A REPORT ON THE GEOARCHAEOLOGICAL BOREHOLE INVESTIGATIONS AND DEPOSIT MODEL AT TIDEWAY WHARF, 87 KIRTLING STREET, NINE ELMS, LONDON BOROUGH OF WANDSWORTH

C.P. Green and D.S. Young
Quaternary Scientific (QUEST), *School of Human and Environmental Sciences, University of Reading, Whiteknights, PO Box 227, Reading, RG6 6AB, UK*

INTRODUCTION

This report summarises the findings arising out of the geoarchaeological borehole investigations undertaken by Quaternary Scientific (University of Reading) in connection with the proposed development at Tideway Wharf, 87 Kirtling Street, Nine Elms, London Borough of Wandsworth (National Grid Reference TQ 293 775; site code: TDE11; Figure 1). The area of investigation is located on the floodplain of the Thames. Recent investigations (Morely, 2009/2010) have identified the site as lying within the immediate vicinity of the former Battersea channel, a subsidiary channel of the Thames which is thought to have run to the south of Battersea Park, roughly from Wandsworth Bridge to Nine Elms. Morley suggests that by the Roman period the channel had been reduced to a narrow creek, due to a combination of climate alterations, changes in sea level and the impacts of human intervention (Morley, 2010).

Geotechnical investigations at the site (between 1978-1979 and 2007) revealed significant quantities of made ground (up to 8m), over alluvial clays, sands and gravels and London Clay. The geotechnical data suggest that peat is present near the northern boundary of the site where the underlying gravel appears to fall away steeply to the north. Elsewhere there is in most places a thin layer of probably silty alluvium over gravel. The gravel surface is quite high (up to 1.5m OD) in the southern two thirds of the site and probably represents a gravel eyot (like the Horseleydown and Bermondsey eyots in the Southwark area). In the SE quarter of the site the made ground cuts down to the gravel and there is no Holocene alluvium preserved.

The existing geotechnical borehole record at the site appears inconsistent with the reconstruction of the early Holocene topography proposed by Morley (above). Where the geotechnical boreholes indicate a gravel high, Morley suggests a continuation of the Battersea Channel. Together with the existing geotechnical data, it is hoped the proposed investigations will provide an opportunity to gain a fuller understanding of the area.

It is also apparent from the geotechnical and historical records that most of the northern half of the site has at some point been excavated to form docks. Most of the southern half of the site appears to be relatively undisturbed, but has only a thin, probably not very organic alluvial cover over a gravel surface at *ca*. 1.0m OD. Three geoarchaeological boreholes were therefore put down at the site in the following positions:

BH <4> in the south to confirm the sediment sequence that appears to be recorded in the existing geotechnical borehole logs;
BH <1C> and BH <3> in the north to try and locate surviving undisturbed natural organic alluvium

The main aim of the geoarchaeological borehole investigations was to produce a basic model of the sub-surface stratigraphy across the site and to clarify the nature, depth, extent and date of any alluvium and peat associated with the Battersea channel and to highlight sediments of potential palaeoenvironmental significance.

GEOLOGICAL CONTEXT

The site is close to the waterfront of the tidal Thames on the right (south) bank between Chelsea Bridge and Vauxhall Bridge and near the eastern end of the gravel 'islands' (former eyots) that underlies Battersea. The present ground surface is at a level of 4.8-4.9m OD, but this reflects substantial ground raising from a natural level probably between 1.0m and 2.0m OD (see Gibbard, 1985, Figs 20 and 43 for cross-sections across the River Thames in the Westminster area, downstream from the present site). The British Geological Survey (BGS) (1:50,000 Sheet 270 South London, 1998) shows the site underlain by the alluvium that occupies the eastern end of the broad palaeochannel (the Battersea Channel) that passes between Battersea and Clapham, to the south of the gravel eyot underlying Battersea. A second palaeochannel can be traced to the north of the Battersea Channel and parallel with it, passing along the southern edge of Battersea Gardens. The BGS shows areas of both made and worked ground close to the present site and from the borehole records it is evident that there has been very considerable ground disturbance and deposition of Made Ground across the whole site.

Less than 0.5km to the west of the present site at Battersea Power Station, Branch *et al.* (2010) recorded the surface of the Shepperton Gravel at levels between -3.06m OD and -2.22m OD, overlain by silty sands and silts with thin peat horizons indicative of episodic peat accumulation at levels between -2.97m OD, radiocarbon dated to 4360-4230 cal yrs BC, and -1.52m OD, radiocarbon dated to 2050-1740 cal yrs BC. Branch et al. (2010) concluded that

these sediments occupied 'a topographic depression, probably a former river channel… which had progressively infilled with mineral sediments and peat during the Holocene'. This channel is probably the more northerly of the two palaeochannels mentioned above. Other sites near Battersea Power Station (Perry & Skelton, 1997; Mackinder, 2002) and on the north side of the river at Buckingham Palace Road (Spurr, 1998) have recorded similar Holocene sequences with episodic accumulation of richly-organic sediments. Further south, but near the middle of the more southerly palaeochannel (the Battersea Channel) Morley (2009/10) has described sediment sequences which produced dates ranging from Early Holocene to Bronze Age. However he also shows (his Fig. 4) that in his area of investigation modern Made Ground extends down to below OD in the central part of the palaeochannel.

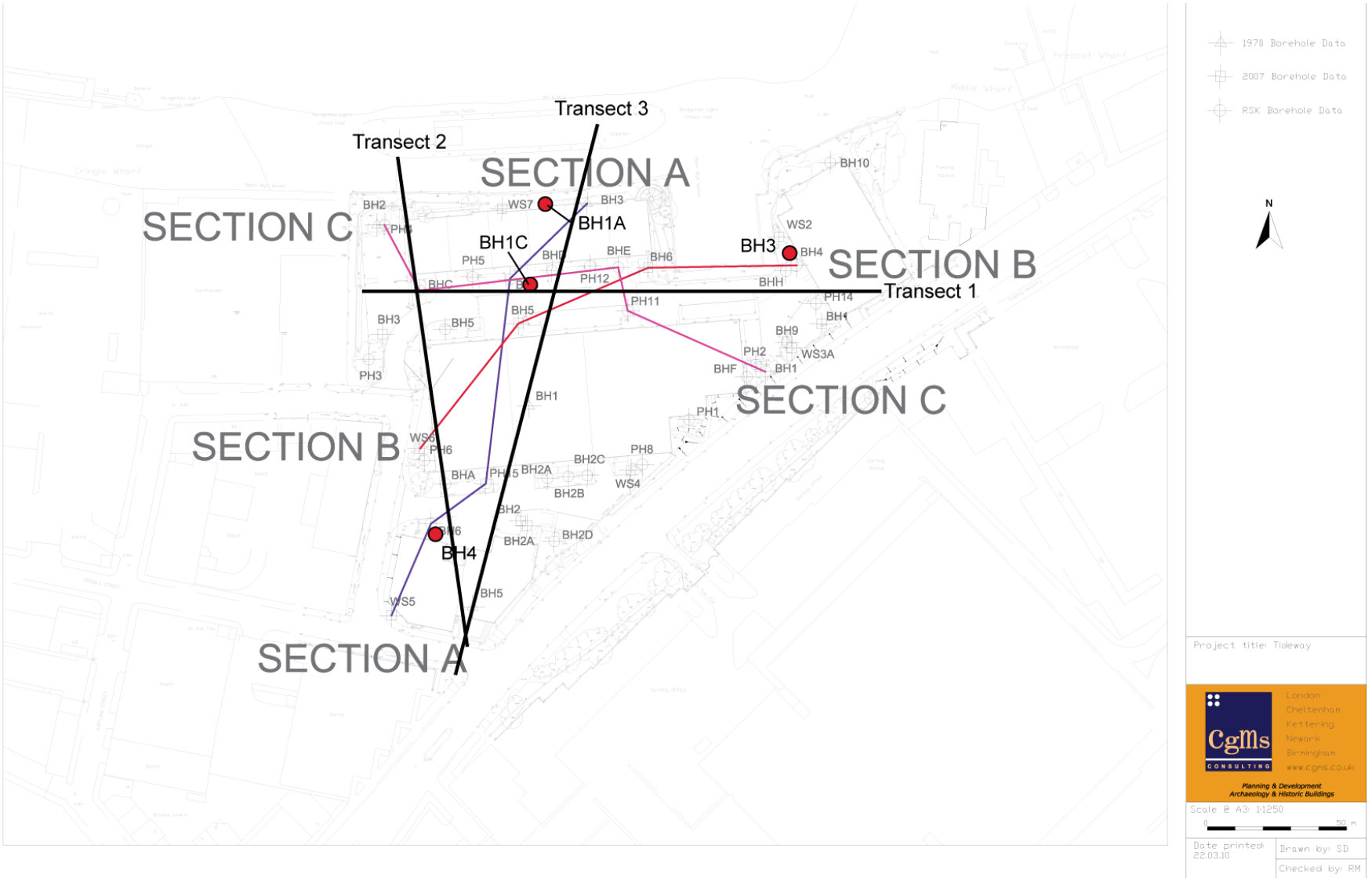

Figure 1: Borehole locations and orientation of Transects 1 (Figure 3), 2 and 3 (Figure 4) at Tideway Industrial Estate, 87 Kirtling Street, London. Site map provided by CgMs Consulting Ltd

METHODS

Field investigations

Three boreholes (<BH1C>, <BH3> and <BH4>) were put down at the site in April 2011 (Figure 1). Prior to visiting the site, <BH1A> (Figure 1) was selected as the preferred location for <BH1>, as close as possible to Geotechnical Borehole <78.BH3>, the only geotechnical borehole in which a peat unit was described; however, due to the proximity of underground services at this location and inadequate headroom in the adjacent building, drilling was not attempted, and the position of <BH1C> was selected. Boreholes were recovered using cable percussion coring, carried out by Tony Bedford Drilling Services, and monitored by a member of Quaternary Scientific staff. Unexploded ordnance testing was carried out during drilling by MACC International Ltd. The spatial attributes of each borehole were recorded (Table 1 and Figure 1).

Table 1: QUEST borehole details

Quest borehole number	Easting	Northing	Height at surface (m OD)
BH1A	529417.399	177612.093	5.017
BH1C	529402.142	177584.602	4.884
BH3	529474.973	177599.016	4.877
BH4	529351.538	177492.868	4.797

Lithostratigraphic descriptions

The lithostratigraphy of (<BH1C>, <BH3> and BH4>) were described in the laboratory using standard procedures for recording unconsolidated sediment and organic sediments, noting the physical properties (colour), composition (gravel, sand, clay, silt and organic matter) and inclusions (e.g. artefacts) (Troels-Smith, 1955). 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 using a Munsell Soil Colour Chart; (3) recording the composition; gravel (Grana glareosa; Gg), fine sand (Grana arenosa; Ga), silt (Argilla granosa; Ag) and clay (Argilla steatoides); (4) recording the degree of peat humification and (5) recording the unit boundaries e.g. sharp or diffuse. The results are displayed in Figures 2, 3 and 4 and Tables 2 to 4.

Deposit modelling

The position of the great majority of the geotechnical boreholes around the periphery of the site, together with the incomplete preservation of the Holocene sediment sequence in many of the boreholes precluded the use of Rockworks software to develop plausible contoured reconstructions of stratigraphic boundary surfaces within the Holocene sediment sequence. The deposit model of the Tideway Wharf site is therefore illustrated in the three transects

forming Figures 3 and 4. Transects 2 and 3 extend across the site roughly from north to south towards its western end, Transect 1 extends from west to east towards the northern end of the site. The positioning of these transects is determined by the availability of geotechnical borehole records that incorporate some fine-grained Holocene alluvial sediment. It has been possible to make use in the deposit model of almost all such boreholes, 16 in number, selected from a total of 47 borehole and test pit records arising from previous investigations of this site (RSK, 2010; Parsons Brinkerhoff, 2007; Wimpey Laboratories Limited, 1978; 1979). In addition the transects include a number of boreholes that record only the pre-Holocene sediments that form the platform on which the Holocene sediments accumulated, and the three boreholes put down by Quest specifically to provide material for palaeoenvironmental investigation (Quest boreholes <1C>, <3> and <4>). The geotechnical records are referred to in the deposit model transects numerically, with the last two digits of the year of production followed by the borehole number within that report, except where the boreholes were carried out by Quest, where the borehole numbers are preceded by Q.

RESULTS, INTERPRETATIONS AND DISCUSSION OF THE LITHOSTRATIGRAPHIC DESCRIPTIONS AND DEPOSIT MODELLING

Transects 2 and 3 (Figure 4) show a broadly similar sediment sequence and a broadly similar spatial arrangement of the sediments. The uneven surface of the bedrock London Clay can be seen in both these transects and in Transect 1 (Figure 3) at levels between *ca*. -5.5m OD and *ca*. -3.5m OD. Sand and gravel rest on the bedrock surface and can be referred to the Late Devensian Shepperton Gravel of Gibbard (1985). Where the boreholes and test pits do not penetrate to the bedrock, they terminate downward in similar sand and gravel which in most cases can also be regarded as part of the Shepperton Gravel. The surface of the Shepperton Gravel is rather consistently recorded at levels between c.1.0m OD and c.2.25m OD towards the southern end of Transects 2 and 3, Quest borehole <4> recording sand and gravel at 2.52m OD and sand present in Borehole 2010/PH6 up to just over 3.0m OD. Further north in both transects the surface of the Shepperton Gravel falls away steeply towards the modern channel of the River Thames, to -3.0m OD in Borehole 1978/BH3 and -3.4m OD in Borehole 1978/BH2. In Transect 1, the surface of the Shepperton Gravel falls away at both ends of the transect to below -1.0m OD, whereas in the middle of the transect the gravel surface rises above 1.5m OD. It appears therefore that a spur of Shepperton Gravel extends northward to the vicinity of Boreholes 2010/BHE and 2007/BH6, with the surface of the gravel falling away to the north, east and west. This feature may represent the eastern end of the more southerly of the two gravel eyots underlying the Battersea area.

In five of the boreholes illustrated in the three transects (2010/BH6, 2010/BHE, 2010/BH2D, 2007/BH5, 2007/BH6) the Shepperton Gravel is directly overlain by Made Ground but in all the other boreholes it is succeeded by deposits recorded in the borehole logs as alluvium and represented predominantly by silts, sands and clays. In most of these fine-grained deposits some gravel was recorded, also remains of mollusc shell and fragmentary inclusions of peat or organic silts, e.g. 'traces of fibrous peat' (1978/2); 'lumps of organic silty clay' (1978/4); 'pockets of peat' (2007/1); 'slightly peaty' (2010/H, 2010/PH11). Only in Borehole 1978/BH3 was a distinct bed of peat recorded between 0.65m OD and -1.45m OD, within the deep alluvial sequence at the northern end of Transect 3.

Detailed laboratory examination of these fine-grained, mainly silty deposits recovered in Quest boreholes <1C> and <3> shows that they contain significant amounts of anthropogenically derived material, including charcoal, burnt flint, CBM and mortar. Peat inclusions are also present. In Units 2 and 3 in Quest borehole <1C>, situated over the crest of the gravel 'spur', the sediment is rather chaotically structured with patchy juxtaposition of sediments differing in texture and colour. In contrast, in Quest borehole <3>, probably situated towards the northern edge of the Battersea Channel, crude layering is present, with some partings of laminated plant material, separating sediment, rich in anthropogenically derived material (Units 3 and 5) from beds of silt in which anthropogenic material is scarce or absent (Units 2 and 4). The results of the detailed laboratory examination of geoarchaeological borehole <4> confirms that the sedimentary sequence was very thin, comprising soil and heavily contaminated sub-soil directly overlying sands and gravels at 2.52m OD.

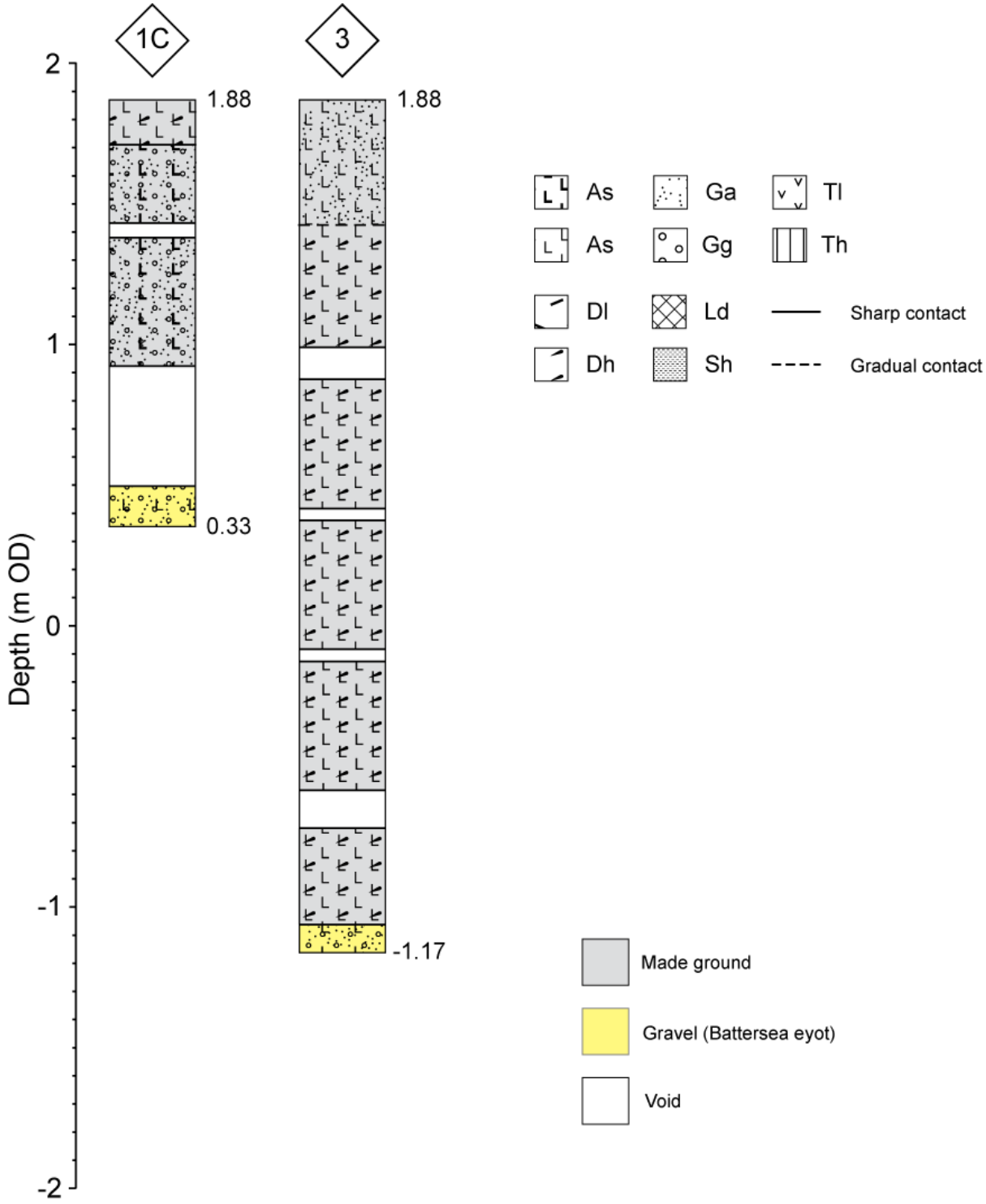

Figure 2: Lithostratigraphic diagram of samples from Quest boreholes <1C> and <3>, Tideway Industrial Estate, 87 Kirtling Street, London

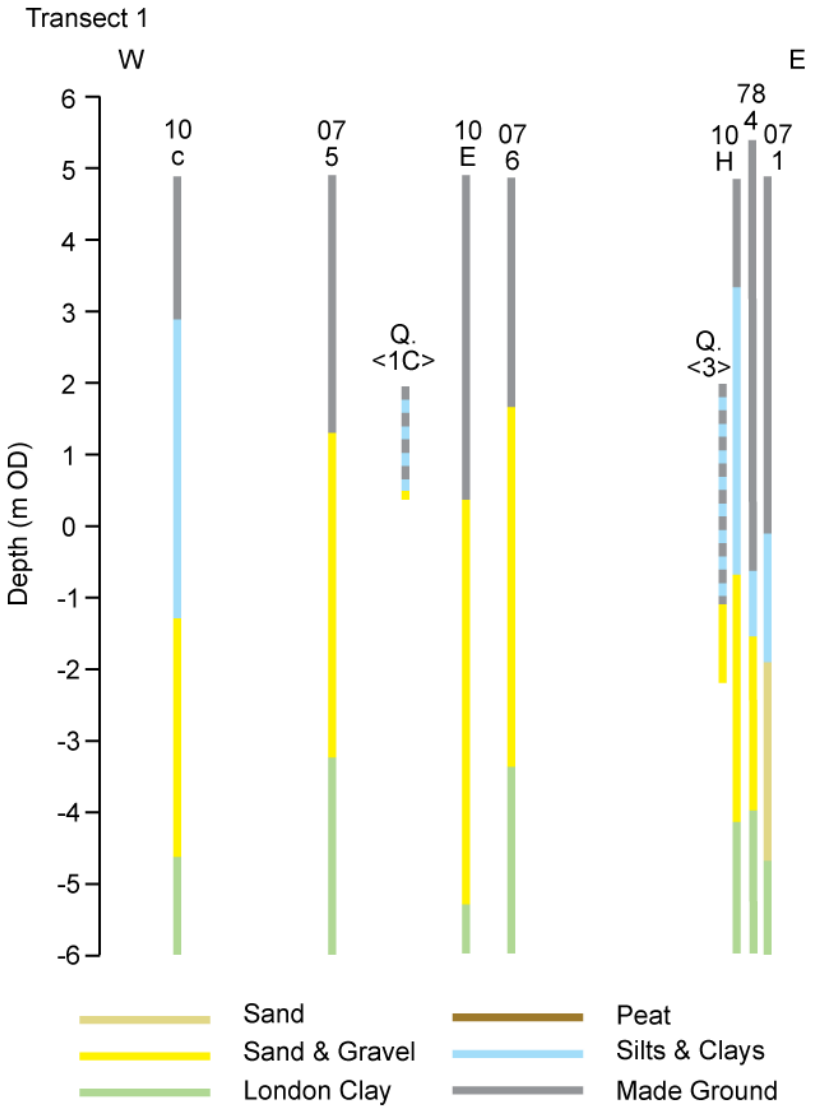

Figure 3: Transect 1, extending from west to east towards the northern end of the site and incorporating previous geotechnical records and Quest boreholes <1C> and <3>. Tideway Industrial Estate, 87 Kirtling Street, London

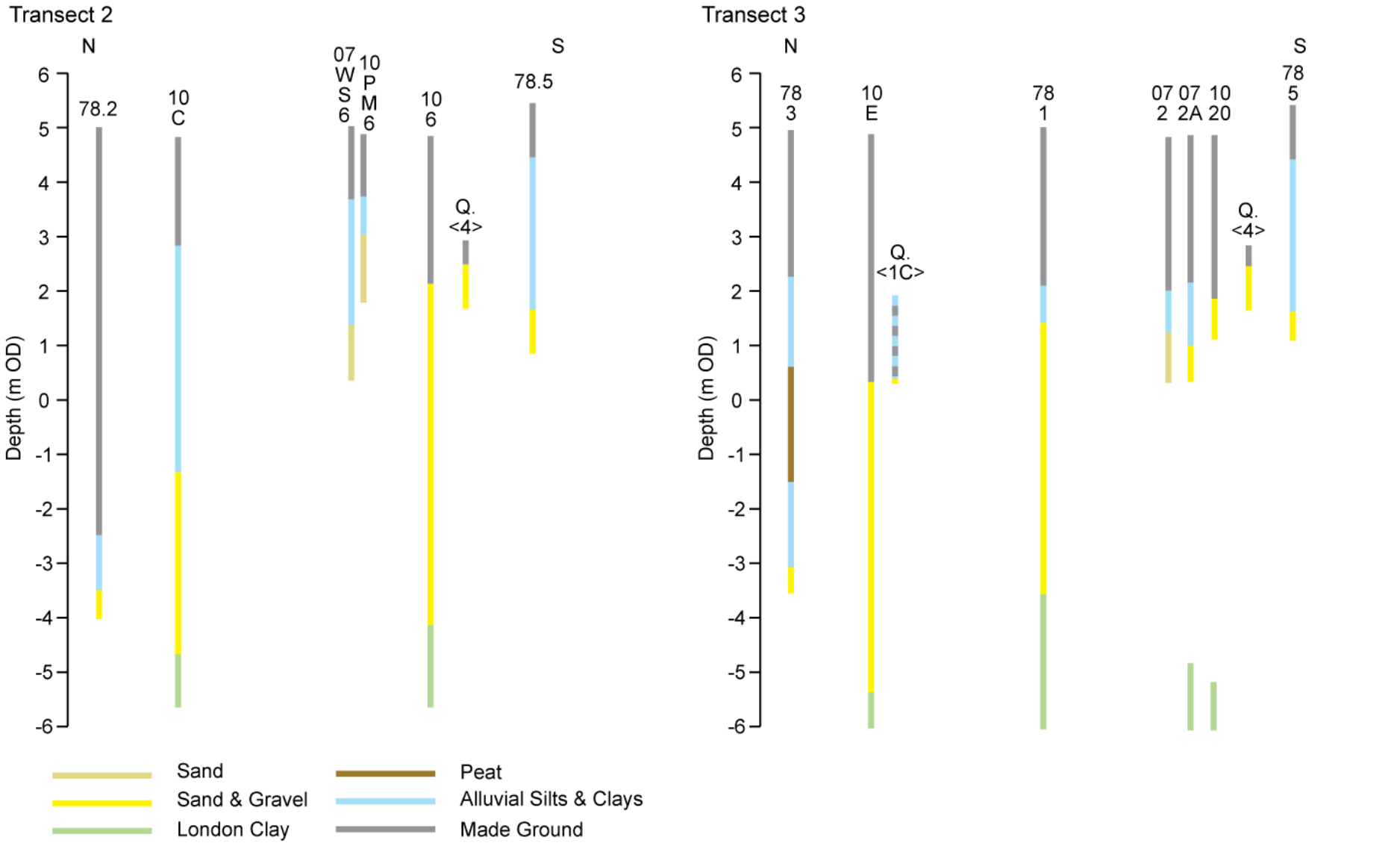

Figure 4: Transects 2 and 3, both extending roughly north to south across the western end of the site and incorporating previous geotechnical records and Quest boreholes <1C> and <4>. Tideway Industrial Estate, 87 Kirtling Street, London

Table 2: Lithostratigraphic description of Borehole <BH1C>, Tideway Industrial Estate, 87 Kirtling Street, London

Depth (m OD)	Depth (m bgs)	Unit	Description
1.88 to 1.71	3.00 to 3.17	3	2.5Y3/2 very dark greyish brown patchily mottled with 5Y3/1 very dark grey, black flecks; very well sorted silt; massive but colours mixed in 'swirls'; common detrital plant remains; no acid reaction; sharp contact with:
1.71 to 1.43	3.17 to 3.45	2	2.5Y3/1 very dark grey; poorly sorted gravelly clayey sand with clasts of sub-angular flint up to 35mm; massive but with patchy variation in clay and gravel content; scattered detrital plant remains; no acid reaction.
1.38 to 0.93	3.50 to 3.95	2	2.5Y3/1 very dark grey; poorly sorted clayey sandy gravel/gravelly sand (clasts up to 20mm); massive with patchy variation of clay and gravel content; scattered detrital plant remains; charcoal common; finely divided CBM; piece of burnt flint; no acid reaction.
0.78 to 0.48	4.10 to 4.40	N/A	Void with debris
0.48 to 0.33	4.40 to 4.45	1	2.5Y3.1 very dark grey; poorly sorted slightly silty sandy gravel of sub-angular flint (clasts up to 40mm); massive; scattered detrital plant remains; no acid reaction.

Table 3: Lithostratigraphic description of Borehole <BH3>, Tideway Industrial Estate, 87 Kirtling Street, London

Depth (m OD)	Depth (m bgs)	Unit	Description
1.88 to 1.43	3.00 to 3.45	5	5Y4/1 dark grey oxidising to 2.5Y3/2 very dark greyish brown with black flecks; well sorted silt with scattered granules and coarse sand grains; massive; scattered detrital plant remains; scattered pieces of broken mollusc shell; scattered pieces of charcoal (up to 50mm); no acid reaction.
1.43 to 0.98	3.45 to 3.90	5	5Y4/1 dark grey and 2.5Y3/2 very dark greyish brown; very well sorted silt; massive; common detrital plant remains; scattered charcoal particles; scattered CBM particles; strong acid reaction.
0.88 to 0.43	4.00 to 4.45	5	5Y4/1 dark grey oxidising to 2.5Y4/3 olive brown; variably sorted silt with thin horizontal beds of peaty plant material and scattered clasts (up to 15mm); crude bedding; common plant remains including grass (still green); common mollusc remains, broken shell and whole gastropods; common charcoal particles; CBM particles scattered and in more densely concentrated horizontal layers; moderate acid reaction.
0.38 to -0.07	4.50 to 4.95	4	5Y4/1 dark grey; very well sorted silt with many peaty inclusions; massive; common detrital plant remains; scattered whole and broken mollusc shell; moderate acid reaction.
-0.12 to -0.57	5.00 to 5.45	3	5Y3/1 very dark grey to black; well sorted silt with

			scattered flint granules and including a layer of clasts of CBM and mortar (up to 15mm); crude layering; common detrital plant remains; scattered mollusc remains including complete gastropod shells; charcoal, scattered and in concentrated layer associated with vivianite; weak acid reaction below -0.36m OD.
-0.62 to -0.72	5.50 to 5.60	N/A	Void
-0.72 to -1.07	5.60 to 5.95	2	5Y3/1 very dark grey to black; very well sorted silt; massive; common detrital plant remains; common mollusc remains including complete gastropod shells; no acid reaction; very sharp contact with:
-1.07 to -1.17	5.95 to 6.05	1	2.5Y3/2 very dark greyish brown to black; slightly silty sandy gravel, mainly sub-angular flint (up to 40mm) but including clasts and granules of CBM; no acid reaction.

Table 4: Lithostratigraphic description of Borehole <BH4>, Tideway Industrial Estate, 87 Kirtling Street, London

Depth (m OD)	Depth (m bgs)	Unit	Description
2.98 to 2.82	1.80 to 1.96	3	Crumbly dark soil.
2.82 to 2.52	1.96 to 2.26	2	Sub-soil heavily contaminated with CBM, mortar and coal.
>2.52	>2.26	1	Sandy gravel

CONCLUSIONS AND RECOMMENDATIONS

The anthropogenically-derived material incorporated in these silty deposits, the nature of their structure and fabric, and the common inclusion of flint clasts within predominantly silty sediments suggest that these deposits are not entirely the result of undisturbed natural processes of sedimentation, but have been significantly influenced by human occupation of nearby areas and possibly by direct impacts on the site itself. Thus, it seems possible that most of the material recovered from Quest borehole <1C>, situated over the crest of the gravel 'spur' may be Made Ground in which sediments from significantly different depositional environments are mixed together in a chaotic fashion typically indicative of severe disturbance and/or artificial re-deposition. The sediment recovered from Quest borehole <3> also incorporated evidence indicating significant anthropogenic disturbance in the immediate vicinity of the site of deposition, with clasts of CBM and charcoal throughout, including substantial concentrations in several horizons. This anthropogenically derived material alternates with thin layers of silt or laminated plant remains. This sequence might be the result of semi-natural deposition in slow-moving or standing water during a late stage in the infilling of the palaeochannel that passed to the south of the Battersea 'eyot'. The anthropogenically derived material probably represents episodic inwash from nearby occupation surfaces rather than deliberate dumping into the water-body. Quest borehole <4> confirmed that the sedimentary sequence in the southern part of the site was very thin,

comprising soil and heavily contaminated sub-soil directly overlying sands and gravels.

The results of the deposit modelling appear to demonstrate that a spur of Shepperton Gravel extends northeastward to the vicinity of Boreholes 2010/BHE and 2007/BH6, with the surface of the gravel falling away to the north, east and west. This feature may represent the eastern end of the more southerly of the two gravel eyots underlying the Battersea area. Only in Borehole 1978/BH3 was a distinct bed of peat recorded, within the deeper alluvial sequence at the northern end of Transect 3. It was not possible to put down a borehole within the vicinity of this deeper alluvial sequence (proposed Quest borehole <1A>) during the present investigation, due to a combination of the existing structures at the site and the proximity of underground services in those areas; with this in mind, and in the absence of sediment sequences that can be confidently regarded as *in situ* products of natural or semi-natural processes, further geoarchaeological excavations at the site and further palaeoenvironmental investigation of Quest boreholes <1C>, <3> and <4> are not recommended.

ACKNOWLEDGEMENTS

Quaternary Scientific would like to thank St James for funding this geoarchaeological investigation and providing practical support during the fieldwork; we are grateful also to CgMs Consulting Ltd. for commissioning Quaternary Scientific to carry out the work. Quaternary Scientific is grateful to Pre-Construct Archaeology Ltd. for surveying the borehole locations, MACC International Ltd. for providing an explosive ordnance supervisor and Tony Bedford Drilling Services for putting down the geoarchaeological boreholes.

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Appendix 1: OASIS form

OASIS ID: quaterna1-100448

Project details

Project name	A REPORT ON THE GEOARCHAEOLOGICAL BOREHOLE INVESTIGATIONS AT TIDEWAY WHARF, 87 KIRTLING STREET, NINE ELMS, LONDON BOROUG
Short description of the project	Three geoarchaeological boreholes were put down at the site: (1) BH <4> in the south to confirm the sediment sequence that appears to be recorded in the existing geotechnical borehole logs; and (2) BH <1C> and BH <3> in the north to try and locate surviving undisturbed natural organic alluvium. A deposit model incorporating all previous geotechnical records from the site was also generated in order to produce a model of the sub-surface stratigraphy across the site and to clarify the nature, depth, extent and date of any alluvium and peat associated with the Battersea channel. The anthropogenically-derived material incorporated in the silty deposits and the nature of their structure and fabric suggest that the deposits were not entirely the result of undisturbed natural processes of sedimentation, but have been significantly influenced by human occupation. It seems possible that most of the material recovered from Quest borehole <1C>, situated over the crest of the gravel 'spur' may be Made Ground, while the sediment recovered from borehole <3> might represent semi-natural deposition during a late stage in the infilling of the palaeochannel that passed to the south of the Battersea 'eyot'. Borehole <4> confirmed that the sedimentary sequence was very thin, comprising soil and heavily contaminated sub-soil overlying sands and gravels, representing a rise in the gravel surface to the south of the site. In the absence of sediments that can be confidently regarded as in situ products of natural or semi-natural processes, further geoarchaeological or palaeoenvironmental investigation of the site was not recommended.
Project dates	Start: 04-04-2011 End: 07-05-2011
Previous/future work	Yes / Not known
Any associated project reference codes	TID11 - Sitecode
Type of project	Environmental assessment
Site status	None
Current Land use	Industry and Commerce 4 - Storage and warehousing
Survey techniques	Archaeology

Project location

Country	England
Site location	GREATER LONDON WANDSWORTH BATTERSEA Tideway Wharf
Postcode	SW8 5BP
Study area	1.91 Hectares
Site coordinates	TQ 293 775 51.4811569056 -0.137744193956 51 28 52 N 000 08 15 W Point
Height OD / Depth	Min: 0.50m Max: 2.50m

Project creators

Name of Organisation	Quaternary Scientific (QUEST)
Project brief originator	CgMs Consulting
Project design originator	Dr N.P. Branch
Project director/manager	D.S. Young
Project supervisor	D.Young
Type of sponsor/funding body	Developer

Project archives

Physical Archive Exists?	No
Physical Archive recipient	LAARC
Digital Archive recipient	LAARC
Digital Media available	'Images raster / digital photography','Images vector','Text'
Paper Archive recipient	LAARC
Paper Media available	'Map','Notebook - Excavation',' Research',' General Notes','Report','Unpublished Text'

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	ARCHAEOLOGICAL DESK STUDY AND IMPACT ASSESSMENT: TIDEWAY WHARF INDUSTRIAL ESTATE NINE ELMS LANE BATTERSEA
Author(s)/Editor(s)	Meager, R.
Date	2010
Issuer or publisher	CgMs Consulting
Place of issue or publication	London
Description	Unpublished DBA

Project bibliography 2

Publication type	Grey literature (unpublished document/manuscript)
Title	A REPORT ON THE GEOARCHAEOLOGICAL BOREHOLE INVESTIGATIONS AT TIDEWAY WHARF, 87 KIRTLING STREET, NINE ELMS, LONDON BOROUGH OF WANDSWORTH

Author(s)/Editor(s)	C.P. Green and D.S. Young
Date	2011
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Description	Unpublished report
Entered by	Daniel Young (d.s.young@reading.ac.uk)
Entered on	6 May 2011

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