemiaceae, Surirellaceae; 2 (3) Centrales, Fragilariaceae, Eunotiaceae; 2 (4) Achnanthaceae*. Fischer, Stuttgart.

Martin, A.C. and Barkley, W.D. (2000) *Seed Identification Manual*. The Blackburn Press, Caldwell, New Jersey.

MoLA (1996) Gallions Reach Urban Village, Thames Reach: Archaeological Desk-Based Assessment. MoLA unpublished report.

MoLA (1997) Gallions Reach Urban Village, Thames Reach: A Geoarchaeological Evaluation. MoLA unpublished report.

Moore, P.D., Webb, J.A. & Collinson, M.E. (1991) *Pollen Analysis*. Oxford: Blackwell Scientific.

NIAB (2004) *Seed Identification Handbook Agriculture, Horticulture & Weeds. 2nd edition*. NIAB, Cambridge.

Reille, M. (1992) *Pollen et spores D'Europe et D'Afrique du Nord*. Laboratoire de Botanique historique et Palynologie, Marsaille.

Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey, C., Buck, C.E., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Haflidason, H., Hajdas, I., Hatté, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., Manning, S.W., Niu, M., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., and van der Plicht, J., (2013) IntCal13 and Marine13 radiocarbon age calibration curves, 0-50,000 years cal BP. *Radiocarbon* 55: 1869-1887.

Pine, C.A. et al. (1994) A report on Thamesmead Site 8B, Thamesmead, London. GSF reference: 94/03.

Provectus (2016) *Geotechnical and geoenvironmental site assessment, The Reach, Plumstead*. Provectus Unpublished Report, April 2016.

Round, Crawford, Mann (2007). *The Diatoms: Biology and Morphology of the Genera*. Cambridge

Scaife, R.G. & Burrin, P.J. (1992) Archaeological inferences from alluvial sediments: some findings from southern England. In (Needham, S. & Macklin, M.G. eds), Alluvial Archaeology in Britain. Oxford: Oxbow Monograph 27, 75–91.

Shennan, I., Rutherford, M.M, Innes, J.B. & Walker, K.J. (1996) Late glacial sea level and ocean margin environmental changes interpreted from biostratigraphic and lithostratigraphic studies of isolation basins in northwest Scotland . In Andrews, J. T., Austin, W. E. N., Bergsten, H. & Jennings, A. E. (eds), *Late Quaternary Palaeoceanography of the North Atlantic Margins*, Geological Society Special Publication No. 111, pp. 229-244.

Sidell, J. (1998) *Assessment of the Borehole Sequences from the Aldi Development, Central Way, Thamesmead*. MoLAS Unpublished Report June 1998.

Sidell, J. (2003) *Holocene sea-level chage and archaeology in the inner Thames estuary, London, UK*. Unpublished Durham Thesis, Durham University.

Sidell, J., Wilkinson, K., Scaife, R. and Cameron, N. (2000) *The Holocene evolution of the London Thames.* MoLAS Monograph 5, Museum of London Archaeology Service.

Stace, C. (2005) *New Flora of the British Isles*. Cambridge: Cambridge University Press.

Tröels-Smith, J. (1955) Karakterisering af løse jordater (Characterisation of unconsolidated sediments), *Danm. Geol. Unders., Ser IV* 3, 73.

Van Dam, H., Mertens, A. & Seinkeldam, J. (1994). A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. Netherlands Journal of Aquatic *Ecology*, 28, (1), 117-133.

van Der Werff & Huls (1958-1974). *Diatomeeënflora van Nederland*. Eight parts, published privately by van der Werff, De Hoef (U), The Netherlands.

Vos, P.C. & de Wolf, H. (1988). Methodological aspects of palaeo-ecological diatom research in coastal areas of the Netherlands. *Geologie en Mijnbouw*, 67, 31-40.

Vos, P.C. & de Wolf, H. (1993). Diatoms as a tool for reconstructing sedimentary environments in coastal wetlands: methodological aspects. *Hydrobiologia*, 269/270, 285-96.

Waller, M.P. (1993) Flandrian vegetational history of south-eastern England. Pollen data from Pannel Bridge, East Sussex. New Phytologist, **124**, 345-369.

Waller, M.P. (1998) An investigation in the palynological properties of fen peat through multiple pollen profiles from south-eastern England. Journal of Archaeological Science **25**, 631-642.

Waller, M.P., Binney, H.A., Bunting, M.J. & Armitage, R.A. (2005) The interpretation of fen carr pollen diagrams: pollen-vegetation relationships within fen carr. Review of Palaeobotany and Palynology, **133**, 179-202.

Wheeler, A.J. (1992) Vegetational succession, acidification and allogenic events as recorded in Flandrian peat deposits from an isolated Fenland embayment. New Phytologist, **122**, 745-756.

Wheeler, B.D. (1980a) Plant communities of rich-fen systems in England and Wales I: introduction, tall sedge and reed communities. Journal of Ecology, **68**, 365-395.

Young, D.S. and Batchelor, C.R. (2014) Rawalpindi House, Hermit Road, London Borough of Newham E16 4PZ (Site Code: HER14): Environmental Archaeological Assessment. *Quaternary Scientific (QUEST) Unpublished Report November 2014; Project Number 037/14.*

Young, D.S., Batchelor, C.R. and Green, C.P. (2016) The Reach, Thames Reach, London Borough of Greenwich Geoarchaeological Deposit Model Report. *Quaternary Scientific (QUEST) Unpublished Report September 2016; Project Number 099/16.*

Zong, Y (1997) Implications of *Paralia sulcata* abundance in Scottish isolation basins. *Diatom Research* 12, 1, 125-150.

10 APPENDIX 1: OASIS

1.1 OASIS ID: quaterna1-264267

Project details

Project name	The Reach, Plumstead
Short description of the project	Geoarchaeological and palaeoenvironmental analysis was instigated at The Reach, Thames Reach, Royal Borough of Greenwich following the findings of previous field- and assessment work. The aim of the analysis was to fully address the seven original project aims outlined in the Written Scheme of Investigation for the site with a specific focus on the environmental conditions during the medieval period. The results of the investigation have revealed a sequence of Gravels overlain by Alluvium capped by Made Ground. The sequence however, is unique within the Lower Thames Valley for two reasons: (1) the presence of apparently reworked gravel beneath the site rather than in situ Shepperton Gravel, and (2) the presence of peat horizon dated to the medieval period. No definitive evidence of human activity was recorded within the sequences analysed. The aims and objectives of the project are considered to have been successfully achieved, providing a unique record from this area of the Lower Thames Valley. The results whilst significant, are not considered worth publishing in isolation, but instead should be held for a wider-ranging paper on the depositional history of the Plumstead Marshes.
Project dates	Start: 01-08-2016 End: 30-09-2016
Previous/future work	No / Yes
Any associated project reference codes	TMR16 - Sitecode
Type of project	Environmental assessment
Monument type	ALLUVIUM Uncertain
Monument type	PEAT Uncertain
Significant Finds	N/A None
Survey techniques	Landscape

Project location

Country	England
Site location	GREATER LONDON GREENWICH WOOLWICH The Reach, Plumstead
Postcode	SE28 0NY
Site coordinates	TQ 45203 79791 51.497877185765 0.092087811211 51 29 52 N 000 05 31 E Point

Project creators

Name of Organisation	Quaternary Scientific (QUEST)
Project brief originator	CgMs Consulting
Project design originator	Dr C.R. Batchelor
Project director/manager	C.R. Batchelor

Project supervisor	D.S. Young
Type of sponsor/funding body	Developer

Project archives

Physical Archive Exists?	No
Digital Archive Exists?	No
Paper Archive recipient	LAARC
Paper Contents	"Environmental"
Paper Media available	"Report"

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	THE REACH, THAMES REACH, ROYAL BOROUGH OF GREENWICH: Environmental Archaeological Assessment Report
Author(s)/Editor(s)	Young, D.S.
Author(s)/Editor(s)	Batchelor, C.R.
Author(s)/Editor(s)	Green, C.P.
Other bibliographic details	Quaternary Scientific (QUEST) Unpublished Report December 2016; Project Number 099/16
Date	2016
Issuer or publisher	University of Reading
Place of issue or publication	Reading
Description	PDF

Project bibliography 2

Publication type	Grey literature (unpublished document/manuscript)
Title	THE REACH, THAMES REACH, ROYAL BOROUGH OF GREENWICH Geoarchaeological and Palaeoenvironmental Analysis Report
Author(s)/Editor(s)	Batchelor, C.R.
Author(s)/Editor(s)	Young, D.S.
Author(s)/Editor(s)	HIll, T.
Author(s)/Editor(s)	Green, C.P.
Other bibliographic details	Quaternary Scientific (QUEST) Unpublished Report April 2017; Project Number 099/16
Date	2017

Issuer or publisher	Quaternary Scientific (QUEST)
Place of issue or publication	University of Reading
Entered by	C.R. Batchelor (c.r.batchelor@reading.ac.uk)
Entered on	11 April 2017