DOCKLANDS LIGHT RAILWAY
3–Car Capacity Enhancement
South Quay
Canning Town Flyover
Delta Junction
London E14

London Boroughs of Tower Hamlets and Newham

Geoarchaeological evaluation

October 2009

MUSEUM OF LONDON ARCHAEOLOGY

REGISTERED ORGANISATION IfA

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Site Code: DJD08 CAJ08 SQS08
National Grid Reference: 537488 180566
539585 180995
537689 179792

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Summary

This report presents the results of a geoarchaeological evaluation carried out by the Museum of London Archaeology (MOLA) at the Delta Junction, South Quay and Canning Town sites of the DLR 3-Car-Capacity Enhancement scheme. This work has been commissioned from the Museum of London Archaeology by Taylor Woodrow (on behalf of Docklands Light Railway).

The sites are located about 2km apart, close to the confluence of the River Lea and the Thames. The Evaluation involved the drilling of purposive geoarchaeological boreholes on each site, at locations where previous desk-based work had identified archaeological potential that will be subject to impact by the piled foundations of the proposed development. The purpose of the evaluation was to obtain geoarchaeological records and samples for off-site examination and assess the potential of the samples for further work.

The evaluation confirmed that deposits of palaeo-environmental interest, preserving evidence of the changing depositional environment in this area East London Thames since the last deglaciation, exist between about 3m OD and -3m OD across the three sites in general. Core samples obtained from the boreholes through these deposits of interest have the potential to provide information on the nature and timing of environmental change in this locality, which spans the northern parts of the Isle of Dogs to the mouth of the river Lea. Understanding how the floodplain has evolved and relative sea level changed throughout our current interglacial is central to a better understanding of developing human communities, their patterns of resource exploitation and interference with the natural environment and is therefore of considerable archaeological significance.

The deposit modelling and assessment of palaeo-environmental remains undertaken as part of the evaluation shows that the Shepperton Gravels deposited during the final stages of the Late Devensian cold stage are overlain by Early Holocene sands that stabilised to form short lived Mesolithic landsurfaces. Wetland deposits, comprising silty clays and peats, represent the inundation affects of relative sea level rise from the Early Neolithic to the Bronze Age. Pollen, diatoms and ostracods preserved in these deposits suggest that the densely wooded floodplain was predominantly freshwater in the Isle of Dogs area but became slightly brackish towards Canning Town, where tidal access could have been felt sooner and more markedly. From the Iron Age onwards silty clays dominate as grass and herb fen mudflats form. At this time the pollen evidence suggests cereal cultivation and pastoral activities are taking place nearby, whilst brackish marine conditions move westwards and a full estuary environment is indicated to the east.

Assessment of the deposits and samples obtained from the boreholes indicates that there is good potential for macro- and microfossil preservation.These remains could provide information about past environmental change in the locality that would make a valuable contribution to our present understanding of the floodplain evolution of East London Thames. The potential is enhanced by the linear nature of the route and the opportunity to compare several sites along it, within a restricted area, which provide an opportunity to understand the archaeo-environmental results in terms of their past topographic context.

It is recommended any additional DLR borehole data available is added to the deposit model and that limited targeted further analysis is undertaken of pollen and diatom samples from the Delta Junction (DJD08) and Canning Town (CAJ08) cores.

A small number of additional radiocarbon dates would also help provide a secure temporal framework and a better understanding of the significance of the past environments represented in terms of their regional context. The objective of this further work would be to reconstruct the pattern of tidal incursion and floodplain vegetation change for the locality of the route and the results, which would build on those presented in this report, should be published as a short article in a journal such as the London Archaeologist or LAMAS.

The core samples obtained from the boreholes will be held in the MOLA store until a decision has been made on whether they are required for further analysis.

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1 Introduction

1.1 Origin and scope of the report

This Geoarchaeological Evaluation Report has been commissioned from the Museum of London Archaeology (MOLA) by Taylor Woodrow (on behalf of Docklands Light Railway). It concerns a geoarchaeological evaluation at three locations along the route of the DLR 3-Car-Capacity Enhancement scheme (Fig 1) and has been prepared within the terms of the relevant standard specified by the Institute of Field Archaeologists (IFA 2000). The purpose of the report is to summarise the results of the evaluation, which comprised the drilling of a series of boreholes on each site, and to recommend what further work, if any, is needed on the core samples obtained.

A preliminary archaeology scoping and design review of the whole scheme was previously undertaken (MoLAS 2007). This allowed the identification of locations where the proposals may have archaeological implications. Each of these locations was subject to a more detailed desk-based assessment (DDBA). At three locations the DDBAs identified potential archaeological survival in the form of an underlying alluvial sequence including peat deposits, which might preserve prehistoric palaeo-environmental landscape evidence, as well as evidence for prehistoric activity. The development proposal comprised the construction of new high-level platform, escalators, stairs and lifts. The main impact of these works on the potential archaeological resource would be the piled foundations, which penetrate the alluvial sequence of archaeological interest in small areas. Such impact was identified by the DDBAs for Delta Junction (MoLAS October 2007), South Quay (MoLAS December 2007a), and Canning Town Flyover (MoLAS December 2007b). As a result, these DDBA reports recommended the drilling of geoarchaeological boreholes at selected locations to sample the alluvial sequence.

1.2 Site background

1.2.1 Delta Junction

The development at the Docklands Light Railway, Delta Junction is located between Westferry and West India Quay Station in the London borough of Tower Hamlets (National Grid Reference 537488 180566: Fig 2). The development proposal comprised the demolition of the existing Delta East Viaduct and the construction of a new viaduct on entirely new columns. This involved the construction of 10 new pile foundations; the demolition and reconstruction of one of the existing piles; and the alteration of 11 of the existing structures.

The site lies in the northern part of the Isle of Dogs. Previous work on the alluvial deposits in this area has revealed a series of prehistoric islands separated by channels (see South Quay below). Compared with South Quay, however, Delta Junction lies closer to the river terrace to the north and thus closer to the drier ground suitable for permanent occupation in prehistory and later. Despite this, previous geotechnical boreholes from the site indicate that the gravel surface might be lower lying here than at South Quay and it is possible that a floodplain edge channel may have existed in this locality in the past. Such a channel might reveal much earlier information than that surviving at South Quay, possibly dating from the Late Glacial. Such evidence is rarely found in the floodplain of the East London Thames. In addition, such a channel, located close to the higher and drier ground of the river terrace might preserve indirect evidence for the vegetation and human activity of the river terrace, which no longer survives on the former dry land surface itself or in more distant wetland areas (such as at South Quay).

No detailed investigation of the prehistoric topography and its network of islands, channels and wetlands has yet been made for the Isle of Dogs. Thus the fragments of data so far obtained from this area do not form part of a coherent picture of the evolving past landscape, which can be tied in to, and which forms the landscape context for, the fragments of evidence of prehistoric activity. This is in contrast to the topographic modelling and past landscape reconstruction work undertaken in Southwark and Bermondsey, Westminster and the lower Lea valley, which have produced significant background information in which the archaeology can be placed and better understood.

The WSI proposed that geoarchaeological boreholes were drilled in three locations at Delta Junction, in order to examine the date and characteristics of the alluvial sequence and its potential for past landscape reconstruction and indirect evidence of past human activity. Although intended to target development impact (at 3 of the c 22 locations of impact) the borehole locations were governed by the network of services existing on the site and accessibility, as dictated by the ongoing construction programme.

1.2.2 South Quay

The development at South Quay is located on Marsh Wall in Tower Hamlets (National Grid Reference 537689 179792: Fig 3). It comprised the complete demolition of the existing South Quay Station, access and concourse and the relocation of the station c 200m to the east of its current position, over the 'Millwall Cut'. This involved the construction of a high level platform, escalators, stairs and lifts. These works are contained within a larger area of landtake.

Previous work on the alluvial deposits in the northern part of the Isle of Dogs has revealed a series of prehistoric islands separated by channels. The area was probably heavily forested for much of prehistory and the channels formed open routeways through the impenetrable woodland. Bronze Age activity is known from the channel margins and prehistoric occupation from the higher ground of the river terrace, which lay roughly one kilometre to the north. The precise nature of the prehistoric topography, the pattern and characteristics of the network of stream channels and the changing environment and vegetation cover of the islands in this area has been little studied, however. Previous geotechnical boreholes indicate possible palaeochannel deposits in the extreme west of the site, where the development impact will be minimal, with the buried topography rising to a possible island in the east, in the area of the new station.

Two geoarchaeological boreholes were drilled, either side of the Millwall Cut, the part of the site that was impacted upon by station construction, to assess the potential of the peaty alluvial deposit sequence fringing the higher ground for past environment reconstruction and indirect evidence of past human activity.

1.1.1 Canning Town Flyover

The development of the Canning Town Flyover is located in the London Borough of Newham (National Grid Reference 539585 180995: Fig 4). The development comprised the construction of a new flyover entailing localised groundworks, piling and pile cap excavation, as well as pile probing.

Previous geoarchaeological work in the Canning Town area has shown that prehistoric peat deposits, together with the remains of early Holocene landsurfaces and Late Glacial channels formerly existed here. Prehistoric occupation and utilisation of a diverse landscape of islands, channels and wetlands has also recently been revealed several hundred metres east of the site. However, river scour in later prehistory and during the historic period has eroded much of this evidence from areas closer to the modern river. On several recent sites peaty clasts that might date from the Mesolithic to Bronze Age have been found in historic foreshore sands and gravels. In addition, thick estuarine mud deposits representing extensive historic mudflats and creeks that developed at the confluence of the Thames and the Lea have been recorded on the Limmo peninsula and nearby areas, directly overlying the truncated / eroded prehistoric sequence. The general archaeological and geoarchaeological potential of the Limmo peninsula / Bow Creek area of Canning Town is therefore considered to be low.

Given the generally poor survival of prehistoric deposits in the Thames/Lea confluence area, the evidence from previous geotechnical boreholes for the good survival of apparently in situ peaty deposits in the central part of the site is of considerable interest. In view of this, a transect of 4 boreholes running north to south in the north-central part of the site was proposed, to examine the date and survival of the alluvium and to assess its potential for providing information about the prehistoric landscape of the Limmo area, which has rarely been found to survive.

1.3 The Planning and legislative background

The Planning and legislative background to the site has been adequately summarised in the *Method Statement* (Corcoran, 2008). The geoarchaeological works were conducted in accordance with the *Method Statement* and comprise the only fieldwork required in order to satisfy the archaeological condition applied to planning consent for the development scheme.

1.4 Geoarchaeological Background

Buried alluvial deposits from the floodplain of the east London Thames are a rich archaeological resource. They have revealed archaeological features and finds as well as environmental information, from which the changing landscape has been reconstructed and the interplay between wetland and dryland, and freshwater to estuarine environments over the past 10,000 years suggested (eg: Devoy 1979; Sidell et al 2000; Bates and Whittaker 2004).

Extensive alluvial sequences underlying substantial depths of 19th and 20th century groundraising have produced sediment archives dating from the Early Mesolithic, a time when the modern floodplain was a dry landsurface, a valley exploited by freshwater streams. Extensive and probably impenetrable forests are known to have developed across the valley floor in the later Mesolithic and Neolithic. Rising sea level during the Holocene impacted on the drainage, causing wetland areas to expand and these in turn were subsequently replaced by saltmarsh and estuarine mud. These estuarine deposits record fluctuations in relative sea level and local environment change for the later prehistoric and historic period.

The changing landscape influenced the types of human activity undertaken in the area and an understanding of the pattern of streams, wetlands and islands in the past, together with the sequence of landscape change, is necessary in order to better understand the context of past human occupation in East London. Although a broad understanding of this environment change already exists, human activity was influenced by detailed local changes and local topography. It is this smaller scale information and, crucially, its relationship to the bigger picture, together with detailed mapping of former islands, stream channels and their dates that is needed in order to reconstruct the context in which past human activity on the floodplain took place.

1.5 Aims and Objectives

1.5.1 Geoarchaeological Evaluations

Borehole studies rarely provide direct evidence for archaeology, but may provide evidence of indirect human impact or indicate where humans may have been exploiting the environment. The overall objective is to understand the depositional and post-depositional processes operating on site in order to reconstruct Holocene environmental change. This will augment existing knowledge of palaeoenvironments and palaeogeography of the Delta Junction, South Quay Station and Canning Town Flyover DLR sites.

The objectives of a geoarchaeological evaluation are:

1. To report in detail on the nature of a site's stratigraphy and to determine how and when this formed
2. To assess the potential of any preserved ecological remains for reconstruction of the changing landscape and environment for specific time frames.
3. To identify horizons which may:
   (a) provide data on past environments and resource availability
   (b) represent events which are likely to have had an impact on local human occupation and activities
   (c) have been deposited or transformed as a result of human activities
   (d) contain indirect evidence of local human activity.
   (e) represent environments that are known to be the focus of human activity, such as: dryland / wetland interfaces, chalk cliff-tops etc

1.5.2 Site specific objectives

The objective of the proposed borehole evaluation is to assess the archaeological (palaeoenvironmental) potential of the deposits likely to be impacted upon by the DLR 3-car-scheme. In particular their potential to:

- add new information to our current understanding of the evolving environment of the floodplain of the East London Thames; and to
- reconstruct the landscape context in which past human activity on the floodplain took place.

2 Methodology

All geoarchaeological on-site drilling and off-site core preparation work was carried out in accordance with the written scheme of investigation (Corcoran 2006).

2.1.1 On-Site

Six cable precussion rig boreholes were sunk for geoarchaeological examination and monitored by a MOLA geoarchaeologist, one at Canning Town Flyover, two at South Quays and three at Delta Junction. Continuous cores were obtained for off-site examination, extending from the present ground surface through the made ground and underlying Holocene sediments into river terrace gravels. The U100 samples (0.45m long plastic tubes) were transported back to the MOLA laboratory for description and sampling.

Borehole locations were recorded plotted on to the OS Grid (Fig 2). The Ordnance Datum (OD) of the ground level at each location was obtained from the contractor's Site Survey and depths of sediment unit boundaries converted to OD levels off-site.

2.1.2 Off-Site

Sediments

The cores were extruded and the sediments described using standard sedimentary criteria (relating to colour, compaction, texture, structure, bedding, inclusions, and clast-size). Depositional environments were preliminarily inferred and sub-samples cut from the cores at key locations for submission to external specialists for radiocarbon dating (^{14}C), to produce a chronological framework for the sediments sampled and the microfossil assessment (pollen, diatoms, foraminifera and ostracods). This will enable evaluation of the potential for more detailed analysis. Such analysis might include further examination of microfossils and dating.

If the sequence is of sufficient interest to contribute to our understanding of the past environment of the East London Thames floodplain, a strategy for analysis and publication of the results will be agreed with the client and GLAAS.

Deposit modelling

The borehole logs were entered into a digital (Rockworks 2006) database. Each deposit component (gravel, sand silt etc) was given a colour and a pattern and, as a result, the two major variables of any deposit were stored in the RW2006 database and used to construct the deposit model.

A series of working cross-sections (transects: vertical slices through the sub-surface stratigraphy) were drawn through the boreholes and correlations were made between key deposits. Interpretation of the data is based to a large extent on examining these transects. Individual lithostratigraphic units with related characteristics within a borehole were grouped together and then linked with similar deposits, which may be made up of a number of individual contexts (lithostratigraphic units) in adjacent boreholes. Linking deposits between boreholes produced a series of site-wide deposits, which are representative of certain environments. Thus a sequence of environments both laterally and through time has been reconstructed for the site.

The transects drawn through the borehole profiles form a major means of illustrating the buried stratigraphy in this report and 2 transects (see Fig 7 and Fig 8) were selected to illustrate the stratigraphic sequence and distribution of deposits across the site. A key to the lithostratigraphy and its interpretation is provided with each transect. Where possible, landscape features (such as palaeochannels, cliff-lines and 'islands') have been identified and their changing morphology, or influence on the pattern of deposit accumulation, inferred.

The Rockworks data was transferred to Arc GIS v.9 where the Spatial Analyst package was used to create a surface plot of the 'Early Holocene surface', which plots the surface topography of the Pleistocene gravels. This gives an approximation of the topography of the site as it existed at the beginning of the Holocene period (i.e. the early Mesolithic, *c* 10 000 years ago). The development of the Holocene floodplain is likely to have been influenced by the gravel topography inherited from the Pleistocene period. This surface would have dictated the course of later channels, with gravel high points forming areas of dry land within the wetlands

Assessment of results
An outline of the development of the site and an assessment of the potential of the samples obtained for further analysis and publication has been inferred from the lithostratigraphic characteristics of the sediments together with the results of dating, environmental assessment and deposit modelling.

Archive
The work has produced site and borehole location plans; a set of MoLA geoarchaeological borehole logs and nine ^{14}C dating records, as well as pollen, diatom and ostracod reports. The records can be found under the site codes DJD08, SQS08 and CAJ08 in the MoL archive.

3 Results

3.1 Borehole Lithostratigraphy

Lithology descriptions of the borehole logs are tabulated below with preliminary stratigraphic interpretations. The locations of the boreholes are shown in Fig 2 with the boreholes shown as part of transects in Fig 7 and Fig 8.

3.1.1 CAJ08 BH1

CAJ08 BH1			**Location:** 5395053.595/181099.791	
Unit	**Depth of unit m bgl (Height of unit m OD)**	**Description**	**Interpretation**	**Facies**
1.8	**6.21 m OD**	**Ground level adjacent to borehole**		
	0.0 - 5.20	Soft V .dark brown sandy silty clay with frequent CBM (ceramic building material)	Post Medieval/Modern Made Ground	Facies 5
1.7	**1.01 m OD**			
	5.20 - 5.60	Blueish grey silty clay ephemeral/faint bedding with flecks of organic	Brackish marine mudflats on the edge of the expanding estuary	Facies 4
1.6	5.60 – 5.65	Blueish grey silty clay with regular humic and weathered bands however no sand content		
1.5	5.65 - 5.73	Blueish grey silt with regular humic then weathered bands (thus episodic), with fine sands		
1.4	6.90 - 8.15	Blueish grey silty clay with irregular, interbedded/interdigitated fine sands		
1.3	**-1.94 m OD**			
	8.15-8.90	Firm compact dark brown peat with visible plant tissue and wood chips pockets of blue grey clay at top.	Fresh water wet or marshy woodland, slightly wet marginal terrestrial environment.	Facies 3
1.2	8.90-9.15	Firm dark reddish brown peat with preserved vegetable matter, sands and gravels at base		
1.1	**-2.94 m OD**			
	9.15-9.2	0.05m of Soft mid brown sandy silty clay grading into subangular to Subrounded fine and medium gravels	Shepperton Gravels	Facies 1
	-2.99 m OD	**Base of borehole**		

3.1.2 DJD08 BH1C

DJD08 BH1C			Location: 537470.700/ 180604.900	
Unit	**Depth of unit m bgl (Height of unit m OD)**	**Description**	**Interpretation**	**Facies**
1C.6	**4 m OD**	**Ground level adjacent to borehole**		
	0-2.80	Made ground, brown loam frequent brick and concrete.	Post Medieval/Modern Made Ground	Facies 5
1C.5	**1.2 m OD**			
	2.80-3.20	Firm mid brown silty clay with organic inclusions	Brackish marine mudflats	Facies 4
1C.4	3.20-3.70	Soft blueish grey silty clay		
1C.3	**0.30 m OD**			
	3.70-3.90	Peat brown spongy with visible fibres/plant tissue	Fresh water wet or marshy woodland and marginal fluvial environment.	Facies 3
	3.90-5.62	Soft blueish grey silty clay with ephemeral fine sands		
1C.1	**-1.62 m OD**			
	5.62-5.65	Matrix supported fine and medium gravels in light brown silty clay with sands	Shepperton Gravels	Facies 1
	-1.65 m OD	**Base of borehole**		

3.1.3 DJD08 BH2

DJD08 BH2			Location: 537457.500/ 180625.300	
Unit	**Depth of unit m bgl (Height of unit m OD)**	**Description**	**Interpretation**	**Facies**
2.7	**3.5 m OD**	**Ground level adjacent to borehole**		
	0-3.5	Made ground brown clayey loam, soft frequent brick/concrete	Post Medieval/Modern Made Ground	Facies 5
2.6	**0.0 m OD**			
	3.5-4.36	Dark blue silty clay with pockets of organic material, increasing towards base	Brackish marine mudflats	Facies 4
2.5	**-0.86 m OD**			
	4.36-4.50	Woody dark brown/back peat with frequent wood fragments	Fresh water woody peat, slightly wet and marginal fluvial environment.	Facies 3
2.4	4.50-4.57	Firm dark yellow grey very slightly silty fine sand		
2.3	4.57-9	Soft pale white slightly sandy clay with twig plant matter		

2.2	4.90-4.95	Blue grey silty clay with ephemeral sandy lenses and rare gravel clasts		
	-1.45 m OD			
2.1	4.95-6.50	Fine and Medium sands with tuffa and occc gravels and some silt bands	Early Holocene sands banked up against gravel highs and then developing into a semi-terrestrial environment	Facies 2
	-3 m OD	**Base of borehole**		

3.1.4 DJD08 BH3

DJD08 BH3			**Location:** 473427.405/ 99861.663	
Unit	**Depth of unit m bgl (Height of unit m OD)**	**Description**	**Interpretation**	**Facies**
	3.5 m OD	**Ground level adjacent to borehole**		
3.7	0-3.67	Compact sandy loam gravel, brown, frequent bricks and strong smell of concrete	Post Medieval/Modern Made Ground	Facies 5
	-0.17 m OD			
3.6	3.67-4.50	Soft dark blue silty clay, with rooting, some Mn staining and pockets of fine sand,	Brackish marine mudflats	Facies 4
	-1.00 m OD			
3.5	4.50-4.52	Yellowish brown medium to coarse sand	Fluvial to marginal fluvial environment	Facies 3
3.4	4.52-4.70	Soft blue grey silty clay with pockets and laminations of fine dark grey and medium coarse sands and putative marl.		
	-1.20 m OD			
3.3	5.50-5.55	Coarse Sand	Early Holocene sands banked up against gravel highs and then developing into a semi-terrestrial environment	Facies 2
3.2	5.55-5.95	Mid grey silts with reoccurring laminations of sand, some possible marl.		
	-2.45 m OD			
3.1	5.95-6.5	Gravel, sandy	Shepperton Gravels	Facies 1
	-3.00 m OD	**Base of borehole**		

3.1.5 SQS08 BH1

SQS08 BH1			**Location:** 53782632/179752.06	
Unit	**Depth of unit m bgl (Height of unit m OD)**	**Description**	**Interpretation**	**Facies**
	5.2 m OD	**Ground level adjacent to borehole**		
1.15	0-5.55	Made ground brown clayey loam, soft frequent brick/concrete	Post Medieval/Modern Made Ground	Facies 5
	-0.35 m OD			
1.14	5.55-6.19	Firm Mid/Dark greyish brown with dark mottling silty clay some humic pockets and base fairly homogenious. Mn and Fe staining	Marine and fresh water mudflats	Facies 4
1.13	6.19-6.21	Sandy band above blue grey silty clay with occ. Organic inclusions		
	-1.01 m OD			
1.12	6.21-6.43	Firm dark brown pockets of woody peat with cracks infilled with blue grey silty clay	Brackish marshland, slightly wet and marginal fluvial environment.	Facies 3
1.11	6.43-6.49	Blue grey silty clay with peat pocket at top and flecks of organic throughout		
1.10	6.49-6.75	Soft blueish grey silty clay with patches of fe staining wood at base iron stained roots and sand assoc with root channels		
1.9	6.75-7.02	Fairly firm mid brownish blueish grey silty clay with freq ill defined pockets of sandy silt freq mn stainig organic at top , small angular flint in organinc		
1.8	7.02-7.25	Soft mid grey sandy silty clay with ephemeral sands some organic and mn staining possible roots, freq white CaCo3 precipitation some shell fragments		
1.7	7.15-.725	Soft blue grey silty clay with a small sand component , occasional preserved organic some Mn present		
	-2.05 m OD			
1.6	7,.25-7.30	Coarse mid yellow sand with occ. Medium and fine subangular and subrounded gravels	Early Holocene mid channel bars and marginal sands	Facies 2

1.5	7.30-7.46	Yellow medium sand with very slightly silty fine grey sand patches frequent fine and rare medium subangular to sub rounded gravels		
1.4	7.46-7.53	Coarse Light to mid yellow coarse sand with occasional fine subangular gravels and rare medium subangular gravels		
1.3	7.53-7.55	Light-Mid Grey fine Medium Sand some light yellow		
1.2	7.55-7.59	Soft Light/Mid grey Sandy Silt with laminations/pockets of fine yellow sand		
1.1	**-2.39 m OD**			
	7.59-7.60	Fine + Medium Subangular to subrounded gravels	Shepperton Gravels	Facies 1
	-2.40 m OD	**Base of borehole**		

3.1.6 SQS08 BH2

SQS08 BH2			**Location:** 537765.55/179760.23	
Unit	**Depth of unit m bgl (Height of unit m OD)**	**Description**	**Interpretation**	**Facies**
2.8	**5.20 m OD**	**Ground level adjacent to borehole**		
	0-3.5	Made ground, mid brown sandy loam, large 5-30cm concrete cobbles.	Post Medieval/Modern Made Ground	
2.7	3.5-5.00	Fairly soft dark blueish grey silty clay with mod. Fine – medium subangular-subrounded gravels		Facies 5
2.6	**+0.20 m OD**			
	5.00-6.00	Firm dark grey silty clay with some Weathered areas and Patches of Fe and and organics patches at base.	Marine and fresh water mudflats	
2.5	6.00-6.10	1.3 Dark brown humic silty clay		Facies 4
2.4	**-0.90 m OD**			
	6.10-6.20	Hard dark brown reed/wood peat comprised of layers of wood/tissue matter	Brackish to freshwater marshland, slightly wet and marginal fluvial environment.	
2.3	6.20-6.60	Spongy dark brown peat with some rare wood chips		
2.2	6.60-7.12	Slightly soft v.dark grey silty clay ephemeral evidence of organic inclusions		Facies 3
2.1	**-1.92 m OD**			

	7.12-7.20	Matrix supported fine,medium and coarse gravels, angular to subrounded, in a mid grey medium sand	Shepperton Gravels	Facies 1
	-2.00 m OD	**Base of borehole**		

Site Code	Borehole	m OD	Lab Number	MoLA Reference	Material and Pretreatment	Measured Age	13C/12C	Conventional Age	2 Sigma Calibration	Averaged age used in text
SQS08	BH1	-1.05	BETA 251273	SQS08B1 #6-25	(peat): acid/alkali/ acid	3320 +/- 40 BP	-28.5 o/oo	3260 +/- 40 BP	Cal BC 1620 to 1440 (Cal BP 3570 to 3390)	1530 BC
SQS08	BH2	-0.96	BETA 251274	SQS08B2 #6-16	(peat): acid/alkali/ acid	3160 +/- 40 BP	-28.0 o/oo	3110 +/- 40 BP	Cal BC 1450 to 1300 (Cal BP 3400 to 3250)	1375 BC
SQS08	BH2	-1.14	BETA 251275	SQS08B2 #6-34	(peat): acid/alkali/ acid	3850 +/- 40 BP	-28.5 o/oo	3790 +/- 40 BP	Cal BC 2340 to 2130 (Cal BP 4290 to 4080),Cal BC 2080 to 2060 (Cal BP 4030 to 4010)	2150 BC
DJD08	BH1	-0.6	BETA 251270	DJD08B1 #4-60	(peat): acid/alkali/ acid	2940 +/- 40 BP	-28.7 o/oo	2880 +/- 40 BP	Cal BC 1200 to 930 (Cal BP 3150 to 2880)	1065 BC
DJD08	BH1	-0.7	BETA 251272	DJD08B2 #4-70	(peat): acid/alkali/ acid	3290 +/- 40 BP	-28.2 o/oo	3240 +/- 40 BP	Cal BC 1610 to 1430 (Cal BP 3560 to 3380)	1520 BC
DJD08	BH2	-0.86	BETA 251271	DJD08B2 #4-36	(peat): acid/alkali/ acid	3110 +/- 40 BP	-26.3 o/oo	3090 +/- 40 BP	Cal BC 1440 to 1270 (Cal BP 3390 to 3220)	1355 BC
CAJ08	BH1	-1.91	BETA 251267	CAJ08B1# 8-12	(organic sediment): acid washes	2860 +/- 40 BP	-26.3 o/oo	2840 +/- 40 BP	Cal BC 1120 to 910 (Cal BP 3070 to 2860)	1015 BC
CAJ08	BH1	-2.90	BETA 251268	CAJ08B1# 9-11	(peat): acid/alkali/ acid	4270 +/- 40 BP	-14.2 o/oo	4450 +/- 40 BP	Cal BC 3340 to 3000 (Cal BP 5290 to 4950),Cal BC 2990 to 2930 (Cal BP 4940 to 4880)	3065 BC
CAJ08	BH1	-2.17	BETA 251269	CAJ08B1# 8-38	(peat): acid/alkali/ acid	3910 +/- 40 BP	-27.6 o/oo	3870 +/- 40 BP	Cal BC 2470 to 2200 (Cal BP 4420 to 4150)	2335 BC
APE08	BH1	-1.36	BETA 259411	BLK/BH1-1.36	(organic sediment): acid washes	3630 +/- 60 BP	-27.9 o/oo	3580 +/- 60 BP	Cal BC 2130 to 2090 (Cal BP 4080 to 4040),Cal BC 2050 to 1750 (Cal BP 4000 to 3700)	2005 BC
APE08	BH1	-1.73	BETA 259412	BLK/BH1-1.71	(organic sediment): acid washes	4680 +/- 70 BP	-27.8 o/oo	4630 +/- 70 BP	Cal BC 3630 to 3570 (Cal BP 5580 to 5520),Cal BC 3530 to 3320 (Cal BP 5480 to 5270),Cal BC 3230 to 3110 (Cal BP 5180 to 5060)	3398 BC

3.2 Radiocarbon dating (chronostratigraphy)

For each site, three samples, taken from either the top or base of the organic deposits present, were submitted to for Beta Analytic, Miami, USA for standard radiometric radiocarbon (^{14}C) dating and provide a basis for the chronology of the site stratigraphy (Table 1).

Site Code	Borehole	m OD	MoLA Reference	Material Pretreatment	Measured Age	13C/12C	Conventional Age	2 Sigma Calibration	Averaged age used in text
SQS08	BH1	-1.05	SQS08B1#6-25	(peat): acid/alkali/acid	3320 +/- 40 BP	-28.5 o/oo	3260 +/- 40 BP	Cal BC 1620 to 1440 (Cal BP 3570 to 3390)	1530 BC
SQS08	BH2	-0.96	SQS08B2#6-16	(peat): acid/alkali/acid	3160 +/- 40 BP	-28.0 o/oo	3110 +/- 40 BP	Cal BC 1450 to 1300 (Cal BP 3400 to 3250)	1375 BC
SQS08	BH2	-1.14	SQS08B2#6-34	(peat): acid/alkali/acid	3850 +/- 40 BP	-28.5 o/oo	3790 +/- 40 BP	Cal BC 2340 to 2130 (Cal BP 4290 to 4080),Cal BC 2080 to 2060 (Cal BP 4030 to 4010)	2150 BC
DJD08	BH1	-0.6	DJD08B1#4-60	(peat): acid/alkali/acid	2940 +/- 40 BP	-28.7 o/oo	2880 +/- 40 BP	Cal BC 1200 to 930 (Cal BP 3150 to 2880)	1065 BC
DJD08	BH1	-0.7	DJD08B2#4-70	(peat): acid/alkali/acid	3290 +/- 40 BP	-28.2 o/oo	3240 +/- 40 BP	Cal BC 1610 to 1430 (Cal BP 3560 to 3380)	1520 BC
DJD08	BH2	-0.86	DJD08B2#4-36	(peat): acid/alkali/acid	3110 +/- 40 BP	-26.3 o/oo	3090 +/- 40 BP	Cal BC 1440 to 1270 (Cal BP 3390 to 3220)	1355 BC
CAJ08	BH1	-1.91	CAJ08B1#8-12	(organic sediment): acid washes	2860 +/- 40 BP	-26.3 o/oo	2840 +/- 40 BP	Cal BC 1120 to 910 (Cal BP 3070 to 2860)	1015 BC
CAJ08	BH1	-2.90	CAJ08B1#9-11	(peat): acid/alkali/acid	4270 +/- 40 BP	-14.2 o/oo	4450 +/- 40 BP	Cal BC 3340 to 3000 (Cal BP 5290 to 4950),Cal BC 2990 to 2930 (Cal BP 4940 to 4880)	3065 BC
CAJ08	BH1	-2.17	CAJ08B1#8-38	(peat): acid/alkali/acid	3910 +/- 40 BP	-27.6 o/oo	3870 +/- 40 BP	Cal BC 2470 to 2200 (Cal BP 4420 to 4150)	2335 BC

Table 1: Radiocarbon samples taken from the organic sediments

3.3 Pollen

Dr Rob Scaife

3.3.1 Introduction

Pollen analysis has been carried out on the profiles from three separate localities associated with the Docklands Light Railway, 3 car extensions. These comprise Delta Junction (DJD08; Boreholes 1c and 2), South Quay (SQS08; Borehole 1) and Canning Town Flyover (CAJ08; Borehole 1). The analysis was undertaken to ascertain if fossil pollen was present in the sediments at these sites and the quality of preservation. Also, to provide a preliminary idea of the vegetation types present, the environment during the time-span of the sediment deposition and the potential for further detailed analysis. Pollen was present in all of the sites although in varying quantities and state of preservation. Useful information has been obtained and this report presents these pollen data.

Site Code	BH	Sample Number	Sample Depth (m)	Sample Height (m.OD)	Pollen Zone
SQS08	1	P1	7.59	-2.39	
SQS08	2	P2	7	-1.8	
SQS08	2	P3	6.7	-1.5	
SQS08	2	P4	6.48	-1.28	SQS08 1
SQS08	2	P5	6.2	-1.00	
SQS08	2	P6	6.08	-0.88	
SQS08	2	P7	5.82	-0.62	SQS08 2
SQS08	2	P8	5.49	-0.29	
DJD08	2	P1	6.12	-2.62	
DJD08	2	P2	5.04	-1.54	
DJD08	2	P3	4.76	-1.26	
DJD08	1C	P4	4.87	-0.87	DJD08 1
DJD08	1C	P5	4.69	-0.69	
DJD08	1C	P6	4.4	-0.4	DJD08 2
DJD08	2	P7	4.13	-0.63	
DJD08	1C	P8	4.04	0.04	
CAJ08	1	P1	9.13	-2.92	
CAJ08	1	P2	8.68	-8.68	CAJ08 1
CAJ08	1	P3	8.4	-2.19	
CAJ08	1	P4	8.12	-1.91	
CAJ08	1	P5	7.73	-1.52	
CAJ08	1	P6	6.9	-0.69	CAJ08 2
CAJ08	1	P7	6.45	-0.24	
CAJ08	1	P8	6	0.21	

Table 2 Samples examined for pollen assessment

3.3.2 Method

Sub-samples of 1.5ml were processed using standard techniques for the extraction of the sub-fossil pollen and spores (Moore and Webb 1978; Moore *et al.* 1992). Micromesh sieving (10u) was also used to aid with removal of the clay fraction from the minerogenic sediments. The pollen and spores were identified and counted using an Olympus biological research microscope fitted with Leitz optics. A total pollen sum of up to 200 grains per sample level was counted where preservation allowed. Other, miscellaneous microfossils, including numbers of algal *Pediastrum,* dinoflaggellates and pre-Quaternary palynomorphs, were also recorded. Data are presented in pollen diagram form (Figs 1-3) and in table 1. The former have been plotted using Tilia and Tilia Graph. Where percentages are given, these have been calculated as follows:

Sum =	% Dry land pollen. (*Alnus* included).
Marsh =	% Sum + Dry Land
Spores =	% total pollen + sum of spores.
Miscellaneous =	% total pollen + sum of misc. taxa.

Taxonomy, in general, follows that of Moore and Webb (1978) modified according to Bennett *et al.* (1994) for pollen types and Stace (1992) for plant descriptions. These procedures were carried out in the Palaeoecology Laboratory of the School of Geography, University of Southampton.

3.3.3 *Results* and *Interpretation*

The pollen data and vegetational and environmental interpretation for the three sites is given below.

3.3.3.1 Canning Town Flyover (CAJ08) Borehole 1 (Fig 3 and Fig 4)

3.3.3.1.1 RESULTS

Sub-samples for pollen analysis were taken through the upper alluvium from + 0.21m OD. to ca. – 2.0m OD and underlying peat ca. - 2.0m OD to –2.92m 0D. All contained pollen but with varying degrees of preservation and absolute pollen numbers. The latter ranged from 10, 900 grains/ml in the lowest sample (9.13m bgl) to 45,550 grains/ml. at 8.40m bgl, the top of the peat. The numbers tend to decline upwards in the alluvium.

Tree and shrub pollen are important throughout the profile with higher numbers present in the lowest level (84%). Averages are 50-60% of total pollen. Herbs are also important from ca. 15% to 55% of total pollen. Two local pollen assemblage zones have been recognised in the pollen profile. These relate to the major stratigraphical change from the lower peats into the overlying alluvium. Thus, a number of the changes in individual pollen taxa (e.g. Cyperaceae and Alnus) are taphonomical relating to the on-site vegetation. These zones are characterised as follows.

Zone CAJ08: 1 (9.13m bgl to 8.26m bgl).

Lower peat. Quercus (oak; 28%), Alnus (alder; 49%) and Corylus avellana type (hazel; 20%) are the dominant trees and shrubs with small numbers of Tilia (lime; 8-9%) and Pinus (pine; 1-2%). Herbs are dominated by Poaceae (grasses; increasing to 38% at top of the zone) and Cyperaceae (sedges; peak to 60% sum + marsh).

Herb diversity is, however, low. Spores of ferns are more abundant than in subsequent zone 2. Pteridium aquilinum (bracken; 18%) and Dryopteris type (typical ferns; 18%) are most important with occasional Polypodium vulgare (polypody fern).

Zone CAJ08: 2 (8.26m bgl to 6.00m bgl).

Alluvium. Trees and shrubs remain important (average 50% of the sum) while herb diversity and percentages increase from the preceding zone. Quercus (25%), Alnus (15-20%) and Corylus avellana type (to 8%) remain the principal taxa. There are sporadic occurrences of Betula (birch), Pinus (slight increase due to fluvial transport), Ulmus (elm), Tilia and Fraxinus (ash) and Fagus (beech). There is an increase in the diversity of herbs types. Poaceae (30-35%), Cereal type (10-15%) and Plantago lanceolata (ribwort plantain; peak to 8%) are important. Also of note are Secale cereale (oat), Ranunculus type (buttercups), Fumaria (fumitory), Chenopodiaceae (goosefoots and oraches), Cannabis type (hop or hemp) and Asteraceae types. Marsh taxa include Cyperaceae (to 10%) which is greatly reduced from the preceding zone) with occasional Typha angustifolia/Sparganium type (bur reed and/or reed mace) and Iris. Also of note in this zone are increased numbers of Pediastrum (algae), Dinoflaggellates and derived pre-Quaternary palynomorphs.

3.3.3.1.2 VEGETATION INTERPRETATION

The profile has been divided into two pollen assemblage zones which correspond with a change from peat to alluvial sediments. The lower peat of zone 1 is dominated by sedges (Cyperaceae) with grasses (Poaceae) and alder (Alnus). These suggest that the depositional habitat was a wet, grass-sedge fen which had anaerobic conditions suited to peat formation. Small numbers of water pondweed (or possibly arrow grass) (Potamogeton type) also suggests some standing water. Although alder pollen percentages are high, these are probably not enough to show on-site growth and, it is probable that there was a fringe of alder carr surrounding the on-site grass-sedge fen.

Outside of the wet fen and marginal alder woodland, the drier interfluves supported oak and hazel woodland. Small numbers of lime/linden may indicate some local growth. Lime/linden pollen is usually poorly represented in pollen spectra because of entomophily and the fact that it flowers in mid summer when trees and shrubs are in full leaf which further inhibits its dissemination. Thus, depending how far away the drier soils were from the sample site, it is possible that lime was more important than the small percentages recorded here indicate. Its importance as a dominant or co-dominant in London (and South East England as a whole) during the middle and earlier part of the late Holocene has been widely demonstrated (e.g. Greig 1982 1991; Scaife 2000).

Above the peat there is a significant change in sediments to minerogenic alluvium, the result of a major shift in the local environment. This alluviation was probably caused by rising (relative) sea levels and/or increased agricultural activity causing sediments to be released into the river systems. The former is perhaps the primary factor and has been widely seen and discussed at other Thames floodplain sites (Devoy 1977, 1979, 1980, 1982, 2000; Sidell et al. 2000; Wilkinson et al. 2000). The effect was a change to a river floodplain with sediments laid down in over bank deposition during periods of high fluvial discharge. There are no definite indicators of marine or brackish water influence. The vegetation appears to have been grass dominated with some fen taxa such as iris and Royal fern (Osmunda) also observed.

The pollen taphonomy will have changed markedly with a fluvial as well as airborne component being introduced thus extending the area of the pollen catchment. There is also the possibility that pollen was reworked from older sediments. This is shown by the increased numbers of derived geological palynomorphs and probable reworked dinoflaggellates. Throughout this zone, there are relatively high percentages/numbers of cereal type pollen and also weeds of pastoral and arable agriculture. These suggest increased agriculture. Fumitory (Fumaria) and Cannabis type (hop or hemp) are also of note, the former being a rare pollen type and the latter possibly coming from hemp cultivation for fibre. It is not possible to say whether the cereal cultivation took place locally and was responsible for the change to mineral sediments or whether the pollen was transported fluvially from elsewhere in the rivers catchment where arable cultivation took place.

3.3.3.1.3 SUGGESTED DATE

Although pollen analysis is not a technique for dating, it is possible to provide some indications of sediment age by comparison with existing data. Here, a late prehistoric age (late Neolithic – Bronze Age) to Historic Iron Age/Romano-British or later date is indicated.

3.3.3.2 South Quay (SQS08) Borehole 2 (Fig 5).

3.3.3.2.1 RESULTS

Samples (8) were taken from between –0.29 m.OD and –2.39 m.OD. Pollen was absent below -1.50 m.OD, in basal silts. The pollen profile spans a highly humified peat horizon from 1.28 m.OD (6.48m bgl) and ca. 0.72 m.OD (6.00m bgl). Absolute pollen frequencies are highest in the peats declining from 298,000 grains/ml at 6.48m bgl to 54,000 grains/ml at 6.08m bgl. Two local pollen assemblage zones have been delimited.

Zone SQS08: 1 (6.48m bgl to ca. 6.14m bgl).

Poaceae-Cereal type-Cyperaceae-Dryopteris type. Trees are dominant (85%) with Alnus most important with occasional Quercus (to 6%), Tilia (1%) and Ulmus (1%). Corylus avellana type (to 18%) is the most important shrub with sporadic Hedera helix (ivy). There are few herbs with only occasional Sinapis type (charlocks), Chenopodiaceae, Poaceae and Cyperaceae.

Zone SQS08: 2 (6.14m bgl to 5.49m bgl).

Poaceae-Cyperaceae. Herbs start to become important from the bottom of the zone with increasing percentages of Poaceae (20%) and Cyperaceae (28%). This is similarly the case for spores with Dryopteris type (48% sum + spores) and Pteridium aquilinum (8%). The latter are dominated by Poaceae (to 54%) with Cereal type (to 18%), Sinapis type (peak to 10%), Chenopodiaceae (increasing to 6%) and Lactucoideae (peak to 11%). Conversely, trees and shrubs are greatly reduced. In the marsh sub-group, Cyperaceae continue with values of 15% (sum + marsh) with small numbers of Nymphaea (white water lily) and Typha angustifolia type. Spores increase with Pteridium aquilinum (5-7%). There is also an increase in pre-Quaternary palynomorphs and dinoflaggellates.

3.3.3.2.2 VEGETATION INTERPRETATION

This profile shows very clearly a change from on-site, damp alder carr floodplain woodland to a very open, wet, grass-sedge fen. The former is demonstrated by the high percentages of alder pollen which, although a massive producer of pollen, are sufficient here to demonstrate on-site growth. The change to herb fen was probably in response to rising ground water table consequent upon the generally rising, relative sea-level, which ponded back the freshwater systems. This has also been noted for other sites in this study and elsewhere on the River Thames floodplain (e.g. Sidell et al. 2000; Wilkinson et al. 2000). White water lily is present in the highest sample suggesting the sediment was deposited in open water or fluvially transported from open water.

The terrestrial, dry land vegetation is not well represented because of the dominance of alder. Oak, elm, lime and hazel are, however, represented in small numbers. With the reduction of alder and the opening up of the habitat, if these trees were of any substantial importance nearby and outside of the alder carr (which may act as a shield to pollen movement), percentages of these would increase. This has not happened and it is likely that the near habitat was open habitat possibly with some hazel (scrub).

With the change to herb fen, the pollen catchment became wider and there is an increase in herb types and numbers. A proportion of the grass pollen increase can be attributed to dry, non-fen, grassland in the surrounding drier zone. Ribwort plantain (Plantago lanceolata) is also present as an indicator of grassland/pasture. Cereal pollen is also evident and might be attributed to local cereal cultivation or pollen which has been fluvially transported from elsewhere in the rivers catchment.

3.3.3.3 Delta junction (DJD08): Borehole 1c (Fig 6)

3.3.3.3.1 RESULTS

The pollen was moderately well preserved and present in 3 of the 4 samples examined. Pollen was absent in the uppermost level at –0.04m.OD (4.04m bgl). Absolute pollen numbers were lowest in the basal sample (4.77m bgl) with 19,707 grains/ml. Values increase to a maximum of 197,700 grains/ml at the top of the profile (4.40m bgl). These numbers facilitated pollen assessment counts of up to 200 pollen grains per sample.

Trees and shrub pollen are dominant (to 84%) with relatively small numbers of herb types and numbers (15% total pollen), the latter increasing in importance upwards in the profile. Even though only three pollen samples have been analysed, there appears to be differences between the pollen assemblages. Two pollen zones have been tentatively recognised. These are characterised as follows.

Zone DJD08 1: at 4.77m bgl (-0.87 m.OD)

Tilia: Tilia is dominant and includes moderately preserved grains (27%) and also numerous degraded grains (22%) which are probably a reflection of poorer preserving conditions in these sediments. Other trees and shrubs include Quercus (6%), Alnus (14%) and Corylus avellana type (26%). There are few herbs with occasional Poaceae. Spores are more important in this basal level with monolete

Pteropsida (Dryopteris type; 19% sum+spores) and Polypodium vulgare (polypody fern; 9%).

Zone DJD08 2: 4.73 – 4.40m. (-0.73 m.OD to -0.40 m.OD)

Alnus-Quercus-Corylus avellana type: Values of Tilia decline while Alnus increases to high values (46%). Quercus also expands to 20% and Corylus avellana declines to 10% at the top of the profile. In the uppermost level, there is an increase in herbs with Poaceae (12%), cereal type (<1%) and Typha angustifolia type.

3.3.3.3.2 VEGETATION INTERPRETATION

High values of lime pollen (Tilia) in the basal sample (zone DJD08: 1) suggest that this was an old land surface on which lime woodland was dominant, along with some oak and hazel. From ca. –0.75m.OD (4.65m bgl), there was an environmental change with increasing wetness. This change, unlike SQS and CAJ sites which show increasing wetness and change to a grass-sedge herb fen, here saw a change from a terrestrial habitat to a damp, floodplain alder carr woodland which colonised this land surface. This also probably occurred in response to rising base levels, which were caused by regionally rising sea levels which ponded back the river systems. In the uppermost level, there is an increase in burr reed/reed mace (Typha angustifolia type) which may be evidence of further increasing wetness. This requires additional pollen work on these upper levels to clarify this.

There is some evidence of increasing human activity with cereal type pollen in zone 2 along with a few other herbs.

3.3.3.4 Delta Junction (DJD08): Borehole 2 (Table 3).

3.3.3.4.1 RESULTS

Four samples were examined from –0.63 m.OD to –2.62 m.OD. of which only the upper sample contained pollen. This sample consists of dark grey/brown humic silt. This contrasts with the more minerogenic/less humic underlying alluvium which was devoid of pollen.

Other than alder, there are few other trees and shrubs and herbs are dominant. Absolute pollen frequencies were calculated at 21,400 brains/ml which enabled as assessment count to be made. Pollen data are given in Table 3 below.

Depth metres	4.13m bgl 0.63m.OD
Trees and Shrubs	
Betula	3
Pinus	1
Quercus	23
Ulmus	3
Tilia	2
Alnus glutinosa	37

cf Viburnum	1
Corylus avellana type	22
Herbs	
Chenopodiaceae	9
Apiaceae	3
Plantago lanceolata	1
Artemisia	3
Lactucoideae	1
Poaceae	27
Cyperaceae	9
Typha angustifolia type	5
Spores	
Dryopteris type	17
Pteridium aquilinum	26
Polypodium	1
Liverworts	1
Abs. Pollen No.s grains/ml.	21,400
Total Pollen	150
Total Spores	45

Table 3 Pollen data from DJD08 BH2.

This pollen spectrum is dominated by Alnus with Quercus and Corylus avellana type. Herbs are also important Poaceae are dominant (21%) with Chenopodiaceae (7%) and the marsh taxa, Cyperaceae (7%) and Typha angustifolia type (4%). Spores are dominated by Pteridium aquilinum (15% sum + spores) and Dryopteris type (10% sum + spores).

3.3.3.4.2 VEGETATION INTERPRETATION

Pollen was not present in any other samples. Therefore, no conclusions relating to the changing vegetation and environment can be made. The single sample at –0.63m.OD indicates that the site was generally a wet, herbaceous fen habitat with alder growing around its fringes or in drier areas (those not subject to standing water for more than 3 months).

The surrounding drier land/interfluves were similarly partially wooded with oak and hazel being the main woodland constituents. Lime is also present, and as noted, its importance may be greater than the pollen representation suggests. Grasses and ribwort plantain suggest that there was some open ground. Chenopodiaceae (goosefoots and oraches) may be an indication of occasional saline/tidal ingress or from growth on nitrogen rich soils (i.e. where animals have been kept). There is no evidence of arable cultivation.

3.3.4 Summary and Conclusions

Data presented here form part of a preliminary environmental assessment of the sediment cores obtained from the Canning Town (CAJ08), South Quay (SQS08) and Delta Junction (DJD08) DLR sites. Useful information has been obtained which details the approximate age of the sediments and the broad character of the past vegetation and environment of this region of the Thames floodplain during the early and middle Holocene.

Pollen was assessed from 23 samples allowing construction of a preliminary pollen diagram with three preliminary, local pollen assemblage zones delimited defining the principal vegetation changes. Preservation and absolute pollen frequencies are variable depending on the depositional environment of the sediment.

The following principal points have been made in this assessment study; Pollen data has been obtained from all of these sites although preservation and pollen numbers are highly dependent on the nature of the sediments (organic/minerogenic). However, of four samples analysed from DJD08 (BH2), only one sample contained sufficient pollen to enable a count. Pollen diagrams have been constructed for the three other samples sets. SQS08 and DJD08 provided the most complete pollen sequences.

All of the sediment and pollen sequences show a depositional environment which was becoming wetter. SQS08 shows a change from alder carr floodplain woodland to a herbaceous grass-sedge fen. At CAJ08, a grass-sedge fen in which peat accumulated with surrounding alder woodland gave way to overbank deposition of alluvial sediments on a river floodplain. At DJD08, a basal humic soil (possible Ah horizon) which was dominated by on-site lime woodland became wetter and was colonised by alder carr woodland. This latter sequence/soil might be of middle Holocene (Atlantic age), i.e. late Mesolithic.

This change to increasing wetness and change from fen peat to alluvial sediments is probably due to rising post-glacial relative sea level at a regional level. This caused local ponding back of freshwater river systems and change in vegetation communities. There are some tentative indications of saline/brackish water ingress with pollen of Chenopodiaceae which may be from salt marsh halophytes. However, this occurred during the late prehistoric period and it is also suggested that increased human activity/agriculture may have released increasing sediment loads in to the fluvial catchments. This major environmental change was also seen in earlier studies along the line of the Docklands Light Railway (Scaife 1999, 2008).

The vegetation of the surrounding dry land region from all sites shows a partially wooded landscape with areas of open grassland and agriculture. Woodland was dominated by oak and hazel with the possibility of some lime. There are also lesser records of elm, ash and beech of local origin and birch and pine which are probably of long distance airborne and fluvial transport.

Evidence of cereal cultivation comes largely from the upper alluvial sediments at the sites examined (esp. CAJ08 and SQS08). This raises the question as to whether this cultivation was in proximity to the sample site or whether pollen has been fluvially transported from farther afield.

The changes from alder carr and fen peat to alluvium is diagnostic of the upper floodplain sediments of the Thames. This change, as noted, was probably driven by rise in relative sea level and took place during the late prehistoric period (middle/late Bronze Age to the Iron Age and Romano-British). Clearly this was asynchronous depending on altitude OD. The pollen assemblages are also diagnostic of the Bronze Age for the organic units examined whilst the minerogenic/alluvium s comparable with other sites of late Bronze Age-Romano-British age. Radiocarbon dating should clarify/verify these suggestions. At DJD08 a possible basal humic soil dominated by lime is possibly of middle Holocene, late Mesolithic age.

3.4 Diatoms

Dr. Nigel Cameron

3.4.1 Introduction

Twenty-four sediment sub-samples have been assessed for diatoms. These were taken from boreholes on the sites of the DLR 3 car capacity enhancement at: South Quay, Delta Junction and Canning Town. The sample depths and sample numbers of the sub-samples assessed for diatoms are shown in Table 4. The three sites from which borehole samples were assessed for diatoms are coded as follows: SQS08 (South Quay); DJD08 (Delta Junction); and CAJ08 (Canning Town).

The purpose of the diatom assessment here is to assess the potential to use diatom analysis of the DLR sequences for environmental reconstruction. Information about the environment of deposition, salinity, aquatic/terrestrial conditions are of particular interest here. The diatom assessment takes into account the numbers of diatoms, their state of preservation, species diversity and diatom species environmental preferences.

3.4.2 Method

Site Code	BH	Sample Number	Sample Depth (m)	Sample Height (m.OD)
SQS08	1	D1	7.59	-2.39
SQS08	2	D2	7.00	-1.8
SQS08	2	D3	6.70	-1.5
SQS08	2	D4	6.48	-1.28
SQS08	2	D5	6.20	-1.00
SQS08	2	D6	6.08	-0.88
SQS08	2	D7	5.82	-0.62
SQS08	2	D8	5.49	-0.29
DJD08	2	D9	6.13	-2.62
DJD08	2	D10	5.04	-1.54
DJD08	2	D11	4.76	-1.26
DJD08	1C	D12	4.87	-0.87
DJD08	1C	D13	4.69	-0.69
DJD08	1C	D14	4.40	-0.40
DJD08	2	D15	4.13	-0.63
DJD08	1C	D16	4.04	0.04
CAJ08	1	D17	9.20	-2.99
CAJ08	1	D18	8.68	-2.47
CAJ08	1	D19	8.40	-2.19
CAJ08	1	D20	8.12	-1.91
CAJ08	1	D21	7.73	-1.52
CAJ08	1	D22	6.90	-0.69
CAJ08	1	D23	6.45	-0.24

CAJ08	1	D24	6.00	0.21

Table 4 Samples examined for diatom assessment

Diatom preparation followed standard techniques (Battarbee 1986, Battarbee *et al.* 2001). Coverslips were made from each sample and fixed in Naphrax for diatom microscopy. A large area of the coverslips on each slide was scanned for diatoms at magnifications of x200, x400 and x1000 under phase contrast illumination.

Diatom floras and taxonomic publications were consulted to assist with diatom identification; these include Werff & Huls (1957-1974), Hartley *et al.* (1996) and Krammer & Lange-Bertalot (1986-1991). Diatom species' salinity preferences are discussed using the classification data in Denys (1992) and the halobian groups of Hustedt (1953, 1957: 199), these salinity groups are summarised as follows:

1. Polyhalobian: >30 g l^{-1}

2. Mesohalobian: 0.2-30 g l^{-1}

3. Oligohalobian - Halophilous: optimum in slightly brackish water

4. Oligohalobian - Indifferent: optimum in freshwater but tolerant of slightly brackish water

5. Halophobous: exclusively freshwater

6. Unknown: taxa of unknown salinity preference.

3.4.3 Results and Interpretation

The results of the diatom evaluation for the borehole sequences from the three sites are summarised in Table 5 and the diatom species recorded are shown in Table 6 along with their halobian classifications.

Diatom Sample No.	Diatoms	Diatom numbers	Quality of preservation	Diversity	Assemblage type	Potential for % count
D1	absent	-	-	-	-	none
D2	absent	-	-	-	-	none
D3	absent	-	-	-	-	none
D4	absent	-	-	-	-	none
D5	absent	-	-	-	-	none
D6	absent	-	-	-	-	none
D7	present	ex.low	ex. poor	very low	bk mar	none
D8	present	mod	poor to mod	mod	bk mar fw	moderate
D9	absent	-	-	-	-	none
D10	absent	-	-	-	-	none
D11	absent	-	-	-	-	none
D12	absent	-	-	-	-	none
D13	present	very low	very poor	low	fw non-pk aero	none
D14	present	low	very poor	low	bk fw aero	low
D15	present	ex low	ex poor	very low	mar-bk	none
D16	present	ex low	ex poor	1 sp.	aero fw	none
D17	present	high	mod	mod	bk-mar	good
D18	present	high	mod	mod	bk-mar	good
D19	present	ex low	very poor	low	mar-bk	none
D20	present	mod high	mod to poor	mod	bk mar fw	good
D21	present	mod high	mod to poor	mod	bk mar fw	good
D22	present	mod high	poor to mod	mod	bk fw mar	good
D23	present	mod high	mod to poor	mod	bk fw mar	good
D24	present	mod high	mod to poor	mod	bk fw mar	good

Table 5 Summary of diatom evaluation results DLR 3 car capacity enhancement sites SQS08, DJD08, CAJ08 (mod – moderately high, ex.low- extremely low, fw – freshwater, pk – plankton, non-pk, non-planktonic, aero- aerophilous, epiphy – epiphytes, mar – marine, bk – brackish, halophil – halophilous, halophobous - hb)

	Sample Number													
Diatom Taxon	D7	D8	D13	D14	D15	D16	D17	D18	D19	D20	D21	D22	D23	D24
Polyhalobous														
Coscinodiscus sp.		1												
Cymatosira belgica							2	2		2	2	1		2
Paralia sulcata		2		1	2		2	1	1	2	2	1		1
Rhaphoneis amphiceros							1	1		1			1	
Rhaphoneis minutissima							2	2		1	2	2	1	2
Rhaphoneis sp.					1		1							1
Rhaphoneis surirella		1					2	2		2	1	2	1	1
Thalassionema nitzschiodes								1						
Triceratium favus		1												
Polyhalobous to Mesohalobous														
Actinoptychus undulatus								1					1	1
Cocconeis scutellum		1			1								1	
Navicula flanatica												1		
Pseudopodosira westii	cf													
Thalassiosira decipiens							1	1			1			
Mesohalobous														
Achnanthes delicatula											1			
Cyclotella striata		3		2	1		3	3		3	3	3	3	3
Diploneis didyma		1								1				
Lyrella pygmaea											1			
Navicula salinicola								1						1
Nitzschia compressa (=punctata)													1	
Nitzschia granulata										1			1	1
Nitzschia hungarica							1							
Nitzschia navicularis	1	2		1	1				1			1		1
Rhopalodia gibberula											1			
Mesohalobous to Oligohalobous Halophilous														
Actinocyclus normanii							1	2		2	1	1	1	
Cyclotella meneghiniana								1						1
Nitzschia							1	1			1			1

levidensis														
Oligohalobous Halophilous														
Navicula mutica							1							
Oligohalobous Halophilous to Indifferent														
Gomphonema olivaceum											1			
Navicula costulata											1			
Rhoicosphaenia curvata										1		2	2	1
Oligohalobous Indifferent														
Achnanthes clevei														1
Achnanthes conspicua							1							
Achnanthes lanceolata			1											
Achnanthes lanceolata var. rostrata													1	
Achnanthes minutissima											1		1	
Amphora libyca			1	1									1	
Amphora pediculus											1		1	1
Aulacoseira sp.			2	1										
Cocconeis disculus		3									1	1	1	1
Cocconeis placentula & var.								2			1	3	3	1
Craticula cuspidata				1										
Cyclostephanos dubius														1
Cymatopleura elliptica								1						
Cymbella affinis													1	
Cymbella sinuata													1	
Diatoma vulgare											1		2	
Ellerbeckia arenaria		1	1											
Fragilaria brevistriata				1				1		2	1	1	1	1
Fragilaria construens var.venter								1			1			
Fragilaria pinnata		1	1				1	1		1	1		2	1
Fragilaria pseudoconstruens										2				
Fragilaria vaucheriae													1	
Gomphonema angustatum & var. productum			1											
Gyrosigma acuminatum											1			1
Gyrosigma attenuatum		1												
Hantzschia						1								

amphioxys														
Navicula tripunctata							1	1						1
Nitzschia amphibia											1			
Opephora martyii		1		1			1	1			1	1		1
Pinnularia major			2	2										
Synedra capitata				1										
Synedra ulna		1	2									1	1	1
Oligohalobous Indifferent to Halophobous														
Cocconeis pediculus												1	1	1
Unknown Salinity Group														
Achnanthes sp.			1							1				
Amphora sp.							1							
Chrysophyte cysts			2	2										
Cocconeis sp.												1		
Diploneis sp.		1	1					1		1		1		
Fragilaria sp.		1		1										1
Gomphonema sp.				1			1					1	1	1
Gyrosigma sp.			1	1			1							
Inderminate centric sp.				1	1			1	1					
Inderminate pennate sp.		1	1		1				1					
Navicula sp.			1	1			1				1	1		
Nitzschia sp.							1	1				1	1	
Pinnularia sp.		1	2	1										1
Stauroneis sp.			1											
Surirella sp.				1						1	1	1	1	
Unknown diatom fragment	1		1		1				1					
Unknown naviculaceae			1				1	1						

Table 6 Counts of diatom species along with their halobian classifications

3.4.4 Discusion

3.4.4.1 South Quay (SQS08) (Diatom sub-samples D1-D8)

Diatoms are present in two samples that were assessed from the South Quay (SQS08) site. These are the uppermost samples in the sequence, at 5.49 m bgl and

5.82 m bgl in BH2. Diatoms are absent from the other six samples that ranged in depth from between 6.08 m bgl and 7.59 m bgl in BH2 and BH1.

The lower diatomaceous sample (D7) at 5.82 m bgl (-0.62 m OD) had an extremely low number of diatom fragments. Amongst these were the epipelic brackish-marine diatom *Nitzschia navicularis* and a possible fragment from the marine brackish, planktonic species *Pseudopodosira westii*. There is no further potential for diatom counting from this sample. The top sample from the SQS08 sequence (D8) at 5.49 m bgl (-0.29 m OD) contained a moderately high number of diatoms. The quality of preservation varied from poor to moderately good and species diversity was moderately high. The diatom assemblage is mainly of brackish and marine species but with significant numbers or freshwater taxa. There is moderately high potential to carry out percentage diatom counting from this sample. The allochthonous marine component of the assemblage includes planktonic diatoms such as *Paralia sulcata, Cymatosira belgica, Rhaphoneis surirella* and *Triceratium favus*. Polyhalobous to mesohalobous and mesohalobous diatoms include non-planktonic types such as *Nitzschia navicularis* and *Cocconeis scutellum*, whilst the estuarine planktonic species *Cyclotella striata* is abundant in sample D8. Despite these indicators of high salinity, oligohalobous indifferent taxa are present and one freshwater species, *Cocconeis disculus* is abundant. Therefore, with the exception of the top sample (D8) there is no further potential for diatom analysis of the sediment sequence from SQS08 sampled in boreholes 1 and 2.

3.4.4.2 Delta Junction (DJD08) (Diatom sub-samples D9-D16)

Diatoms are present in the upper four samples (D13-D16), -0.69 m OD to +0.04 m OD, from the DJD08 sequence and are absent from the lower four samples (D9-D12), -2.62 m OD to -0.87 m OD, from DJD08.

Although diatoms are present in D13-D16, the diatoms are generally in very low numbers and the quality of valve preservation is very poor, with low or very low species diversity. Only in sample D14 (-0.40 m OD, 4.40 m bgl) is there a low potential for percentage diatom counting. There is therefore no potential to analyse a sequence from these borehole samples.

The lowermost diatomaceous sample (D13) is from peat. The diatom assemblage is composed of freshwater, non-plankton such as *Achnanthes lanceolata, Amphora libyca, Aulacoseira* sp., *Fragilaria pinnata, Gyrosigma attenuatum, Opephora martyii* and *Synedra ulna*. These diatoms inhabit shallow freshwater environments. The aerophilous/sand surface species *Ellerbeckia arenaria* and the aerophile *Pinnularia major* are also common. In sample D14, taken from silty clay, the diatom assemblage is comprised of mesohalobous (*Cyclotella striata, Nitzschia navicularis*) and freshwater diatoms (*Amphora libyca, Craticula cuspidata,* and *Synedra capitata*). The aerophile *Pinnularia major* is also common in D14 and the polyhalobous planktonic species *Paralia sulcata* is the only marine diatom present. In D15 the extremely low number of poorly preserved diatoms is nevertheless consistent in reflecting marine and brackish environments. In D15 *Paralia sulcata* is common and the marine and marine-brackish taxa *Rhaphoneis* sp. and *Cocconeis scutellum* are present. Also present are the mesohalobous species *Cyclotella striata* and *Nitzschia navicularis*. Freshwater diatoms are absent from the blue grey silt of sample D15. A single, very poorly preserved, freshwater aerophilous species, *Hantzschia amphioxys*, is present in D16.

3.4.4.3 Canning Town Flyover (CAJ08) (Diatom sub-samples D17-D24)

Diatoms are present in all eight samples in the CAJ08 sequence (diatom samples D17-D24). With the exception of sample D19 (-2.19 m OD, 8.40 m bgl), which was taken from a compacted peat, where diatoms numbers are extremely low and preservation is very poor, diatom numbers are high, many valves are moderately well preserved and species diversity is moderately high throughout CAJ08. There is therefore good potential to make percentage diatom counts for seven of the eight samples from this sequence.

In the basal silty clay sample from CAJ08 (D17, -2.99 m OD, 9.20 m bgl) the diatom assemblage is dominated by marine and brackish water species with fewer halophiles and freshwater diatoms present. Most common here are marine planktonic diatoms such as *Cymatosira belgica, Paralia sulcata, Rhaphoneis minutissima* and *Rhaphoneis surirella*. The planktonic estuarine species *Cyclotella striata* is abundant. The grey silty clay (with some organic material) of D18 contains a similar marine-brackish flora, dominated by *Cyclotella striata* and a number of polyhalobous taxa are common (*Cymatosira belgica; Rhaphoneis* spp.). However, in D18 the planktonic halophile *Actinocyclus normanii* and freshwater epiphyte *Cocconeis placentula* are also common, this may reflect the organic material recorded in the sediment description. There are also a greater number of freshwater diatoms present than in the bottom sample, for example *Cymatopleura elliptica, Fragilaria brevistriata, Navicula tripunctata* and *Fragilaria construens* var. *venter* are present. As noted above the diatom assemblage of D19 is poorly preserved. Despite the peaty nature of the sediment, including wood remains, the diatoms present are marine (*Paralia sulcata*) and brackish-marine (*Nitzschia navicularis*). The presence of only these robust saltwater diatoms may be the result of preferential preservation.

Samples D20 to D24 all have a moderately high diatom concentration, many of the diatom valves are relatively well preserved and species diversity is moderately high. There is therefore good potential to carry out percentage diatom analysis for these samples. In every case, these samples lying between -1.91 m OD and +0.21 m OD, the diatom assemblages are composed of a mixture of brackish, marine and freshwater diatoms. In all five samples common allochthonous marine plankton components (e.g. *Cymatosira belgica, Paralia sulcata, Rhaphoneis* spp., *Actinoptychus undulatus*) along with the abundant planktonic estuarine species *Cyclotella striata* and the presence of a number of benthic mesohalobous diatoms (e.g. *Diploneis didyma, Lyrella pygmaea, Navicula salinicola, Nitzschia compressa, Nitzschia granulata* and *Nitzschia navicularis*) reflect tidal conditions. However, apparent variations in the abundance of these components along with increased numbers of non-planktonic halophilous (e.g. *Rhoicosphaenia curvata*) and freshwater (e.g. *Cocconeis placentula, Diatoma vulgare, Fragilaria pinnata, Fragilaria brevistriata, Synedra ulna, Cymbella sinuata, Cymbella affinis*) diatoms, seen for example in samples D22 and D23, where sand was recorded within the clay, suggest that diatom analysis of the sequence might show trends in the abundances of diatom halobian groups within the blue-grey estuarine clay related to salinity or other changes in the source diatom communities.

3.4.5 Conclusions

Diatoms are present in fourteen samples and absent from ten samples assessed from the three DLR sites. Approximately 80 diatom taxa were identified in the assessment counts.

The quality of preservation in two of the sequences (SQS08 and DJD08) evaluated is generally poor or diatoms are absent. Of the eight samples assessed from SQS08 only the top sample (-0.29 m OD) has moderate potential for percentage diatom analysis. None of the eight samples from DJD08 has further potential for diatom analysis, with the exception of the sample from -0.40 m OD which has only low potential for percentage diatom analysis. However, where diatoms are preserved it has been possible to make some inferences about the aquatic environment from the poorly preserved assemblages in these two borehole sequences.

Diatoms are present in all eight samples from CAJ08 and in six of these samples diatom numbers are relatively high, the quality of valve preservation is often good and species diversity relatively high. There is therefore good potential for percentage diatom analysis of much of this sequence.

The two top samples from SQS08 have brackish-marine diatom assemblages. The top sample also has significant numbers of a non-planktonic freshwater species. The sample taken from peat in DJD08 (D13) contains a shallow freshwater and aerophilous diatom assemblage. The sample from the overlying clay in DJD08 (D14) contains a brackish (both plankton and benthic species) and shallow freshwater assemblage with some freshwater aerophiles. The clay of D15 contains a marine-brackish diatom flora. The only species preserved in the top sample D16 is a freshwater aerophile.

The diatom assemblages in the CAJ08 sequence show a consistent brackish and marine diatom component with increased input of halophilous and freshwater diatoms seen in a number of samples. All samples reflect tidal conditions although the composition of the single poorly-preserved diatom assemblage in this sequence (D19) may partly be the result of preferential preservation of strongly silicified diatom valves within the peat.

3.5 Foraminifera and Ostracoda

Dr. John Whittaker

3.5.1 Introduction

Twelve samples, four each from three sites on the Docklands Light Railway, East London, were submitted for microfaunal analysis. The aim of the microfossil assessment is to produce an environmental reconstruction of the sites, firming up the preliminary interpretation of the sequences, based on their sedimentological characteristics.

3.5.2 Materials and Methods

Site Code	BH	Sample Depth (m)	Sample Height (m.OD)	Weight
CAJ08	1	6.45	-0.24	35g
CAJ08	1	7.73	-1.52	35g
CAJ08	1	6.9	-0.69	35g
CAJ08	1	6	0.21	40g
DJD08	2	4.13	-0.63	25g
DJD08	1C	4.04	0.04	25g
DJD08	2	6.12	-2.62	35g
DJD08	1C	4.87	-0.87	40g
SQS08	2	6.2	-1.00	20g
SQS08	2	5.82	-0.62	35g
SQS08	2	6.7	-1.5	35g
SQS08	1	7.59	-2.39	35g

Table 7 samples examined from BH1 and BH2 for formaminfera and Ostracoda assessment

After weighing, each sample was put in a ceramic bowl. The sediment was first broken by hand into very small pieces and then dried in the oven. Boiling water was then poured on the sample and a little sodium carbonate added to help remove the clay fraction on washing. It was then left to soak overnight. Breakdown was readily achieved when washed with hot water through a 75 micron sieve. The resulting residue was finally decanted back into the bowl for drying in the oven. When dry the sample was stored in a labelled plastic bag. Examination of the residue was undertaken under a binocular microscope. First the residue was put through a nest of dry sieves (>500, >250 and >150 microns) and then sprinkled out a fraction and a little at a time onto a tray. Any organic remains or items of interest were noted and the data incorporated, on a presence (x)/absence basis, into tables. The ostracods and foraminifera on the other hand, if they occurred, were picked out and placed on 3x1" faunal slides for archive purposes, the species being listed semi-quantitatively. Tables 8 – 11 list the microfaunal remains found in the samples.

3.5.3 Results

CAJ08 BH1

ORGANIC REMAINS

Depth (O.D.)	+0.21m	-0.24m	-0.69m	-1.52m
plant debris + seeds	x	x	x	x
insect remains	x	x		
molluscs	x	x	x	x
large diatoms (>75μ)	x	x	x	x
ostracods	x	x	x	x
foraminifera	x	x	x	x

Ecology	*mudflats with latterly, saltmarsh development; marginal fringe of open estuary*
	tidal

BRACKISH INDIGENOUS FORAMINIFERA

Depth (O.D.)	+0.21m	-0.24m	-0.69m	-1.52m	
Ammonia sp.	xx	xx	xx	xx	calcareous foraminifera of low-mid saltmarsh and tidal flats
Haynesina germanica	xx	xx	xx	xx	
Elphidium williamsoni	x	x		xx	
Elphidium waddense	x				
Jadammina macrescens	xx	x			agglutinating foraminifera of mid-high saltmarsh
Trochammina inflata		x			

OUTER ESTUARINE AND MARINE FORAMINIFERA

Depth (O.D.)	+0.21m	-0.24m	-0.69m	-1.52m	
miliolids	x	x	xx	xx	essentially marine species, but can penetrate outer estuaries
Elphidium excavatum	x	x	x	x	
Elphidium margaritaceum	x	x	x	x	
lagenids	x	x	x	x	
discorbids	x	x	x		
bolivinids		x	x	x	

Table 8 Foraminifera results for CAJ08 BH1

CAJ08 BH1

BRACKISH INDIGENOUS OSTRACODS

Depth (O.D.)	+0.21m	-0.24m	-0.69m	-1.52m
Leptocythere lacertosa	xx	x	xx	xx
Leptocythere castanea		x		
Leptocythere psammophila		x	x	x
Cyprideis torosa			x	
Loxoconcha ellipica			x	x

brackish ostracods of tidal flats and creeks

OUTER ESTUARINE AND MARINE OSTRACODS

Depth (O.D.)	+0.21m	-0.24m	-0.69m	-1.52m
Pontocythere elongata	x	x		x
Hemicythere villosa	x		x	x
Hirschmannia viridis	x	x	x	x
Semicytherura sella	x			
Paradoxostoma spp.		x	x	x
Hemicytherura cellulosa		o		
Cytheropteron nodosum			x	
Loxoconcha rhomboidea			x	x

essentially marine species, but can penetrate outer estuaries

"EXOTIC" OSTRACODS

Depth (O.D.)	+0.21m	-0.24m	-0.69m	-1.52m
Carinocythereis whitei	x			
Aurila convexa	o			

warm "southern" marine species

Organic remains are listed on a presence (x)/absence basis only
Foraminifera and ostracods are listed: o - one specimen; x - several specimens; xx - common

Table 9 Ostracod results for CAJ08 BH1

DJD08 BH1

ORGANIC REMAINS

Depth (O.D.)	-0.04m	-0.87m
Iron	x	
plant debris	x	x

Ecology	*alluvium; weathered*	*freshwater marsh*
	freshwater	

DJD08 BH2

ORGANIC REMAINS

Depth (O.D.)	-0.63m	-2.62m
plant debris + seeds	x	
insect remains	x	
Rhizoliths		x

Ecology	*freshwater marsh*	*riverine; drying out*
	freshwater	

Organic remains are listed on a presence (x)/absence basis only

Foraminifera and ostracods are listed: o - one specimen; x - several specimens; xx - common

Table 10 Ostracod results for DJD08 BH1 and BH2

SQS08 BH1

ORGANIC REMAINS

Depth (O.D.)	-2.39m
BARREN	

Ecology	*riverine; high energy*
	freshwater

SQS08 BH2

ORGANIC REMAINS

Depth (O.D.)	-0.62m	-1.00m	-1.50m
iron minerals	x		
Ostracods	x		
Foraminifera	x		
plant debris + seeds		x	x
Insects		x	
		peaty	

Ecology	*brackish tidal flats; weathered*	*marsh*	*low energy channel*
	tidal	freshwater	

OSTRACODS

Depth (O.D.)	-0.62m	-1.00m	-1.50m	
Cyprideis torosa	x			brackish ostracods of tidal flats and creeks

FORAMINIFERA

Depth (O.D.)	-0.62m	-1.00m	-1.50m	
Elphidium williamsoni	x			calcareous foraminifera of low-mid saltmarsh and tidal flats

Organic remains are listed on a presence (x)/absence basis only

Foraminifera and ostracods are listed: o - one specimen; x - several specimens; xx - common

Table 11 Ostracod results for SQ08 BH1 and BH2

3.5.4 Discussion

3.5.4.1 CANNING TOWN (Table 8 and Table 9)

The four samples provided, covering the interval +0.21 down to -1.52m OD in BH 1, produced excellent microfaunas, all typical of mudflats on the marginal fringe of a large open estuary. Very similar results have occurred in other Holocene sites which I have recently studied on the Thames-Medway. Fig 1 shows clearly, with the colour-coding adopted, the various components that go to make up the microfossil assemblage found: the indigenous brackish foraminifera and ostracods and the outer estuarine and more marine species washed in by the tide and on floating sea-weed. Molluscs also occur in all the samples but only as juvenile spat. The sediments are very fine-grained (most of the residue is <150 microns), indicative of mudflats, and is very rich in microfossils – many more species, no doubt, could have been added to the table with more time and more diligent picking. The picture, however, given is already clear enough. Large circular diatoms were much in abundance, which is usually indicative of a rich and healthy sediment interface and these undoubtedly gave rise to the large indigenous *in situ* foraminiferal fauna (colour-coded grey) living on the sediment (foraminifera foster diatoms as symbionts in their shells, as well relying on them for their main food supply). The indigenous ostracods (colour-coded green), were significantly represented by carapaces, rather than discrete valves, which indicates there are also living *in situ* and were not transported. Many of the marine microfossils, on the other hand, were often coloured black or dark brown and if ostracods, were always present as single valves, indicative of transport or reworking. Two species (colour-coded yellow) and labelled "exotic" are at the northernmost limit of their geographical distribution; they could be derived from "climatic optimum" sediments within the Holocene. Finally, the uppermost two samples (+0.21 and -0.24m OD) give some evidence of accretion at the end of the sequence with an onset of saltmarsh at the site, as they contain quite significant numbers of the agglutinating foraminifera *Jadammina macrescens* and *Trochammina inflata* (colour-coded dark green), which are markers for mid-high saltmarsh worldwide (Murray 2006).

3.5.4.2 DELTA JUNCTION, POPLAR (Table 10)

Two samples each from two boreholes (BH1C and BH2) were examined for microfauna. None contained any ostracods, foraminifera or any other calcareous remains. BH1C contained iron minerals in the upper sample (-0.04m OD), the residue of which also had grey-blue clay fragments (the product of gleying). This seemed, therefore, to be alluvium which had been subject to both weathering and waterlogging. The other samples (-0.87m OD) contained much plant material and was quite peaty as was the upper sample of BH2 (-0.63m OD). Very small, often rounded, organic-walled bodies were much in evidence which I understand are algal cysts. In the absence of any other evidence I consider both of these samples indicative of freshwater marsh. If it were true saltmarsh, agglutinating foraminifera, which have a shell made of mineral grains cemented to an organic template, would have surely survived. I did not find any. The lowest sample (at -2.62m OD) of BH 2 contained rhizoliths, tubes formed round plant rootlets and probably the tufa listed in the preliminary sedimentological interpretation provided by MoLA. Rhizoliths, according to Candy (*in* Ashton *et al.,* 2005: 16), reflect (when associated with a freshwater environment)…."the drying out of the environment and the formation of fully terrestrial conditions either as a result of the initiation of a drier climate....or because of sediment infilling/lateral migrations of the channel system. Rhizoliths, along with other calcrete types, are typically used to indicate the existence of a dry climate, either a semi-arid climate or a humid climate with pronounced dry months". ...."As rhizoliths may form over relatively short periods of time, i.e. the lifetime of the root, these features may not represent a long-lived period of land surface stability and soil development but could reflect a relatively short-lived land surface". The same author has something to say about iron tubes, nodules, and precipitates (often goethite), which also indicated under the "Organic Remains" in BH 1C (Fig 2; left). These seem to be associated with weathering or near-surface groundwaters, formed prior to the onset of fully terrestrial conditions, or pedogenic activity (Candy, *ibid.*, 2005).

3.5.4.3 SOUTH QUAYS, TOWER HAMLETS (Table 11)

If the Poplar site at Delta Junction was too peripheral to the Thames for tidal access, the South Quays site only achieves tidal access, just, in the uppermost sample of BH2 (-0.62m OD). For the lower two samples (-1.00m OD and -1.50m OD), on very little evidence of my own, I would concur with the preliminary interpretation by MoLA personnel that they represent a freshwater marsh and a subsidiary, low energy channel, respectively. The one sample from BH1 was completely barren, the residue being composed of pure angular sand, this immature sediment being indicative of a high energy river channel. A palynological analysis of both the South Quays and Delta Junction sites, especially of the organic-rich samples, would be the only chance of enhancing their environmental reconstructions.

3.6 Integrated Palaeoenivironmental Discussion

The tabulated sedimentary units (section 3.1) have been grouped into sediment packages or facies with key markers in the sequence, which denote major events, used as points of correlation. These principally comprise the change from clast supported gravels to Early Holocene sands (at -1.2m OD); marginal wetland and fluvial deposits (between -1.2 and -2.94m OD); the marine/freshwater inundation recognised at -1.94m to 0.3m OD.

Gravels (facies 1) are superceded by fluvial sands and freshwater peat (facies 2 and 3). Following this, rising sea levels lead to tidal access and inundation of freshwater to estuarine mudflats and marine clays (facies 4). The deposit sequence at each site is compared and is illustrated in two transects drawn across the area; Fig 7, which depicts Delta Junction and Canning Town; and Fig 8, which looks at South Quay. Both transects present the information from the sites themselves, as well as putting this information within the context of the surrounding Thames Valley.

3.6.1 Pleistocene: Facies 1 (-0.1 to -3.77m OD)

3.6.1.1 Transect 1 (Fig 7)

The lowest deposit presented in the deposit models are sands and gravels related to deposition under a braided river environment during the final phases of the last (Devensian) glaciation (*c* 15,000 to 10,000 years ago. These sediments represent the Shepperton Gravel formation. Transect 1 shows the surface of these gravels between -0.53 and -3.77m OD, and is likely to reflect preferential scouring of softer underlying beds of Tertiary sedimentary units. Transect one covers the areas of the Delta Junction and the Canning Town sites. Within the boreholes from Delta Junction the gravel surface is evident between -1.62 and -2.45m OD, whist at Canning Town the gravel surface was recorded at -2.94m OD. Downcutting events occur at the end of cold stage episodes and were initiated by the great volume of meltwater introduced into the system during the initial thawing of ground ice. This is coupled by very low sea-levels during these periods which ultimately led to an incision/downcutting event. Transect 1 shows that in between, and slightly to the north of, the Delta Junction and Canning Town sites is an area of high gravel around -1m OD (low island, Fig 9). This may be a remnant of the Kempton Park Terrace, which lays to the north of the site or have a similar origin to the Early Holocene sands discussed below.

The surface of the Pleistocene gravel formed the Early Holocene topography and influenced subsequent environments. This topography is shown as a green line on Figs 7 and 8 and is modelled for the local area in Fig 9.

3.6.1.2 Transect 2 (Fig 8)

Transect 2 runs from west to east to the south of Transect 1 (Fig 7) and crosses the location of the South Quay site. The gravel surface is recorded between -0.1 and - 2.39m OD across the whole of the transect, and between -1.92 and -2.39m within the boreholes located on the South Quay site. These gravels would also have been deposited in a braided river environment during the final phases of the last (Devensian) glaciation (*c* 115,000 to 10,000 years ago).

3.6.2 Mesolithic to Early Neolithic: Facies 2 (c -1.2 to -3.00 m OD)

3.6.2.1 Transect 1 (Fig 7)

To the west of Transect 1 in the boreholes at Delta Junction, sands and sandy silts were recorded to the base of the sequence, between -1.2 and -2.45m OD. These deposits probably formed during the early Holocene when high water flux evident at the end of the Devensian glaciations had abated to an extent, leading to a reduction in the size of the particles that the river could entrain. However, medium to coarse sand, still available in the fluvial system, was still being transported along the river and was being deposited and banked up against gravel highs, or forming point and mid-channel bars within the network of anastomosing channels. The presence of rhizoliths in the ostracod sample (see section 3.5) from -2.62m OD in borehole DJD08 BH2 indicates the drying out of a fresh water environment and a short period of soil formation. The elevation of these deposits suggest that this dry land surface would have only been exposed during the Mesolithic and then inundated as a result of relative sea level rise and the ponding back of inland rivers during the Late Mesolithic or Early Neolithic. To the east of Transect 1 and near to the Canning Town site previous borehole data records a silty sand at a much lower elevation, between -3.38 and -5.16m OD in borehole TQ38SE1585, may indicate the route of an Early Mesolithic channel running close to the Canning Town site.

3.6.2.2 Transect 2 (Fig 8)

Similar sand deposits as those discussed above for the Delta Junction site have previously been identified to the south of Delta Junction and to the west of South Quay. These are shown between -1 and 1m OD in the CubaST window samples on Transect 2. The surface of these deposits is at a higher level than those at Delta Junction and would have formed a dry landsurface for longer. No evidence of dry landsurfaces was identified in the relatively thin Early Holocene silts and sands recorded in borehole SQS08 BH1 from the South Quay site, which lay between -2.39 to -2.05m OD. It is likely these silts and sands relate to the silting up of another Early Mesolithic channel.

3.6.3 Neolithic to Bronze Age: Facies 3 (0.3 to -2.94 m OD)

3.6.3.1 Transect 1 (Fig 7)

The sequence of deposits belonging to facies 3 at the west end of the transect, is generally slightly sandy silty clays overlain by peats. At Delta Junction facies 3 lies between 0.3 and -1.62m OD. The diatom report suggests that these sediments accumulated in a primarily freshwater environment. Evidence found within the microfaunal samples suggest that these deposits were subject to gleying from the waterlogged conditions but also showed signs of drying out and weathering. Therefore, the early deposition of sandy silty clay may indicate the silting up or rising, as a result of RSL rise, and the ponding back of inland waters, perhaps relating to a nearby river or area of standing water. Considering the microfaunal report it is likely these deposits are a result of seasonal overbank flooding of the terrestrial landsurface found in facies 2. The sands and silty clays are thickest in DJD08 BH1 suggesting that within this area of the site this process occurred to a greater degree and was closer to the channel. The results of the pollen data from the base of facies 3 (see section 3.3.3.3, pollen zone DJD08: 1) indicates the nature of the environment that ws inundated by rising river levels. The presence of lime and some oak and hazel suggests that the (Mesolithic) landsurface development discussed in facies 2 above was forested at bthe time it became flooded.

In two of the three boreholes (DJD08 BH1c and BH2) the sandy silty clays are overlain by 0.2m of woody peat, indicating a return to a more stable, albeit now a wetland, environment. The diatom evidence again indicates a fresh water environment with some surface species indicating potentially standing not flowing water (section 3.4). The pollen data (see section 3.3.3.3, pollen zone DJD08: 2) depicts increasing wetness throughout facies 3 and the development of an alder carr woodland. The overlying deposits of sandy silty clay indicate rising river levels and a high fine-grained sediment load, deposited during episodic or prolonged flooding. Radiocarbon dates give a Mid Bronze Age date (1520 BC, section 3.2) to the onset of peat formation with it continuing into the Late Bronze Age/Early Iron Age (1065 BC, section 3.2).

This sequence appears to continue eastwards along Transect 1 with deposits thinning out over the eastern slope of the low island, as it dips into the palaeochannel (Fig 9).

The peat (facies 3) is also recorded at the eastern end of the transect. Within the borehole from the Canning Town site, facies 3, directly overlies the gravels, and is comprised entirely of a woody peat, recorded between -1.94 and -2.94m OD. The pollen data (section 3.3.3.1) suggests that this is a wet grass-sedge fen with some standing water with a fringe of Alder Carr. The diatom results (section 3.4.4.3) indicate a brackish possibly tidal environment with some fresh water species. The base of the peat was dated to the Late Neolithic/Early Bronze Age (3065 BC, section 3.2) and peat formation continued until the Late Bronze (1015 BC, section 3.2). The prehistoric landsurface at Canning Town was located at a lower elevation and further downstream than Delta Junction. Thus the affects of RSL rise would have occurred earlier at Canning Town than at Delta Junction, where peat formation did not begin until around the Mid Bronze Age (section 3.2) following a period of overbank flooding.

3.6.3.2 Transect 2 (Fig 8)

Across Transect 2 facies 3 lies between 0.2 and -2.05m OD. At the South Quay site, towards the centre of the transect, facies 3 comprises occasionally sandy, silty clays overlain by peats, lying between -0.9 and -2.05m OD. The lower silty clay deposits are interpreted as the silting up of or overbank deposits from a nearby channel. Little pollen, diatom or microfaunal remains were recorded from these deposits. The pollen evidence from the overlying peats indicate a damp Alder Carr floodplain with a possible nearby open hazel habitat. The microfaunal evidence further supports the sedimentary interpretation with indications of a freshwater marsh and a subsidiary low energy channel (section 3.5). The radiocarbon dates put the onset of peat formation slightly earlier than that at the Delta Junction site to the north, but not as early as the Canning Town site to the north east. The dates provide an Early Bronze Age (2150 BC, section 3.2) time frame for the onset of peat formation with peat development continuing until the Mid Bronze Age (1375 BC, section 3.2).

3.6.4 Iron Age to Historic: Facies 4 (3.05 to -1.94m OD)

3.6.4.1 Transect 1 (Fig 7)

Facies 4 is a variably organic silty clay up to c. 6m in thickness across the length of the transect, but only recorded to c. 1m in thickness within the 3 sites. To the west of Transect 1 and within the Delta Junction site the facies lies between 1.2 and -1m OD and is a brown slightly organic silty clay. The pollen evidence attests to the increasing wetness of the environment represented by facies 4, compared with facies 3, and the development of a grass-sedge and herb fen. This is supported by the diatom evidence, as the sand surface and fresh, shallow water species found in facies 3 are replaced by marine brackish species from about -0.6m OD in facies 4 (section 3.4). Suggesting flooding by estuarine water.

These deposits continue towards the east along the route of Transect 1. The deposits thin out over the low island (the area of higher gravel, possibly a remnant of the Kempton Park Terrace), but appear to thicken in the palaeochannel area. At the Canning Town site, at the eastern end of Transect 1, facies 3 is recorded between 1m and -1.94m OD and represented by a predominantly blue grey silty clay. The pollen samples indicate that some trees and shrubs remain while grass and fen environments dominate. Although, the pollen results do also indicate some reworking of the sediments, or inwash from a wider catchment, cereal and arable related weeds are also present, suggesting cultivation activities marginal or close to the mudflats. The diatom remains suggest mudflats in a fresh water to brackish environment with some marine species present (section 3.4). This is supported by microfaunal evidence (section 3.5) of indigenous brackish species with transported marine species brought in with the tide and subsequently reworked.

3.6.4.2 Transect 2 (Fig 8)

Along the length of Transect 2, facies 4 lies between c. 1.5 and -1m OD and is generally a slightly organic silty clay. It varies in thickness, up to c. 1m, and is more organic to the west of the South Quay site on the margins of a former channel. Within the boreholes from the South Quay site facies 4 was recorded between 0.2 and -1m OD. The sedimentary descriptions indicate a similar environment of mudflats as found in facies 4, transect 1. The pollen data indicates a herb-fen environment with some non-fen grassland in the wider area. Cereal and pastural related pollen is also present but has probably been transported in by fluvial processes from the wider catchment. This is supported by the diatom results, as they suggest brackish marine mudflats, and the microfaunal results, which also indicate tidal access. Near the top of facies 4 at -0.29m OD the diatom samples show an influx of fresh water species as well as well as the marine, potentially marking the boundary of the salt and fresh water environments (section 3.4). This addition of fresh water species may be the result of Roman to Medieval embankment and land reclamation in the marginal areas of the estuary.

No samples from facies 4 were dated in Transect 1 or 2 but with a *terminus post quem* from facies 3 of Bronze Age, an Iron Age to historic date is likely for facies 4 (section 3.2). Facies 4 may be truncated in places across the 3 sites due to an absence of any visible soil formation in the upper portion of this unit. It is directly overlain by made ground and in some cases redeposited/disturbed alluvial deposits (facies 5).

3.6.5 Historic: Facies 5 (c. 8 to -2.5m OD)

Facies 5 is variably a made ground dump and redeposited/disturbed alluvial deposit. Within the boreholes from the Delta Junction, Canning Town and South Quay sites it ranges between 4 to -0.17m OD, 6.2 to 1.01m OD and 5.2 to -0.35m OD respectively and is of a post-medieval to modern date.

4 Archaeological and Palaeoenvironmental Potential

4.1 General discussion of potential

The potential of the core samples and records collected from the three sites for contributing to our understanding of the prehistoric environment of the Isle of Dogs to Lea/Thames confluence area is discussed below.

4.1.1 Pleistocene (facies 1)

No samples were taken from the Pleistocene gravels. However, the levels of the surface of gravels, obtained during the evaluation provide an approximation of the topography at the start of the Holocene (the Mesolithic) and there is good potential to refine the model of this surface produced for the evaluation (Fig 9) by incorporating any additional borehole data that might be available from the DLR scheme.

4.1.2 Mesolithic to Early Neolithic (facies 2)

Sands, sandy clays and channel fills found immediately above the surface of the floodplain gravel were likely to have been laid down during the very early stages of the Holocene when the meltwater flux of the Late Pleistocene had abated, but the flow velocity of the River Thames was still fast enough to transport medium to coarse sand, with fine gravel seen in some of the channel fills.

Sand units found in some areas across the three sites (eg: in DJD08 BH2, DJD08 BH3 and SQS08 BH1) are thought to represent point and mid-channel bar formation, and are likely also to have formed as sand banked up against, and sometimes possibly over, gravel highs. These channel proximal sand accumulations may have formed small islands at the margins of, and sometimes in, channels on the floodplain, which would have been attractive to early and middle Mesolithic settlers roaming the landscape along channel margins in search of resources. Sandy silts seen predominantly across the Delta Junction site (in DJD08 BH2 and DJD08 BH3) have been interpreted as being contemporaneous with the period of sand deposition in the early Holocene. They appear to represent backwater areas of the floodplain, which were prone to overbank flooding throughout the early Holocene. These sediments most likely accreted over long periods of time and would have most likely been subject to occasional hiatuses in deposition, allowing pedogenesis (soil formation) to occur.

Although there is potential for finds of Mesolithic age within these deposits, especially where associated with Early Holocene landsurfaces, the environmental potential of the sands (as obtained in the core samples) is low. Little or no diatom or microfossil remains survive (see section 3.4 and 3.5), although some pollen survival at the top of the unit does occur at Delta Junction and more work on the vegetation history would be useful in order to examine lateral variation in the Mesolithic environment. In addition, by identifying evidence for palaeosol development in the sands sampled in the cores, a better understanding could be obtained of where landsurfaces with potential for prehistoric activity might be found, which would be of use in identifying areas of significance in the future.

4.1.3 Neolithic to Bronze Age (facies 3)

During the Neolithic and Bronze Age the floodplain in this area comprised a dense mixed 'dryland' woodland of oak, lime and hazel which gradually changed to a thick, most likely impenetrable alder-carr. This wet woodland would have been difficult to navigate through and would have presented quite an obstacle to late Neolithic and Bronze age people traversing the floodplain. It is likely that varying degrees of both alder-carr and mixed woodland typical of a dryland environment would have existed as a mosaic across the floodplain, dictated by local factors (such as proximity to channels and surface elevation). Both Delta Junction and South Quay are in channel proximal locations, especially DJD08 BH1, which may have had an effect on the species of trees growing in these areas, compared with the woodland that may have existed across the floodplain in other parts of the route. A study of the Neolithic woodland of the submerged forest downstream at Erith (Seel 2000) shows that the composition and distribution across the floodplain of tree species can vary markedly.

The woodland represented by the peat is likely to have proved too thick for carrying out subsistence activities. However, the channels flowing across this forested landscape would have acted as open corridors aiding movement across the floodplain. Therefore, the potential for recovery of archaeological remains is thought to be higher in channel proximal locations such as Delta Junction (DJD08 BH1). Although direct evidence for such past human activity is unlikely to be recovered from the core samples, indirect evidence for landscape disturbance might be obtained, especially from pollen assemblages. In addition, by modelling the deposits recorded in borehole logs along the line of the route, various landscape features and deposit configurations, representing environments that could have been appealing for exploitation by Neolithic and Bronze Age people might be identified and more information about the past landscape context of archaeology already known might be obtained. Within the peaty wetland deposits timber trackways have been found, of both Neolithic and Bronze Age origin, associated with the exploitation of gravel 'highs' in this area and timber platforms found in channel proximal settings. Both islands of high ground and channels have been identified close to the DLR sites investigated (see Fig 7 and Fig 9). There is good potential for adding more data, in particular any obtained as part of earlier DLR site investigations, to the models produced to refine our understanding of the prehistoric floodplain environment.

The organic nature of the facies 3 deposits has preserved good assemblages of palaeo-environmental remains (pollen, in particular) as well as being particularly suitable for dating using radiocarbon methods. The exact nature of the local (as opposed to general) floodplain environment and its evolution through the Neolithic and Bronze Age is unclear, especially with regard to the mosaic of woodland cover on the floodplain and its comparative value for exploitation. In order to better understand the heterogeneous mix of different woodland types that existed at this time and the impact of rising (and fluctuating) river levels at a scale likely to have been recognised by contemporary prehistoric communities, small-scale local studies are needed. The opportunity the DLR scheme provides for comparing results at several places along its route and in particular from the sediments and pollen assemblages preserved within the core samples from Delta Junction (DJD08) and Canning Town (CAJ08) offers good potential for address this issue.

4.1.4 Iron Age to Historic (facies 4)

Following a rise in RSL during the Late Bronze Age, the floodplain landscape changed dramatically as it became inundated by the rising river levels. This inundation could be associated with Devoy's (1979) Thames IV estuarine expansion event, which he identified just downstream from about 2600 BC. However, at the Delta Junction and South Quay sites the onset of this estuarine expansion and any subsequent affects of water ponding back was recorded much later, with the date from the interface with the underlying peat (facies 3) being 1065 BC (section 3.2). Even at Canning Town, where indicators of brackish water environments were noted in the underlying organic deposits (facies 3), the peat continued to form until after 1015 BC (section 3.2) .

When inundation occurred, woodland became waterlogged and died off and the whole area changed to a much more open landscape, with an expansion in herbs and grasses to match the reduction in local alder woodland. During this time the topography of the landscape began to level out and any former depressions in the floodplain area silted up. At the northern margins of the meandering River Thames, watermeadows formed which would have been prone to episodic overbank flooding, which deposited fine-grained sediment that gradually built up as an accretionary floodplain soil. Later in the medieval period this land may have been used as pasture, and sometimes was reclaimed by making up the surface of the ground with domestic and industrial waste. At Delta Junction and South Quays, microfossil and palaeo-environmental remains were poorly preserved in the minerogenic sediments of facies 4. However, diatom and pollen preservation was good within the Canning Town borehole, which could provide valuable insights into the evolution of the historic floodplain environment and the local cultivation and pastoral activities indicated in the pollen results.

4.2 Realisation of the original research aims

The objectives of the evaluation were to:

Add new information to our current understanding of the evolving environment of the floodplain of the East London Thames.

The opportunity provided by the linear nature of the DLR scheme has enabled us to examine discrete sites within their wider landscape contexts. It has also allowed us to correlate deposits between sites and this has shown that the date and environments represented by apparently similar deposits vary laterally and through time. A better understanding of these differences could provide detail at a local scale that is meaningful for understanding past human activity.

Examination of the sediments, the palaeoenvironmental evidence they contain and modelling the buried deposits has highlighted the existence of potentially Mesolithic soil formation on raised areas of Early Holocene sand deposits, most notably at the Delta Junction site. This land surface was mantled by a dense, wet Alder Carr woodland from 3065 BC at Canning Town in the east, to 2150 BC at South Quay in the west (section 3.2), of the area spanned by the DLR sites. This predominantly fresh water environment continued until 1015 BC (section 3.2), when marine inundation occurred, creating mudflats and herb-fen (facies 4). Subsequently, over bank deposits levelled out the landscape an accretionary floodplain soil developed in a water meadow environment.

Reconstruct the landscape context in which past human activity on the floodplain took place.

The landscape evolution represented by the sediments examined has been related to known and potential archaeology in section 4.1. The Shepperton Gravel (of Palaeolithic age) was proved at the base of every borehole (facies 1) and its surface formed the topography for the Holocene landscape. The overlying channel proximal sand accumulations at Delta Junction and South Quay may have formed small islands at the margins of, or within, multiple channels on the floodplain. Evidence for Mesolithic activity is known from such riverine locations elsewhere, as the river channels would have been attractive to early and middle Mesolithic hunter-gatherer-fishers, roaming the landscape along channel margins in search of resources.

From the Neolithic a dense alder carr environment dominated and thick peat deposits accumulated. The forest (alder carr) was wet and impenetrable. However, the channels flowing across this landscape would have possibly acted as open corridors along which people could have traversed the floodplain. Although assemblages of palaeo-environmental remains tend to be dominated by alder in the Neolithic to Bronze Age peat, the evaluation has shown that the pollen assemblage has different characteristics at each of the sites examined. This indicates that pollen and botanical evidence from different parts of the floodplain landscape is needed in order to reconstruct the prehistoric environment the peat represents.

From the Late Bronze/Early Iron Age onwards the landscape consisted mainly of open mudflats to water meadows, which would have been prone to episodic overbank flooding. In historic time this land may have been used as pasture, and sometimes was reclaimed by making up the surface of the ground with domestic and industrial waste.

4.3 Significance

The geoarchaeological samples obtained from the sites provide information about the floodplain environment from the early Holocene onwards. The deposits sampled preserve pollen, ostracods, foraminfera and diatom assemblages that document the changing landscape and possible human activities on this part of the East Thames River floodplain. By taking advantage of the strengths of the different micro-fossils preserved and of the opportunity to compare evidence from different localities along the DLR route, the information available from the core samples taken from the DLR sites could be of local to regional significance, in providing a landscape context for past human activity.

5 Recommendations

Geoarchaeological evaluations often look at discrete sites, but in order to understand past landscape evidence from individual sites the information needs to be synthesised and placed in a wider landscape context. Because of the linear nature of the DLR route, the three sites examined as part of the present project provide an opportunity to examine a tract of the floodplain from the Isle of Dogs to Canning Town.

The evaluation has shown that good potential for microfossil analysis exists in the core samples from Delta Junction and Canning Town. In particular, further pollen analysis, might provide a better understanding of the contrasting contemporary environments represented by the Neolithic to Bronze peat. This local variation in vegetation cover is likely to have been significant to the Prehistoric inhabitants of the area and might be explained by differences in the underlying topography and other factors such as distance from the river. These factors might be better understood by improving on the deposit modelling undertaken for the evaluation. The results of the evaluation and of any further analysis undertaken are likely to be of use and interest to archaeologists working on the floodplain of the East London Thames, as although much work is done by geoarchaeologists and environmental archaeologists in this area, it is rarely published and the emerging picture therefore little known.

It is therefore recommended that the deposit model produced for this evaluation is refined, if possible, by the inclusion of any additional borehole data held by the DLR and that limited additional pollen analysis of the cores from Delta Junction (DJD08) and Canning Town (CAJ08) is undertaken. A small number of additional radiocarbon dates would also help provide a secure temporal framework and a better understanding of the significance of the past environments represented in terms of their regional context. The results of the evaluation and this further work should be made available by their publication in a local journal (London Archaeologist or LAMAS).

The core samples obtained from the evaluation will be held in the MOLA store until a decision has been made on whether they are required for further analysis.

6 Acknowledgements

The author would like to thank: PJ Drilling and Taylor Woodrow for their onsite work; Dr Mike Morley, Tom Hoyle and Jason Stewart for the on and off site recording and labwork; Dr Nigel Cameron, Dr Rob Scaife and Dr John Whittaker for specialist work and advice; Judit Pereztegi for work on the Figs; Jane Corcoran for geoarchaeology advice; and Stewart Hoad for overall project management.

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8 Appendix:

8.1 OASIS DATA COLLECTION FORM

OASIS ID: molas1-65030

Project details

Project name	Docklands Light Railway 3-Car Capacity Enhancement South Quay Canning Town Flyover Delta Junction Report
Short description of the project	This report presents the results of a geoarchaeological evaluation carried out by the Museum of London Archaeology (MoLA) at the Delta Junction, South Quay and Canning Town sites of the DLR 3-Car-Capacity Enhancement scheme. This work has been commissioned from the Museum of London Archaeology Services by Taylor Woodrow (on behalf of Docklands Light Railway). The Evaluation involved the monitoring of purposive geoarchaeological boreholes, which confirmed that deposits of palaeo-environmental interest exist between about 3m OD and -3m OD. These deposits will be subject to impact by the piled foundations of the proposed development and the purpose of the evaluation was to obtain geoarchaeological records and samples for off-site examination. Deposit modelling and the integration of specialist palaeo-environmental data shows that at the base of the Holocene deposits lies the Late Devensian Glacial formation of the Shepperton Gravels. These are overlain by Early Holocene banked sands that stabilised to form short lived Mesolithic landsurfaces. Silty clays and peats mark the inundation affects of relative sea level rise from the Early Neolithic to the Bronze Age. Towards the west these dense wooded environments were predominantly freshwater but became slightly brackish to the east of the route with the onset of tidal access. From the Iron Age onwards silty clays dominate as grass and herb fen mudflats form and brackish marine conditions move westwards and a full estuary environment is indicated to the east. At this time evidence suggests cereal cultivation and pastoral activities to the margins of this environment.
Project dates	Start: 16-06-2008 End: 01-09-2009
Previous/future work	Yes / Not known
Type of project	Field evaluation
Site status	None
Current Land use	Transport and Utilities 2 - Other transport infrastructure
Monument type	BURIED LAND SURFACE Mesolithic

Project location

Country	England
Site location	GREATER LONDON TOWER HAMLETS POPLAR Docklands Light Railway 3-Car Capacity Enhancement South Quay Canning Town Flyover Delta Junction
Postcode	E14
Study area	2.00 Kilometres
Site coordinates	537488 180566 537488 00 00 N 180566 00 00 E Point
Site coordinates	539585 180995 539585 00 00 N 180995 00 00 E Point
Site coordinates	537689 179792 537689 00 00 N 179792 00 00 E Point
Lat/Long Datum	Unknown
Height OD / Depth	Min: -3.77m Max: -0.10m

Project creators

Name of Organisation	MoL Archaeology
Project brief originator	Docklands Light Railway
Project design originator	Taylor Woodrow
Project director/manager	George Dennis
Project supervisor	Stewart Hoad
Type of sponsor/funding body	Taylor Woodrow Developments Limited and George Wimpey South London Limited

Project archives

Physical Archive Exists?	No
Physical Archive recipient	LAARC

Digital Archive recipient	LAARC
Digital Archive ID	SQS08 CAJ08 DJD08
Digital Media available	'Database','GIS'
Paper Archive recipient	LAARC
Paper Archive ID	SQS08 CAJ08 DJD08
Paper Media available	'Notebook - Excavation',' Research',' General Notes'

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	Docklands Light Railway 3-Car Capacity Enhancement South Quay Canning Town Flyover Delta Junction Report for Geoarchaeological Evaluation
Author(s)/Editor(s)	Yendell, Y.
Date	2009
Issuer or publisher	MoLA
Place of issue or publication	London
Description	Report for Geoarchaeological Evaluation

Entered by	Virgil Yendell (vyendell@molas.org.uk)
Entered on	1 October 2009

Fig 1 Location of geoarchaeological boreholes

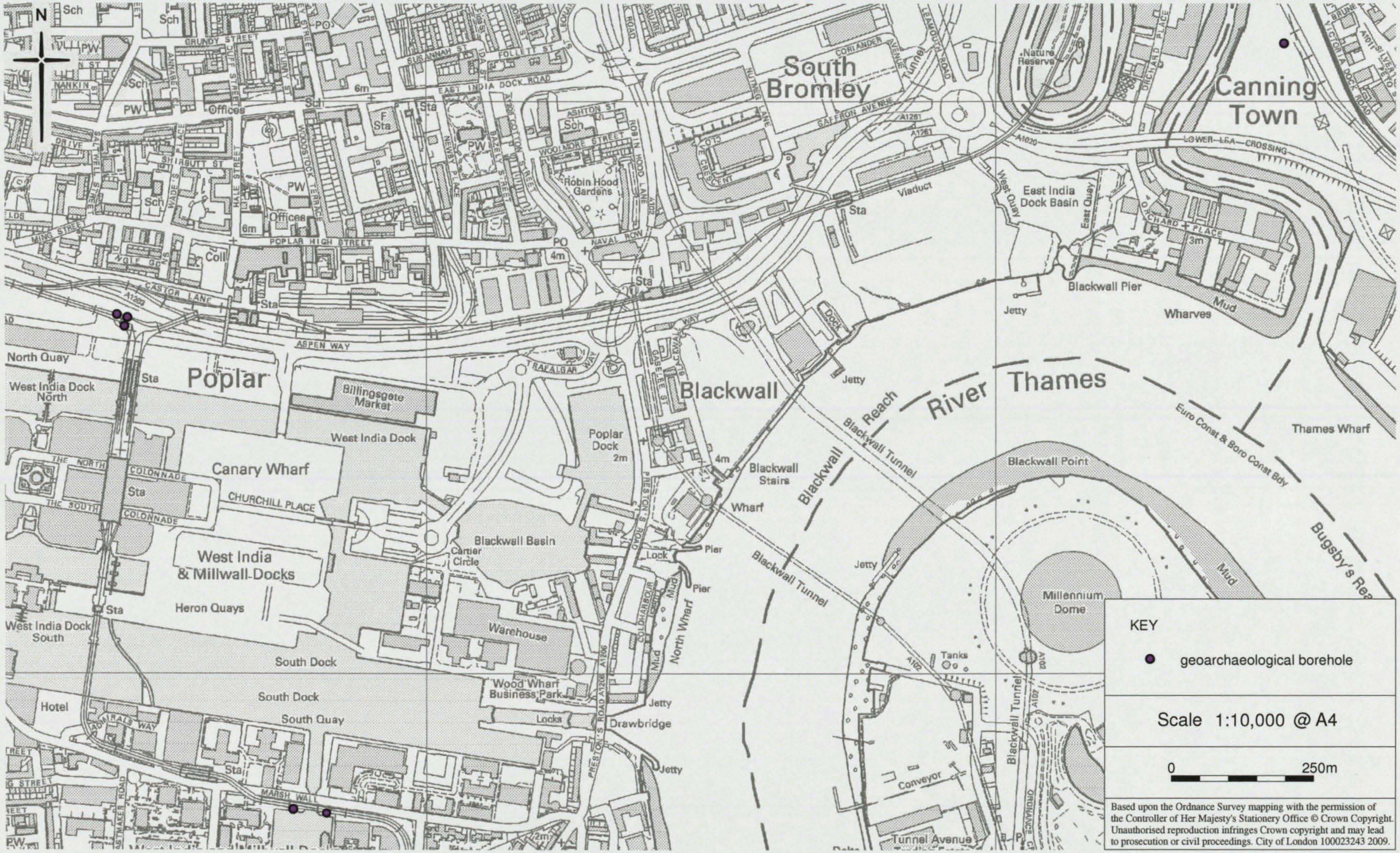
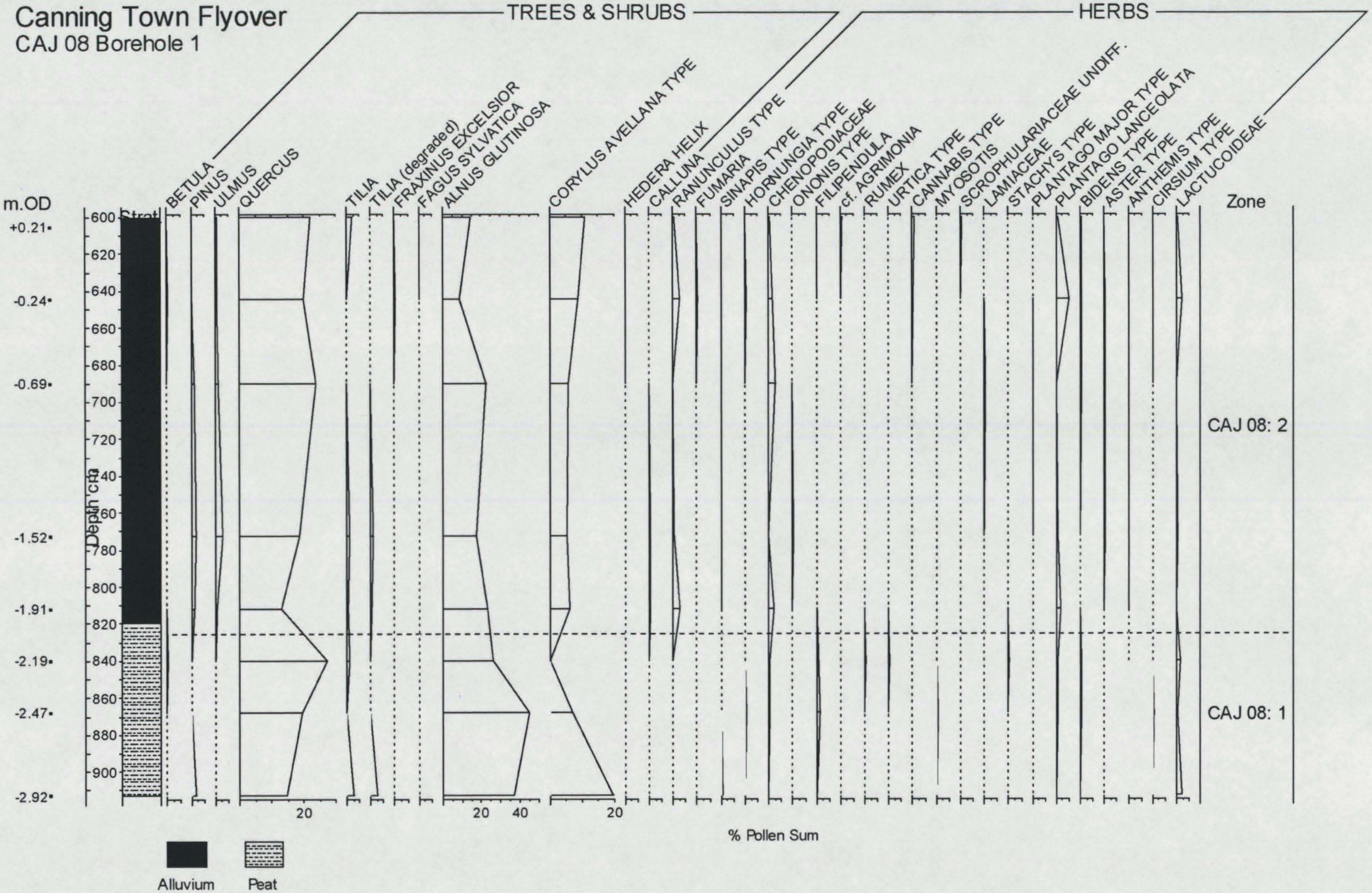


Fig 2 Location of geoarchaeological boreholes



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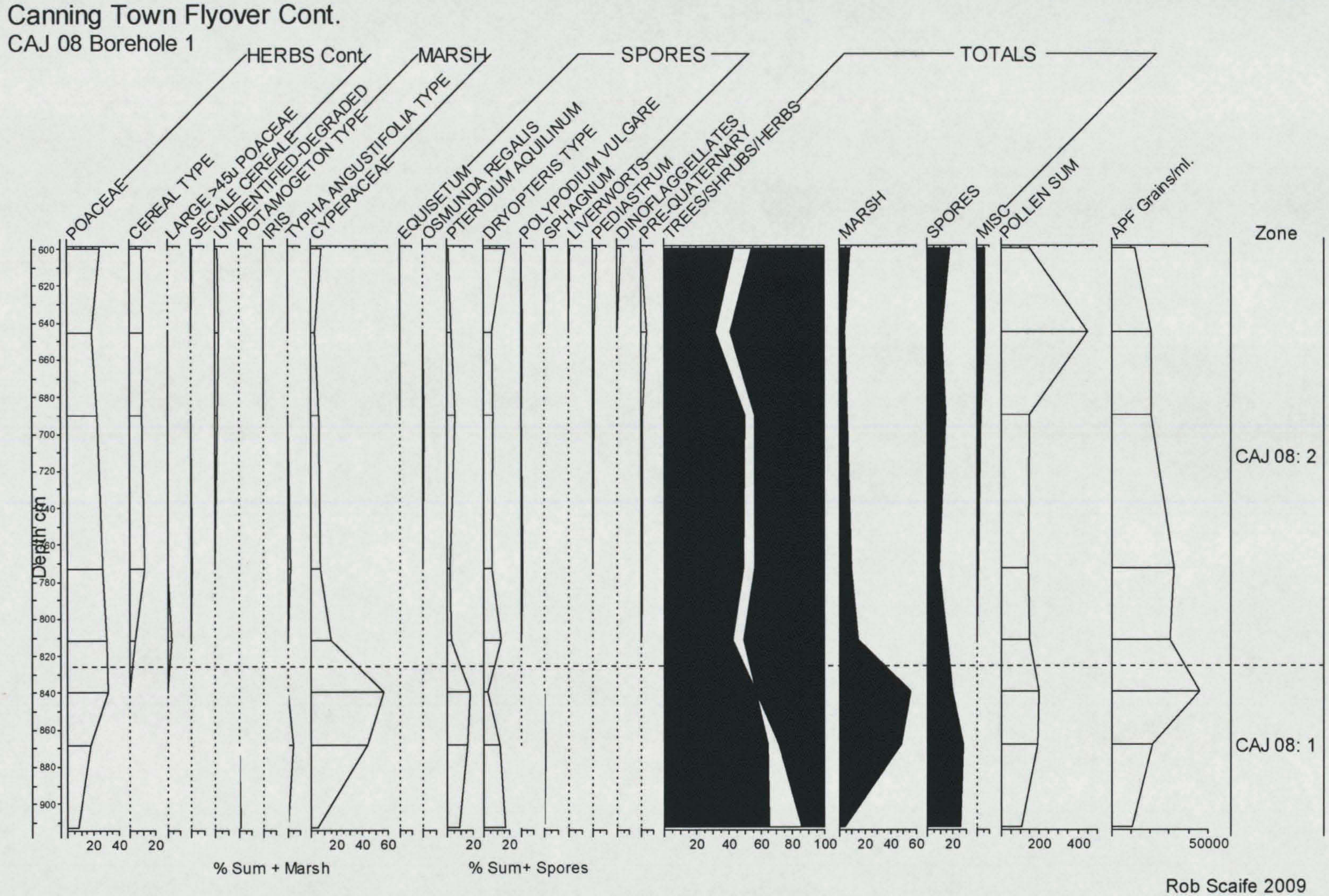
Georchaeological Evaluation MOLA 2009

Fig 3 Pollen Diagram: Canning Town BH1



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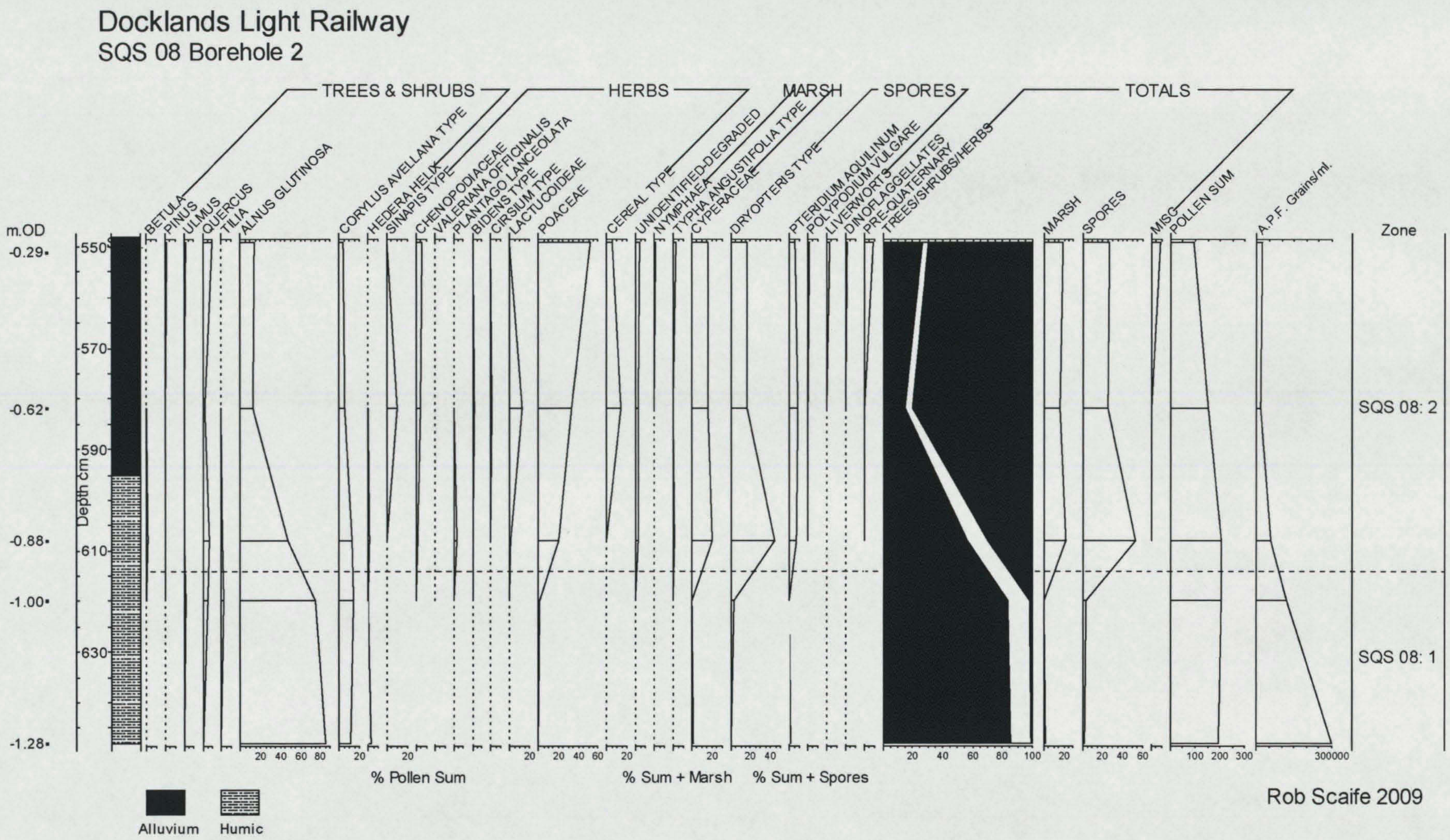
Geoarchaeological Evaluation MOLA 2009

Fig 4 Pollen Diagram: Canning Town BH1 (continued)



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Geoarchaeological Evaluation MOLA 2009

Fig 5 Pollen Diagram: South Quay BH2

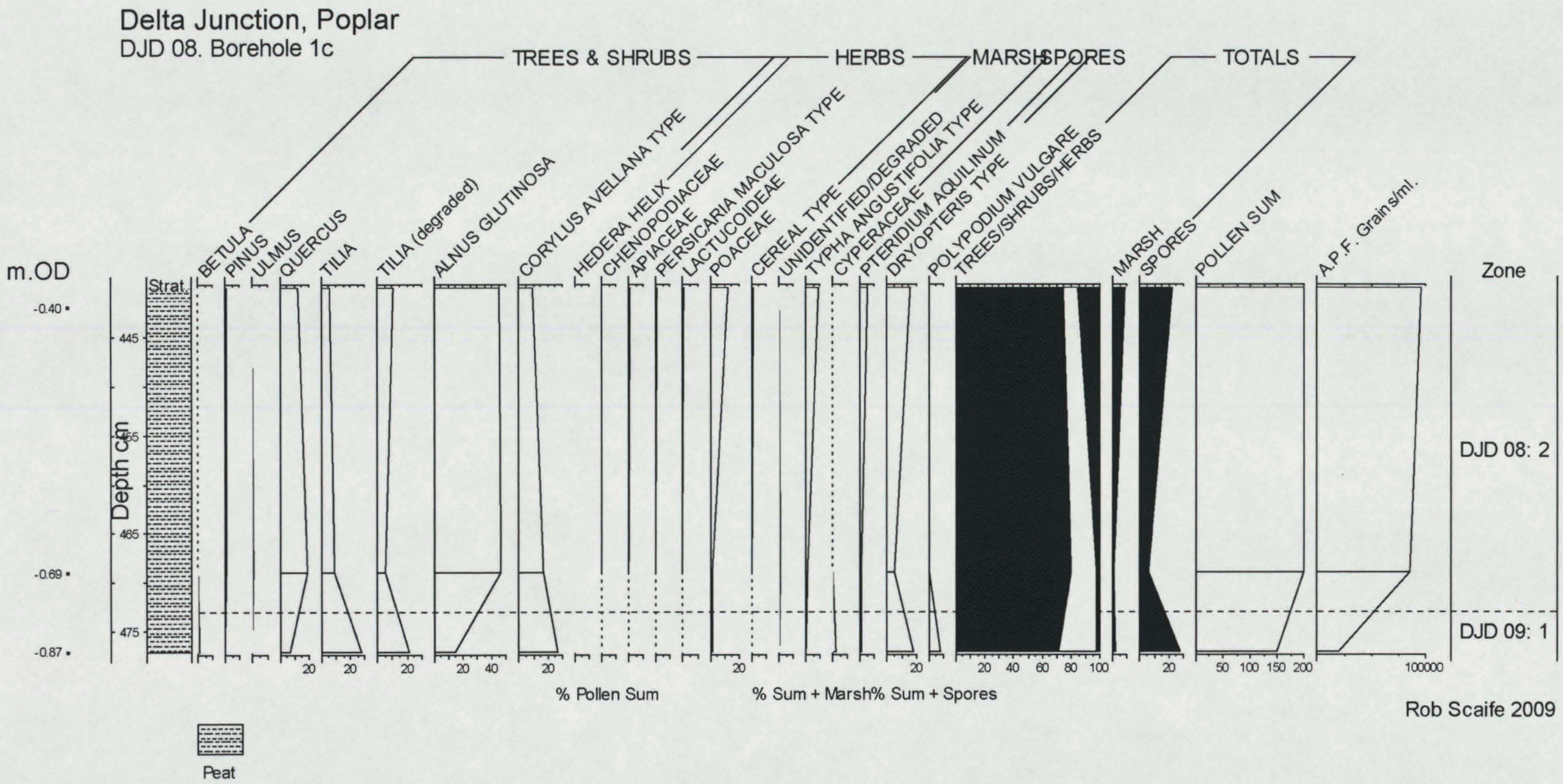

Fig 6 Pollen Diagram: Delta Junction BH1c

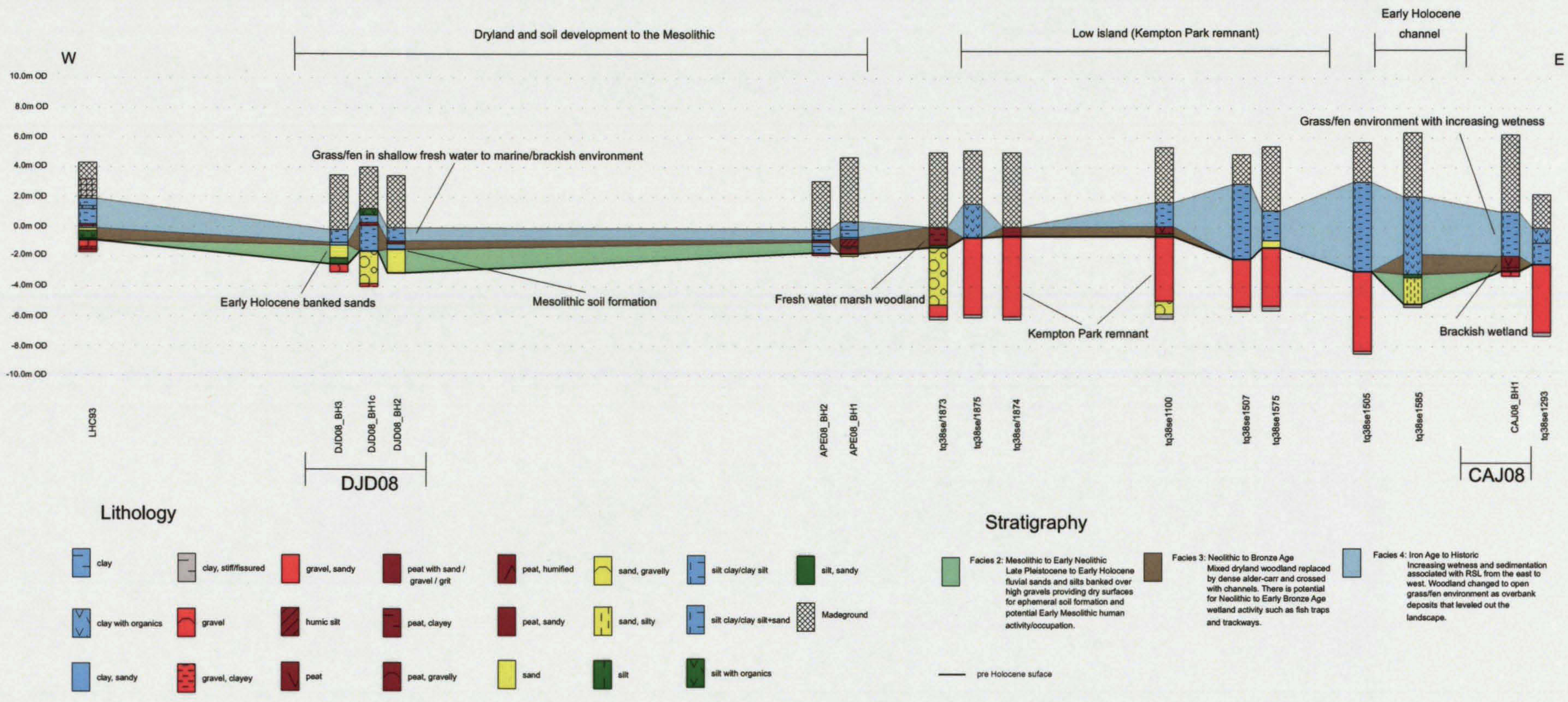

Fig 7 Transect 1: Northern west to east transect

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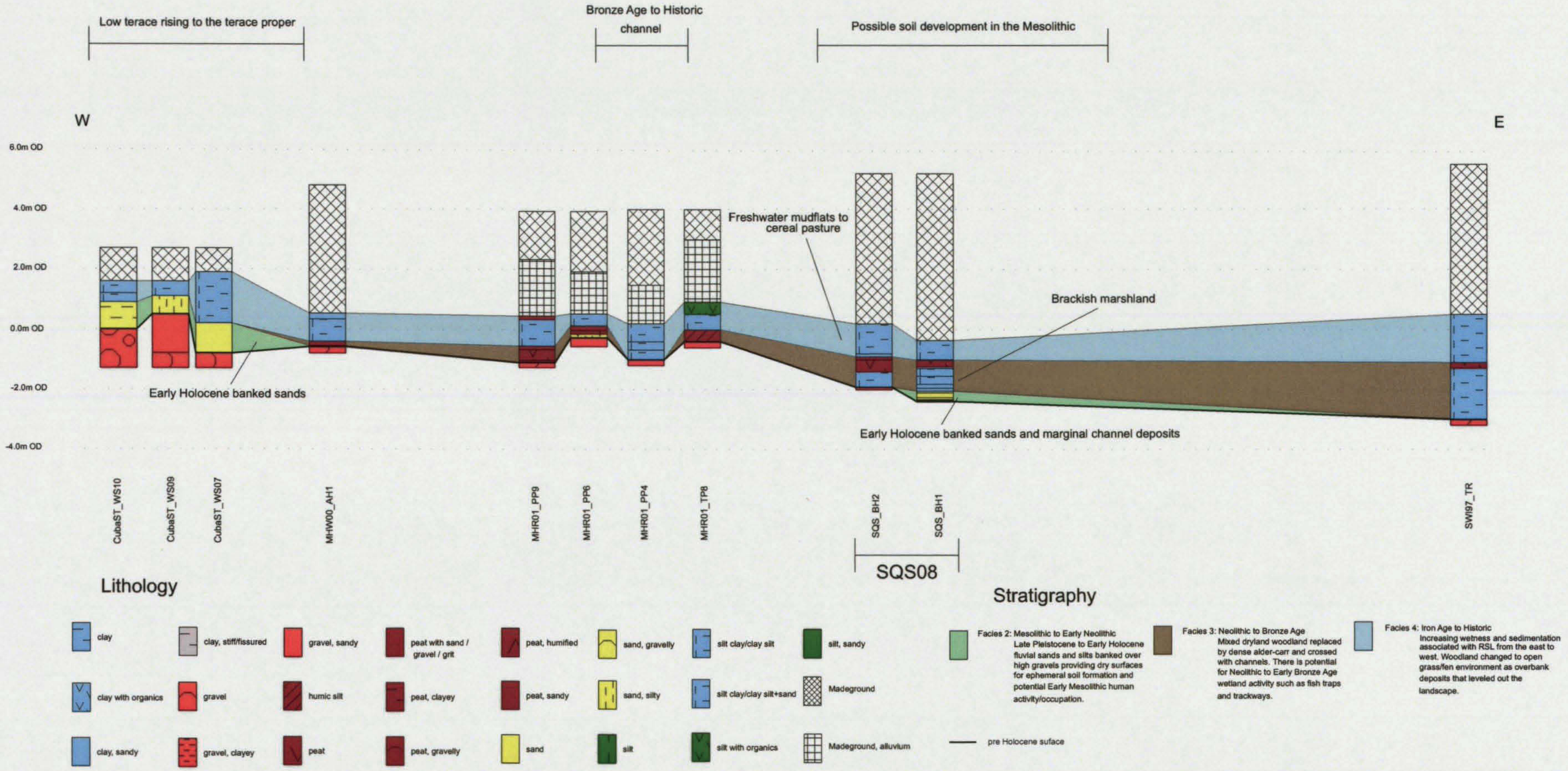

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Fig 8 Transect 2: Souththern west to east transect

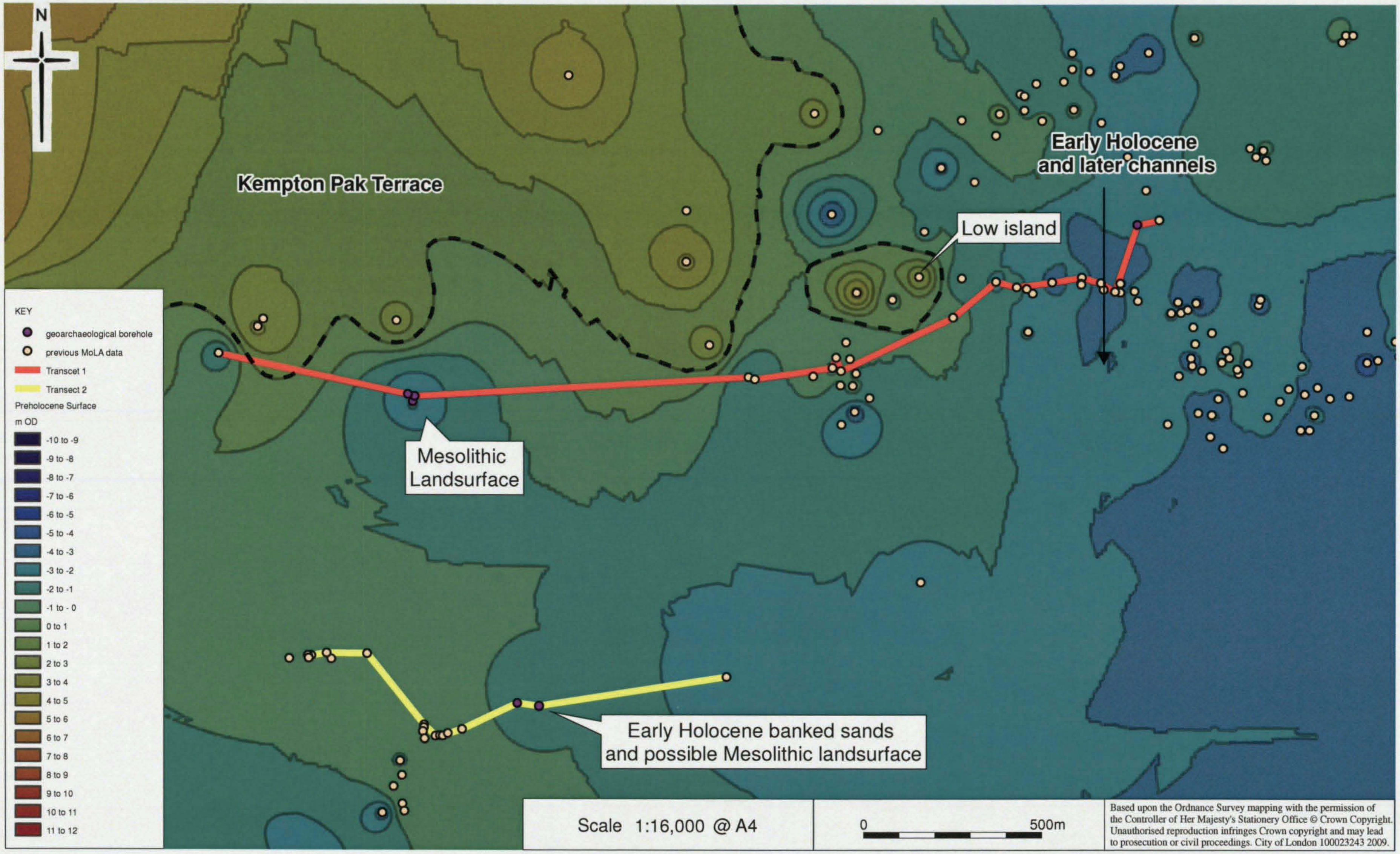

Fig 9 Pre Holocene surface and transect locations