NEWHAM (NE)

CATN
907/

Canning Town Limmo Site

Archaeological Field Evaluation 1993

OXFORD ARCHAEOLOGICAL UNIT

CANNING TOWN LIMMO SITE

ARCHAEOLOGICAL FIELD EVALUATION 1993

A report on the evaluation undertaken between 29/11/93 and 10/12/93 at the Limmo site, Canning Town, London E16.

NGR TQ 395811

Oxford 8/2/94

List of contents **Page No.**

List of illustrations

Appendices

Acknowledgements

The Oxford Archaeological Unit would like to thank Ian Robertson and Bill Pomeroy of the Jubilee Line Extension team for their help and persistence in setting-up and running what was never a straightforward project. We are also grateful to Mike Hutchinson (Museum of London) for visiting and commenting on the site, and for the help and support of Martin Bates, Chris Pine and Tony Barham of the Geoarchaeological Service Facility.

1 Summary

Archaeological field evaluation by trenching and boreholes revealed a complex stratified sequence comprising, in order of deposition: Thames Gravel, peat and organic silts, organic sands and silts/silt clays, upper clay silts, and made ground. The total depth of the sequence is up to 6.4 m. The deposits, particularly the peat and organic silts, have considerable archaeological potential in that it will be possible to analyse the samples taken and build up a detailed picture of past habitats in the area, as well as add to our understanding of the palaeoenvironment of the Lower Thames. Recommendations for a two-stage programme of analysis are made (Section 8).

2 Introduction and aims

2.1 Introduction to the evaluation

The Oxford Archaeological Unit (OAU) undertook a field evaluation at the Canning Town Limmo site, London E16, on behalf of the Jubilee Line Extension team (JLE) from London Underground Limited (LUL). Archaeological fieldwork began on the 29th of November 1993 and finished on the 10th of December 1993. The site is located at the southern end of a narrow strip of land between the Docklands Light Railway and the North London Line (Figs 1,2), where the JLE will emerge from below a pre-laid slab which has been constructed as part of the DLR advanced works.

2.2 Aims

The following evaluation aims were proposed:

1 To evaluate whether further archaeological work, by excavation, drilling or watching brief, is likely to be required on the site.

2 To describe, record and, where appropriate, sample the stratified sequence from the upper portion of the Thames Gravel.

3 To identify and sample any deposits from which dating might be obtained.

4 To further investigate the gravel/alluvium interface.

5 To record differences in the alluvial sequence away from the large feature sampled in the 1991 evaluation.

6 To intersect, sample and date peat layers within the alluvium, assessing their potential for prehistoric and /or Roman studies

3 TOPOGRAPHY AND GEOLOGY

3.1 Topography

The area evaluated begins at the north end of the Canning Town Station site (Newham Way). From here it runs southwards for some 0.6 km, forming a narrow strip between the Docklands Light Railway and the North London Line which varies from 13 to 30 m in width. The River Lea runs just west of the strip thus defined (Fig.2).

Ground level along the strip varies from 102.18 to 102.67 m TD[1], although some of these levels may have been altered by recent works associated with construction of the Docklands Light Railway.

3.2 Geology and geomorphology

The site lies within an area of low ground in the Thames and Lea floodplain on a firm, fine-grained alluvium overlying Thames Gravel. Given that geology and palaeoenvironmental evidence form a substantial element of this study, only a brief summary is given here. Further detail can be found throughout the report, and particularly in Appendix 1.

The profile of the Thames Gravel surface varies considerably, from 96.8 m TD in the south-east, to 97.86 m TD in the north-west. In between, it reaches a height of 99.57 m TD. this information is set out in detail in Appendix 1, Fig.2. In certain locations the gravel is overlain by coarse sand (Fig.2, BH6) or by organic-rich silts/peats (Fig.2; Trench 2, BH1). All of the above stratigraphic units are covered by a deep, complex sequence of silts/silty clays, the top of which varies from 99.4 m TD to 101.47 m TD within the area of study.

1 All levels are expressed relative to Tunnel Datum (TD) which is 100 metres below Ordnance Datum.

4 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

4.1 Archaeological Background

Where alluvial deposits have been investigated within the Thames and Lea basin, peat lenses have been dated by Carbon 14 analysis from the prehistoric to the Roman period. Devoy (1979) obtained Carbon 14 dates from samples taken at Tilbury, Stone-Marsh and Broadness Marsh which dated to the middle to late Bronze Age and similar deposits have been recovered at Southwark and Lambeth. Peat layers containing plant and animal remains dating from the prehistoric period have been found in the Isle of Dogs, which are superficially similar to layers observed in the borehole survey at Canning Town Station. Sporadic recovery of prehistoric archaeological material from these deposits is known both from East London (Appendix 2, P.8) and from Southwark (Tyers 1988: 7-12).

A trench excavation at Canning Town Station carried out by the OAU in November 1991 identified the traces of an eroded ground surface at the base of the investigated sequence, which was immediately above the Thames Gravel (at 98.27m TD). Above the gravel was a deep (3 m), sequence of alluvial clay-silts which may have resulted from sedimentation within a lake or lagoon, or possibly on the margins of a tidal or frequently-flooding channel. The clay-silts were cut by a small E-W channel which is undated, although there was a strong possibility that it is post medieval or later (OAU 1991).

The potential for gaining information about palaeoenvironments was observed to be moderately high, if dating for the sequence could be obtained.

4.2 Historical Background

The limited historical sources show that until 1845 this site was open ground, being part of the Middle Marsh of West Ham. The construction of the North Woolwich Railway which opened in 1846 (along the line of the present North London Line), and the construction of the nearby Queen Victoria Dock completed in 1855, prompted the growth of industrial development on a considerable scale. The present Canning Town was built to house the growing working population.

By 1916 the site was a large yard for the Thames Iron Works, Shipbuilding and Engineering Co. (later J.C.Mare and Co.), which included an iron foundry with four blast furnaces, puddling and scrap furnaces, tinning plants, and iron and brass foundries (OAU 1993).

5 METHODOLOGY AND STRATEGY

5.1 Desk-top and research

An initial desk-top study of the archaeological implications of the entire Jubilee Line Extension was undertaken by MOL and PEM, coordinated by Environmental Resources Limited (ERL 1990). Since contracting to carry out the field evaluation, the OAU has carried out further background research, including consultation with The Docklands Museum and checking information held on the Sites and Monuments Record. In July 1993 the OAU produced a report on the industrial history and possible sources of ground contamination, which was commissioned by JLE, covering the route and worksites from Stratford to Canning Town.

5.2 Evaluation strategy

There were a number of restrictions on the type of evaluation which could be carried out at the Limmo site, as discussed in Proposal for Further Evaluation: OAU, 22/5/91. It was decided that the southern end of the site could be evaluated by a single trench, and would measure approximately 10 m wide at the top and 13 m long, excluding the assess ramp for a machine excavator. The trench was positioned in the widest area of the site (approximately 25 m) to ensure adequate clearance from the two adjacent railways and space for manoeuvring the machine excavator.

Owing to the length of the evaluation area, and because the northern area could not safely be further evaluated by trenching (as discussed in the above-mentioned document), a series of boreholes drilled to archaeological specifications were made to obtain a stratigraphic profile along the site. To obtain the best information from the drilling, the Geoarchaeological Service Facility (GSF) carried out research on the area to determine borehole positions, and took 6 boreholes down to the Thames Gravel and below (Fig. 2). Technical detail regarding the borehole survey is contained in Appendix 1.

5.3 Excavation

To acquire a complete sequence through the alluvium down to Thames Gravel it was estimated from previous JLE boreholes that a depth of 5.6 m from ground surface would be required. To comply with health and safety regulations and to ensure that the trench would in no way undermine or be hazardous to either of the adjacent railways, whilst removing the initial 2.4 m of modern overburden and alluvium the edges of the trench (10 x 13 m at the top) were battered at an angle of 45 degrees. Thereafter two shafts were excavated, both 3.5 m square and 1 metre apart, in the base of the trench leaving a clearance of a metre from the bottom of the battered sides (Fig. 3). The northern shaft was excavated to its required depth before work started on

Shaft 2 due to limited machine access, the same procedures (see below) were carried out for both shafts.

Once a shaft depth of 1.2 m had been reached a record was made of the sections before the first Mabey hydraulic frame was lowered into place. Sheet piles were sunk around the edges of the shaft, leaving a gap of 0.4 m in the middle of each profile to allow for further records to be made. When the sheet piles were in place the Mabey frame was pumped out, effectively securing the sheets from any movement. Excavation continued a further 1.2 m and this procedure was repeated. Machine excavation continued until the peat levels were exposed. Hand excavation followed, first ensuring that no further machine excavation was necessary. A small sondage was excavated in Shaft 2, in an attempt to reach gravel once all necessary recording was complete (Figure 3).

Environmental monolith (continuous undisturbed core samples) and optical dating samples were taken by staff from GSF once the trench excavation had revealed a complete archaeological profile, together with bulk samples of peat and gravel. The general excavation methods used follow those set out in the Archaeological specifications for sites east of the River Lea which can be referred to in Appendix 3, with notes attached. The site was given a site code compatible with the cataloguing system employed by the Passmore Edwards Museum: HW-SW-93 LDPEM/ACHW/139.

6 Description of stratification

6.1 Shaft 1 trench description (Fig. 4)

Compact peat (238) was identified at 96.99 m TD and continued to the extent of excavation 96.68 m TD. This was overlain by patches of a tenacious dark brown peaty clay (236), below a tenacious mid-grey clay (237) which contained rounded pebbles.

A series of alternating light grey clays and thin bands of sandy clay (235, 234, 233, 232, and 231) followed and were overlain by a succession of light grey and blueish grey clays (213 to 230); this sequence was occasionally interrupted by layers of brownish grey clay (216 and 224) and continued to a depth of 100.48 m TD. The upper layers in the sequence were observed to be thin and laminated (213).

No cultural artefacts were recovered from this phase of excavation.

6.2 Shaft 2 trench description (Fig. 5)

A rolled gravel in a grey sand matrix (269) was the lowest deposit identified in Shaft 2 at 96.20 m TD. This was overlain by a tenacious dark grey clay (268) containing shell remains. A layer of dark reddish brown peaty clay (267) containing a quantity of wood and with a thickness of 0.6 m sat above 268 and was sealed by a compact dark brown peat (262) at 98.1mTD, containing sizable pieces of wood. The described deposits all exhibit a south to north downwards slope and could possibly represent fills of a large E/W-aligned channel (266), although the evidence is inconclusive.

The compact peat (262) was overlain by a thick (>0.6m) tenacious dark blueish grey clay (265), which was overlain by a sequence of blueish, brownish and light grey clays (264, 261, 260, 259, 258, and 257) all within the range of 0.1 to 0.2 m thick. This sequence was interrupted by a thin band of light grey sandy clay (256), overlain by a light grey clay (255) 0.16 m thick; sandwiched between a similar band of sandy clay (254). The sequence continues with concurring characteristics to a depth of 100.61 m TD.

No cultural artefacts were recovered during this phase of excavation.

6.3 Upper stratification description (Shaft 1 and 2)

The sequence of clays observed in Shafts 1 and 2 continued and layers 213 and 239, previously described were overlain by a mid grey clay (212). This was cut by a possibly linear ditch (208), filled by a dark reddish brown clay (207) which contained plant matter. The cut was disturbed by a more recent pipe trench (211) and layers of make-up (209), below a mid-grey clay, (205). Railway lines were laid on the surface of 205. This was overlain by a series of make-up layers (204, 203, 202 and 201) below the present ground surface (200) at 102.65 m TD.

19th and 20th century brick was recovered from the make-up deposits during this phase of excavation.

6.4 **Stratification recorded from the borehole survey** (by Martin R. Bates et. al.)

The stratigraphic sequences discussed below have been identified after careful study of the borehole logs and the extruded sediment cores. The interpretation of the sequences has been based on consideration of the sediment parameters in conjunction with the nature of the included biostratigraphic data (e.g. molluscs, plant fragments etc) and the topography and three-dimensional relationships between the different boreholes and units.

Seven major stratigraphic units can be identified in the boreholes. This classification may require further revision should further laboratory-based analysis of the material take place. The major stratigraphic units are described in order of deposition and readers are referred to the schematic cross-section presented in Appendix 2, Fig. 2.

1 *Basal gravels*

These deposits are recorded as dark grey to brown, poorly sorted, coarse and angular flint gravels with, in places, a sandy matrix. This unit is present at the base of all boreholes and represents the topographic surface on which the organic sequences were deposited. In places the upper part of the gravel sequence appears to contain some organic material. This may however be a result of mixing of sequences during drilling rather than a real sedimentological feature.

2 *Coarse sands*

This unit is only present in Borehole 6 where it appears as a well-bedded coarse to medium sand with variable amounts of organic and shell material. In places it appears that the sand has been rooted.

3 *Organic-rich silts/peats*

These deposits are only present in Borehole 1 but have been observed and sampled in detail in Trench 1 (see above and Appendix I.V). The sequence varies from a woody highly organic rich silt or peat to well-bedded silts with a significant organic content. The sequence is not compact or dense and identifiable plant material is present. In the remaining boreholes this unit is missing but the base of Unit 4 (see below) shows an increasing organic content with the underlying sediments.

4 *Silts/silty clay*

This unit shows considerable variation throughout the profile and is present, with the possible exception of Borehole 3, in all boreholes. Typically, the unit appears to become coarser with depth and bedding and laminations appear to increase in frequency with depth. The unit becomes drier and more compact towards the lower contact and organic material including *Phragmities* sp. and molluscs are present sporadically throughout the unit. Occasional sand lenses are noted throughout the sequence.

5 *Soft black silt-clay*

This unit is present in Boreholes 1 and 4. Typically the unit is very soft, unconsolidated and contains organic material (e.g. *Phragmities* sp.).

6 *Fine mid-grey clay-silt*

This unit occurs in Boreholes 5 and 6. Typically hard, compact and possessing a possible ped structure this unit contains terrestrial molluscs and is heavily rooted. Iron staining is noted. In Borehole 323 the equivalent unit was noted to contain frequent fissures.

7 *Made ground*

For a description of this unit see 6.3 (above).

The data observed from a study of the borehole logs and field data has been confirmed by the examination of the extruded cores. Additional detail was noted during the cleaning and description of these cores and a detailed record of each core is archived in Appendix III. Two cores were examined in detail to illustrate some of the characteristics of the sequence and after cleaning each core was sliced at (typically) 1 cm intervals. Individual sub-samples were bagged separately and are available for microfossil analysis. Each core was then X-rayed and examined.

Borehole 1, 4.50 - 4.95 m (depth from ground level)

This core samples the organic-rich silts and peats at the base of the sequence (Unit 3 above). Visual description of the core indicated a high degree of stratification towards the base of the core. The X-radiograph (Appendix 1, Plate 1) illustrated the bedded nature of this part of the sequence. Textural variations between 20 and 25 cm on the x-radiograph were not visible in the preliminary stratigraphic description of the core.

Borehole 4, 3.8 - 4.25 m (depth from ground level)

This unit (unit 4 above) appeared well-stratified after cleaning. Observation of the X-radiograph (Plate 2) indicates that the core is very well laminated and that there appear to be repetitive cycles culminating in the deposition of a coarse sand. The sediment immediately below the sand appears dense with close-set wavy laminae. In places deformation to the laminae has been noted.

It is clear from the study of the borehole and extruded core data that a series of stratigraphic units are present that, in some places, exhibit a high degree of stratification and that post-depositional disturbance through sediment deformation or bioturbation appears minimal. Examination of core 4.5-4.95 m from Borehole 1 indicates the location of likely breaks in deposition or unconformities. A major break in sedimentation, accompanied by a substantial phase of erosion was clearly seen in Trench 2 where the upper surface of the peat exhibited pitting (in places the entire thickness of peat had been removed).

The observations made during the recording and sampling of Shafts 1 and 2 (Trench 2) confirm the observations made from the study of the drill cores (Appendix V). Large samples were recovered during the fieldwork and will provide adequate samples for both plant macrofossil investigation and Carbon-14 dating.

6.5 Sampling

Details of the samples taken from both the boreholes and the trench excavation are contained in Appendix 1, pp. 32ff. The samples from the boreholes are U4/U100 cores, 0.45 m long. Samples from the trench comprise environmental monoliths (making up a continuous record throghout the sequence), C14 dating samples, Optical Luminescence dating samples and bulk peat and gravel samples.

7 Discussion

7.1 Reliability

During excavation the site remained fairly dry, until the final metre of machine excavation, which significantly weakened the alluvium seal above the water table. This did not reduce the level of recording for the upper layers, but created problems during the recording of the lower alluvium and peats. A pump was used to keep water levels to a minimum, but a level of 0.4m of water remained at the NW-end of Shaft 2, and sample holes through the peat in Shaft 1 filled with water. Although the lower layers were recorded adequately, these conditions made it impossible to completely expose the layers of peat in both shafts and maintain a safe working environment. A small sample excavation through the lower alluvium and peat down to Thames gravel was carried out at the south-east end of Shaft 2 (Fig. 5), to complete the recording of the sequence.

7.2 Discussion of the stratigraphy

The numbers given after the sub-headings refer to the Units described in 6.4 (above) and to the context numbers from the trench excavation (6.1-6.3) and Appendix 2)

7.2.1 **The gravels** Unit 1; 269

The Thames Gravel at the base of the examined sequence showed considerable variation in height, reaching a high of 99.57 mTD in Borehole 2 and a low of 96.2 mTD in Trench 2 (Shaft 2). The lower measurement clearly coincides with the occurence of peat and organic silts (Appendix 1, Fig.2). Gravel deposition is likely to have occurred in the late Devensian (15000 - 10000 years BP) under high-energy braided channel conditions which would account for the variations in surface level. In general, the data suggest that the topography of the gravel had an important influence on the remainder of the sequence.

7.2.2 **Peat and organic silts** Unit 3; 236, 238, 262, 267

The presence of wood-rich peat and organic silts in Trench 1 and Borehole 1 represents the most successful part of the fieldwork. These deposits will have formed on land, in an area of damp or wet ground, representing a major change from the fluvial regime in which the gravels were deposited. Other important points are the fact that the peat occurs at a low point in the gravel, perhaps part of a wide, shallow 'channel' or 'pond', and that the surface of the peat is clearly eroded, indicating that it is a remnant of a more extensive deposit.

No archaeological material (i.e. artefacts or bone) was recovered from the peat or organic silts but this is unsurprising in the circumstances. Firstly, the excavated sample was necessarily small, and secondly the favoured places for human acitivity would probably be on the slightly higher and drier ground from whence the peat has since been eroded. Examples can be cited to show that this is not an uncommon situation: peat deposits exposed in Southwark and Lambeth were also usually eroded and rarely contained archaeological material (Tyers 1988: 7-11).

The dating of the peat deposit from Canning Town will be a key factor in understanding the stratified sequence. Peats examined both upstream (Southwark and Lambeth, Tyers 1988) and downstream (Tilbury, Devoy 1979) have been ascribed to a regression event termed 'Tilbury IV', by virtue of their broadly contemporaneous radiocarbon dates. The dates obtained suggest the event took place in the middle to late Bronze Age (c. 1500 - 1000 BC) and the regression is normally explained as the result of a drop in sea-level. Two samples from the Canning Town peat are currently being dated to see if they fall within the same range. It will also be desirable to select further samples for dating from various points throughout the peat, including dendrochronological dates from the larger pieces of wood, to gain an idea of how long it took to form. Relatively little of this kind of research has been undertaken in the lower Thames area.

The peat has further potential for analysis in that it certainly contains molluscs and plant remains, and is also likely to contain pollen, diatoms and ostracods, although this requires further assessment (Appendix 1, p.21). It may well be that sufficient material is present for laboratory analysis to provide important information as to the surrounding habitat(s) which existed during the formation of the peat.

7.2.3 Organic sands and silts/silt clays Units 2,4,5; 212-235, 237, 239-261, 263-265

Both of these types of deposit appear to represent the return of fluvial conditions, on both sides of the highest gravel point in Borehole 2. Fining upwards into clay and clay-silts points to a gradual decrease in energy levels, and this may be associated with a shift from fluvial deposition to sub-tidal conditions - analysis of diatom flora within the sediments could be used to detect this change.

In general these deposits have moderate to high biostratigraphic potential, and could be used to further understanding of the habitat development. Some dating should also be possible either using the organic content of the layers for radicarbon dating, or by employing Optical Luminescence dating, which is possible due to the presence of a sand fraction.

7.2.4 Upper clay-silts Unit 6; 205

This unit of deposition, which lies immediately below definite made ground, gives some cause for concern as to whether a satisfactory interpretation has been arrived at. Bates et. al. (Appendix 1, p.17) see the unit as a palaeolandsurface of unknown age, but possibly prehistoric. Another possibility, however, is that the deposit was laid down much later in association with industrial activity in the area. A key to the proper understanding of this part of the sequence will clearly be the dating of the deposits below, as suggested in 7.2.2 and 7.2.3. Whatever the interpretation in terms of age, the unit clearly represents a return to dry, sub-aerial conditions.

It should also be noted that if this deposit is ancient, it has been subject to considerable subsequent disturbance from the construction and use of the Thames Iron Works (OAU 1993). The railway lines found on the surface of layer 205 can be clearly identified as part of the Iron Works, as they are shown on a map of 1916.

8 Recommendations for further work

The evaluation work at the Limmo Site, taken together with the 1991 evaluation at Canning town Station (OAU 1991), has revealed a stratified sequence of considerable potential for our understanding of the past environment at the junction of the Rivers Thames and Lea and, to a lesser extent, of the lower Thames generally. Two qualifying factors which must be taken into account are the lack of archaeological material and the local aspects, particularly the topography of the underlying Thames gravel, which have strongly influenced the stratification. An advantage of the data from the evaluation is that we now have sequences from two trenches which are linked by a number of boreholes, and it is quite clear that this has considerably aided interpretation, and will continue to do so during further analysis. The use of boreholes as an evaluation technique for these kind of deposits has been more than vindicated by the results. In addition to the value of the data recovered, we should also consider the intensity of development in the area concerned (DLR, JLE, Lower Lea Crossing etc) which either has or will lead to destruction of a high proportion of these archaeologically valuable deposits.

In general, it is not considered necessary to return to the site for further specifically archaeological fieldwork, i.e. evaluation or excavation. However, given the presence of, in particular, the peat deposits and the possible landsurface (7.2.1, 7.2.4), it is recommended that a watching brief should be carried out during below-ground construction at both the Limmo and Canning Town Station sites. It is envisaged that there may well be opportunities during this watching brief to record further palaeoenvironmental evidence and to take further samples, and in this case allowance will need to be made for analysis of this material.

Regarding the data already gathered from the 1991 and 1993 evaluations, it is clear that there is sufficient potential to justify further analysis and publication of the results. It is proposed that this would take place in two stages:

Phase I Description and photography of all material from trench excavations

Sub-sampling of selected cores, X-radiography and preliminary sedimentological analysis

Preliminary assessment of plant macrofossil, molluscan, pollen and diatom content

Establishment of dating framework by OL and C14 dating (NB results of first two evaluation dates on peat deposits are expected late February)

Phase II Detailed study of core material leading to the development of a full sedimentological facies model

Construction of detailed pollen and diatom diagrams

Further dating as required to refine sequence

Publication of results including full discussion of results in the context of other palaeoenvironmental work in the area[2].

It is important to note that some deterioration of samples has already been detected, and in order to prevent this from progressing further Stage I work should begin as soon as possible. Subject to an initial agreement in principle of the need for this work, the OAU would provide a detailed costed programme for Stage 1, and an outline programme for Stage 2.

David Wilkinson and Rob Early
OAU 1994

---

2 Discussions with James Rackham (then of the Greater London Environmental Archaeology Service) before fieldwork began in 1991 led to the production by Rackham of a document outlining the palaeoenvironmental potential of the Jubilee Line Extension Project. Phases I and II (above) would fulfil the kind of work envisaged by Rackham, thus enabling the results to be compared, contrasted and discussed in the light of other JLE archaeological sites.

Appendix 1 **A report on the stratigraphy at the Canning Town site, Jubilee Line Extension Project, by Martin R. Bates, Christopher A. Pine and Vaughan D. Williamson of the Geoarchaeological Service Facility.**

FOR THE ATTENTION OF THE OXFORD ARCHAEOLOGICAL UNIT

A REPORT ON THE STRATIGRAPHY AT THE CANNING TOWN SITE, JUBILEE LINE EXTENSION PROJECT

MARTIN R. BATES, CHRISTOPHER A. PINE and VAUGHAN D. WILLIAMSON

DEPARTMENT OF HUMAN ENVIRONMENT,
INSTITUTE OF ARCHAEOLOGY,
UNIVERSITY COLLEGE LONDON,
31 - 34 GORDON SQUARE,
LONDON, WC1H OPY.

January 14th 1994

GEOARCHAEOLOGICAL SERVICE FACILITY
SITE ASSESSMENT REPORT 94/01.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

1. INTRODUCTION

This work was undertaken by the GSF for the Oxford Archaeological Unit (OAU) at the request of project manager Mr. Dave Wilkinson. Previous work by the GSF in the area to the east of Victoria Dock Road was summarised in a letter to the OAU on 13th March 1993. The discovery of well stratified clay-silt and peat sequences overlying gravels at this site indicated that further work was necessary in the area to be occupied by the new station. The assessment objectives (see 1-3 below) were submitted to the OAU on the 7th April 1993. These objectives were accepted and the fieldwork was undertaken during December 1993. This report summarises the data recovered from the field and preliminary laboratory work (Section 4.0), discusses the results and addresses the objectives set out in the project brief (Section 5.0) and makes recommendations for further possible work on the recovered material (Section 6.0).

All sample material taken from the boreholes is currently stored under controlled conditions in a cold store in the Wolfson Archaeological Science Laboratories at the Institute of Archaeology. The storage conditions are designed to minimise sample deterioration and retard growth of bacteria, fungi etc. However rapid decisions regarding future work (see Section 6.0) and processing of the samples are necessary as significant mould growth on the cores has already been noted despite storage of samples in cool, light tight conditions. Bacterial degradation may prejudice both ^{14}C dating and microfossil preservation.

The following objectives were set in the project brief:

1. To establish the lateral extent and variability of the organic silt/peat horizons identified during previous work.

2. To recover suitable undisturbed samples for subsequent palaeoenvironmental analysis (e.g. ^{14}C dating, molluscan analysis, pollen/diatom assessment).

3. To develop a model of variability in the three-dimensional surface of the underlying gravels, which could be of critical importance to both modelling the variation in position of the Bow Creek channel and the likely occurrence of archaeological occupation sites in the area.

These objectives can be simplified:-

i. Are the sequences well stratified?

ii. Are they likely to contain biostratigraphic material suitable to formulate high resolution palaeoenvironmental sequences?

iii. Are there indications within the sequences of palaeolandsurfaces and palaeotopography?

iv. Is there suitable material within the samples for dating (e.g. ^{14} C and OL (Optical Luminescence -Aitken, 1992) dating)?

v. Are the sequences similar to others observed in the area?

vi. What is the likely archaeological potential and significance of the sequences?

vii. What are the major environments of deposition of the sediments?

viii. Is the sequence of local (i.e. Lea Valley) or regional (i.e. Thames) significance?

ix. What are the problems relating to topographic setting, disturbance of sediments, discontinuous nature of the sequences, and lack of spatial data?

As the field project progressed and OAU trenching commenced in the vicinity of BH 1 (Figure 1) it became clear that well stratified sequences were present within the trench and that a significant increase in data recovery would be possible through careful recording and sampling within the trench. As a result the project brief was modified to allow GSF staff time and access to the trench. A full list of all samples taken and a brief description of the recorded sequences is presented in Appendices IV and V. Unfortunately, due to project brief restrictions, it was not possible to clean, record and photograph the sampled material in detail and this work remains to be undertaken. The implications of this data and future work necessary from both boreholes and trench localities are discussed in Section 6.0.

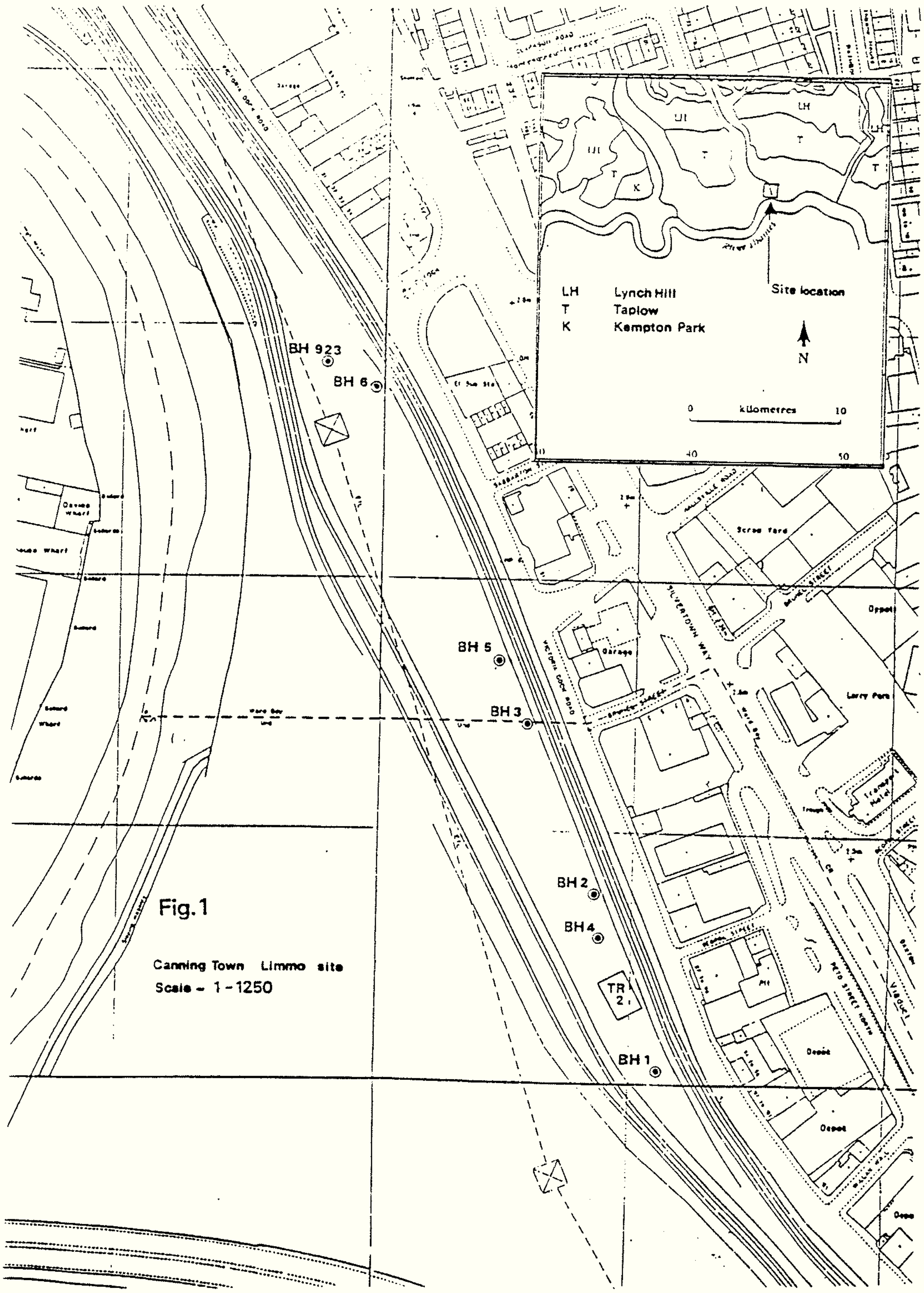


Figure 1. Site location plan showing location of boreholes and trench examined in this study. Inset: mapped sediment units in the area of the lower Lea/Thames confluence (based on Bridgland, 1994).

2.0 SITE LOCATION, GEOLOGY AND GEOMORPHOLOGY

The site lies immediately to the west of Victoria Dock Road, east of the River Lea and close to the confluence of the Lea and Thames in Blackwall Reach (Figure 1). Ground elevations are close to 5m O.D. and the area of investigation runs from north north west to south south east parallel to the line of the North London Railway.

Located close to the confluence of the river Thames with the Lea patterns of sedimentation and erosion in the area of investigation are likely to be complex and influenced by both the Thames and Lea (the contribution of the two systems to these processes is likely to have varied through time). Critically gravel deposition at the base of the sequence and the topography associated with the onset of soft sediment deposition may reflect the activity of the Thames, Lea or a combination of both. This is of considerable importance when attempting to understand the significance of the results in a regional context. Additionally the area of investigation lies within a zone of the Thames currently influenced by a tidal regime. Geomorphological processes at the site will have been sensitive to the movement of the tidal front (i.e. the limit of tidal influence) and hence considerable complexity in sequence generation in the area is likely.

The area of investigation lies entirely within ground mapped as alluvium by the British Geological Survey (see Bromehead, 1925) (Figure 1, inset). Sediments outcropping at higher elevations to the east have recently been mapped as Taplow Gravel and to the west as Kempton Park Gravel. These have been ascribed ages of immediately pre- and post-Ipswichian (sensu Trafalgar Square) age (Bridgland, 1994) (Appendix VI). Gravels underlying the sediments investigated in this study are submerged gravels likely to relate to the Devensian Shepperton Gravel of the Middle Thames area (Bridgland, 1994). Gravel deposits within the area deposited by the river Lea are poorly understood.

Gravels and associated sands and silts in the lower Thames area are frequently associated with archaeological material (e.g. Swanscombe - Wymer, 1968/Bridgland *et. al*, 1985, Purfleet - Bridgland and Harding, 1993) and both *in situ* and rolled or reworked material have been recovered. Predominantly this material is associated with the higher terraces and is of Palaeolithic type. Archaeological material from the alluvium has been noted but due to the nature of the sequences (i.e. below the watertable in many cases) extensive collection of this material has not taken place.

In and adjacent to the study area most previous geomorphological research work (Churchill, 1965; Devoy, 1979, 1982; Greensmith and Tucker, 1980; Kelsey, 1972; Shennan, 1983; 1987, 1989a and b) has focused on i) establishing regionally applicable relative sea-level curves, ii) calibrating long-term tectonic movements and iii) tying the biostratigraphic peat units into the classic Godwin pollen zonation schemes (Godwin, 1940). No studies have yet proposed either a model for the spatial distribution of Holocene intertidal lithostratigraphic units or associated palaeolandsurfaces indicated by terrestrial peat sequences buried at datums below present day high tidal datums. Dated peat horizons e.g. Tilbury IV (sensu Devoy, 1979) are sometimes correlated with other sites by inference where datums/sequences appear similar. However, given recent verification of the complex three-dimensional architecture of intertidal sediment units (Allen and Rae, 1987) and recent pollen studies illustrating that the pollen zones defined by Godwin are time diachronous (i.e. non-synchronous) over space (Bennett, 1984, 1989), it is clearly advisable to avoid chronostratigraphic correlation without well-controlled radiocarbon age-estimates for the stratigraphy and local area under study.

2.1 'Alluvial' Sediments

The term alluvium is often used rather loosely by fieldworkers and many definitions can be found in the literature. In geological and engineering reports, where the objectives of the investigation are the characterisation of the physical properties of the sediment for engineering purposes, the term is used to refer to unconsolidated clays, silts, sands and even gravels close to the modern ground surface. No inferences regarding environments of deposition are made, however it is often implied that such sediments are of recent date, i.e. belonging to the Holocene or last 10 thousand years. Others (see Wyatt, 1986) adopt a process definition and define alluvium as sediment brought down by the river and deposited on the flood-plain or in submerged areas.

It is recognised that the term alluvium, as used both by drillers, geotechnical consultants and British Geological Survey geologists encompass a wide range of sediments types, deposited over a long time range in a variety of environments of deposition ranging from fluvial to estuarine and terrestrial. Such sediments include terrestrial peats, fluvial sands and gravels and tidal/sub-tidal clays and silts. In this study the interpretation of extant data sources and the new data generated during the fieldwork is based on inferred environments of deposition (a facies-based sedimentological approach sensu Miall, 1978/Middleton, 1973), e.g. intertidal silt-clays, terrestrial peats. The tentative conclusions are predictive and require calibration thorough analysis of core material to refine facies environments of deposition and to provide independent age estimates based on radiometric (^{14}C and possibly (OL) Optical Luminescence Dating techniques).

Sections through the 'alluvium' in the vicinity of the area of investigation include exposures at the West India Docks, Green's Dock, Blackwall, Victoria Docks and Royal Albert Docks (all Whitaker, 1889). Within the valley of the Lea extensive sections were observed in the excavations for the Walthamstow Reservoir where a large mammal fauna was recovered (Bromehead, 1925). More recently an extensive investigation of borehole data from the area adjacent to the north portals of the Blackwall Tunnel has been undertaken and a complex architecture of off-lapping sequences noted (Bates and Barham, 1992). Recent work on comparable interdigitating peat and silt-clay intertidal sediments in the Severn Estuary has demonstrated that in large estuarine systems lithostratgraphic units can be mapped into discrete units and assigned formation status (Allen and Rae, 1987). No formal lithostratigraphic nomenclature has yet been assigned to the Holocene fluvial and estuarine stratigraphy for the middle or lower Thames estuary.

Archaeological material has been recovered sporadically from these sequences and include a canoe in the Albert Docks (Whitaker, 1889) and Roman pottery between 8 and 9 feet below ground surface near Ham Manor Way (Whitaker, 1889). Recent work by Shennan (1989a and b) suggests the area is a zone of net subsidence at rates of c. 1.9m/1000 years since 4000 B.P. Therefore, former terrestrial landsurfaces - and associated archaeological horizons - are likely to be well preserved in water-logged sediments within the 'alluvial' sequences in the route corridor as a consequence of relative rise in tidal datums/flood frequency over this time period.

3.0 STUDY METHODOLOGY AND RATIONALE

The project brief allowed for a maximum of six boreholes to be drilled along a transect orientated parallel to the projected path of the new rail line (Figure 1). The boreholes were to be spaced at nominal intervals of 50m along the 300m transect. All boreholes were to be drilled to a maximum depth of 10m or until gravel was encountered. Sampling of sequences was to be undertaken using U4/U100 0.45m length drill cores to produce undisturbed samples at key points in the sequence. A maximum of 20 U4/U100 cores were to be taken. Stratigraphic logging of drill cores was to be undertaken, where possible on site, and supplemented by detailed descriptions of sediment cores once extruded, in the laboratory.

In addition to the recording of the borehole stratigraphic sequences key profiles were recorded and sampled in the two shafts opened by the OAU. This did not form part of the original brief as received by the GSF and does not form a major part of this report. A full list of all samples taken from the trench is presented in Appendix IV and brief comments regarding the nature of the sequences are made in Appendix V. Comments and recommendations for further work include comments on the material and sequences from these two trenches.

Stratigraphic sequences are discussed in the section 4.0. Detailed stratigraphic descriptions for the boreholes and individual U4/U100 cores are presented in Appendix II and III. Borehole logs for the boreholes drilled by LUL contractors are presented in Appendix I.

Stratigraphic descriptions followed standard sedimentological procedures and where possible colour has been classified using the Munsell Soil Colour Chart (Munsell, 1975).

The objectives of the study were established prior to commencement of the project and were listed in section 1.0. To reiterate they were:

1. To establish the lateral extent and variability of the organic/peat horizons identified during previous work.

2. To recover suitable undisturbed samples for subsequent palaeoenvironmental analysis (e.g. ^{14}C dating, molluscan analysis, pollen/diatom assessment).

3. To develop a model of variability in the three-dimensional surface of the underlying gravels, which could be of critical importance to both modelling the variation in position of the Bow Creek channel and the likely occurrence of occupation sites in the area.

The data has been examined and a cross-section plotted (Figure 2). The sequence has been simplified to allow summarisation of the information. A full list of all samples taken during the study is presented in Table 1.

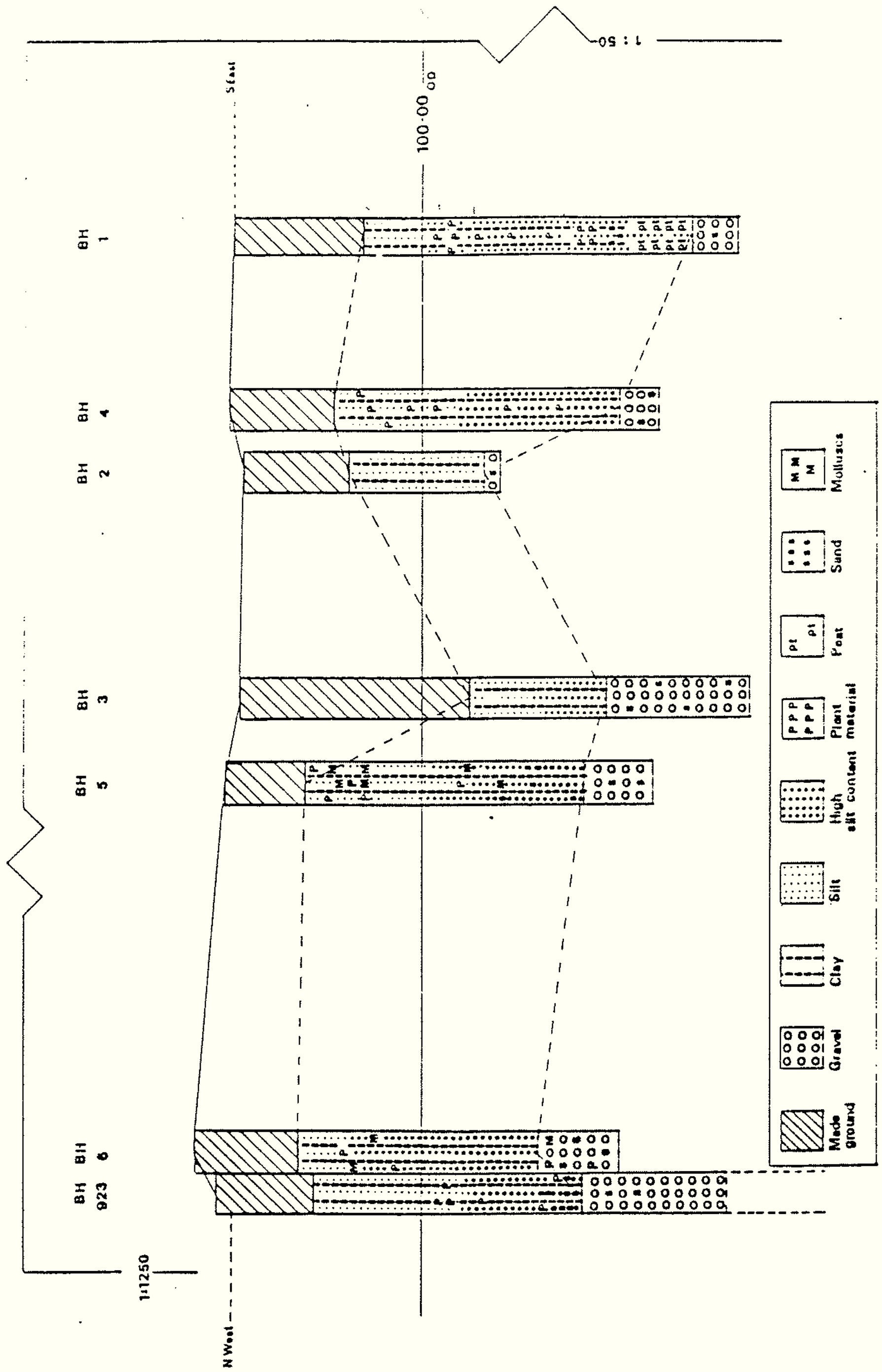


Figure 2. Cross section along line of transect showing major stratigraphic units identified from the borehole and trench data.

Borehole Number	U4/U100	Bulk/Disturbed samples
BH 1	3.00-3.45m 4.50-4.95m 5.00-5.45m	3.45m 4.30m 4.45m 5.35m 5.50-6.00m
BH 2		1.60-2.00m 2.60-3.00m
BH 3	3.00-3.45m 4.00-4.45m	3.45m 3.80m 5.50-6.00m
BH 4	3.80-4.25m 4.25-4.75m	2.10-2.60m 3.00-3.50m 4.20m 4.65m 4.70-5.00m
BH 5	1.20-1.65m 3.20-3.65m 3.90-4.35m	1.00-1.20m 1.65m 3.15m 4.15m 4.50-5.00m
BH 6	2.50-2.95m 4.00-4.50m	4.50-5.00m

Table 1. List of all U4/U100 and disturbed/bulk samples taken during fieldwork.

4.0 STRATIGRAPHIC SEQUENCES RECORDED IN THE BOREHOLES

The stratigraphic sequences discussed below have been identified after careful study of the borehole logs and the extruded sediment cores. The interpretation of the sequences has been based on consideration of the sediment parameters in conjunction with the nature of the included biostratigraphic data (e.g. molluscs, plant fragments etc.) and the topography and three-dimensional relationships between the different boreholes and units.

Seven major stratigraphic units can be identified in the boreholes. This classification may require revision should further laboratory based analysis of the material take place. The major stratigraphic units are described in order of deposition and readers are referred to the schematic cross-section presented in Figure 2.

1. Basal gravels. These deposits are recorded as dark grey to brown, poorly sorted, coarse and angular flint gravels with, in places, a sandy matrix. This unit is present at the base of all boreholes and represents the topographic surface on which the organic sequences were deposited. In places the upper part of the gravel sequence appears to contain some organic material. This may however be a result of mixing of sequences during drilling rather than a real sedimentological feature.

2. Coarse sands. This unit is only present in borehole 6 where it appears as a well bedded, coarse to medium sand with variable amounts of organic and shell material. In places it appears that the sand has been rooted.

3. Organic rich silts/peats. These deposits are only present in borehole 1 but have been observed and sampled in detail in trench 1 (see Appendix V). The sequence varies from a woody highly organic rich silt or peat to well bedded silts with a significant organic content. The sequence is not compact or dense and identifiable plant material is present. In the remaining boreholes this unit is missing but the base of unit 4 (see below) shows an increasing organic content towards the contact with the underlying sediments.

4. Silts/Silty-clay. This unit shows considerable variation throughout the profile and is present, with the possible exception of borehole 3, in all boreholes. Typically the unit appears to become coarser with depth and bedding and laminations appear to increase in frequency with depth. The unit becomes drier and more compact towards the lower contact and organic material including *Phragmities* sp. and molluscs are present sporadically through the unit. Occasional sand lenses are noted through the sequence.

5. Soft black silt-clay. This unit is present in boreholes 1 and 4. Typically the unit is very soft, unconsolidated and contains organic material (e.g. *Phragmities* sp.).

6. Fine mid-grey clay-silt. This unit occurs in boreholes 5 and 6. Typically hard, compact and possessing a possible ped structure this unit contains terrestrial molluscs and is heavily rooted. Iron staining is noted. In borehole 323 the equivalent unit was noted to contain frequent fissures.

7. Made ground.

The data observed from a study of the borehole logs and field data has been confirmed by the examination of the extruded cores. Additional detail was noted during the cleaning and description of these cores and a detailed record of each core is archived in Appendix III.

Two cores were examined in detail to illustrate some of the characteristics of the sequence and after cleaning each core was sliced at (typically) 1cm intervals. Individual sub-samples were bagged separately and are available for microfossil analysis. Each core was then X-rayed[1] and examined.

Borehole 1, 4.50 - 4.95m. This core sampled the organic rich silts and peats at the base of the sequence (unit 3 above). Visual description of this core indicated a high degree of stratification towards the base of the core. The X-radiograph (Plate 1) illustrates the bedded nature of this part of the sequence. Textural variations between 20 and 25cm on the X-radiograph were not visible in the preliminary stratigraphic description of the core.

Borehole 4, 3.80 - 4.25m. This unit (unit 4 above) appeared well stratified after cleaning. Observation of the X-radiograph (Plate 2) indicates that the core is very well laminated and that there appear to be repetitive cycles culminating in the deposition of a coarse sand. The sediment immediately below the sand appears dense with close set wavy laminae. In places deformation to the laminae has been noted.

It is clear from the study of the borehole and extruded core data that a series of stratigraphic units are present that, in places, exhibit a high degree of stratification and that post-depositional disturbance through sediment deformation or bioturbation appears minimal. Examination of core 4.5-4.95m from borehole 1 indicates the location of likely breaks in deposition or unconformities. A major break in sedimentation, accompanied by a substantial phase of erosion was clearly seen in trench 2 where the upper surface of the peat exhibited pitting (in places the entire thickness of peat had been removed).

The observations made during the recording and sampling of Shafts 1 and 2 confirm the observations made from the study of the drill cores (Appendix V). Large samples were recovered during the fieldwork and will provide adequate samples for both plant macrofossil investigation and ^{14}C dating.

[1] Both cores were submitted to X-radiography and exposed onto 180x240mm format Kodak Industry film at exposure times of 45 seconds at 65 Kv setting on a Faxitron machine.

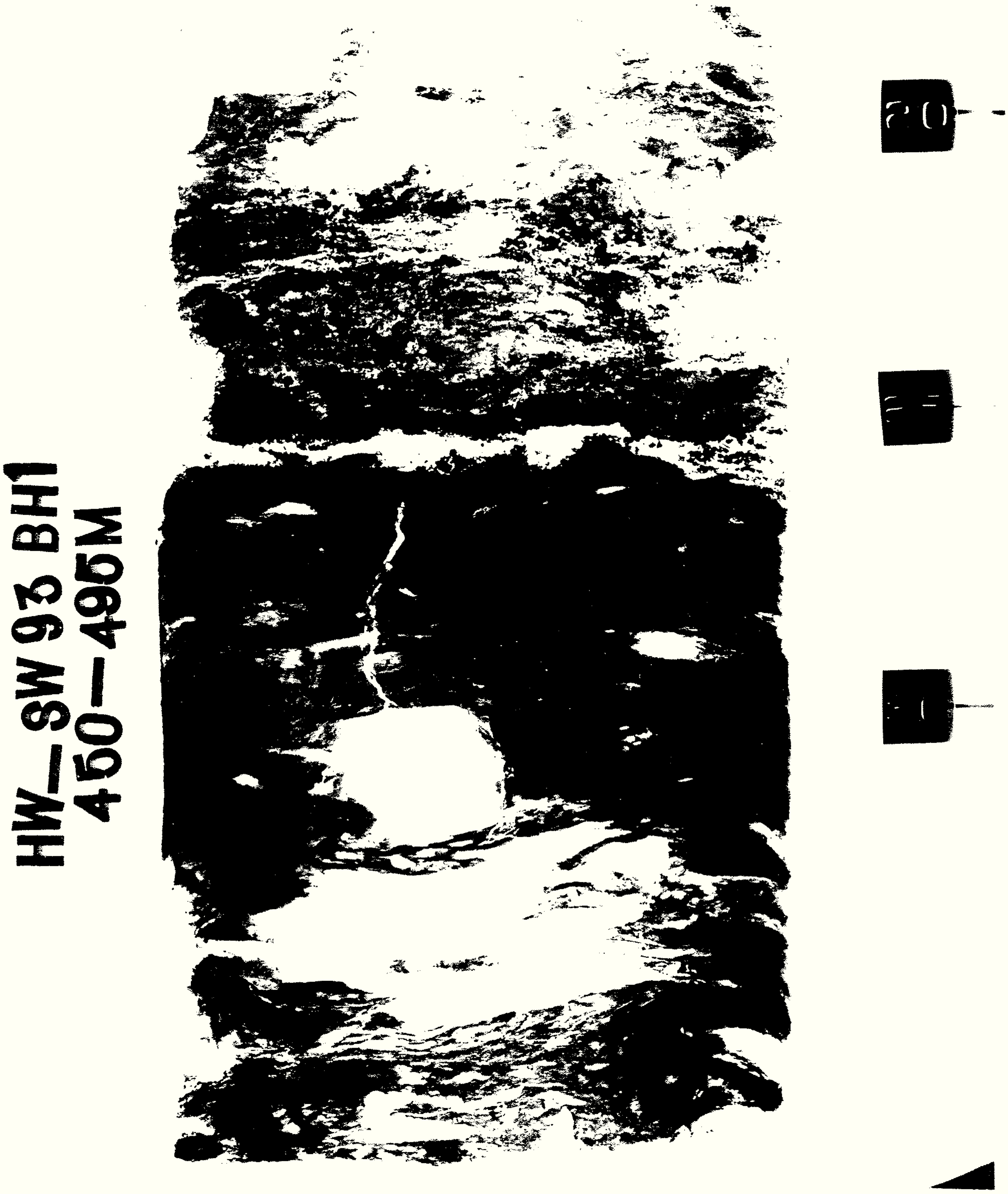


Plate 1. X-radiograph of core 4.50-4.95m, borehole 1.

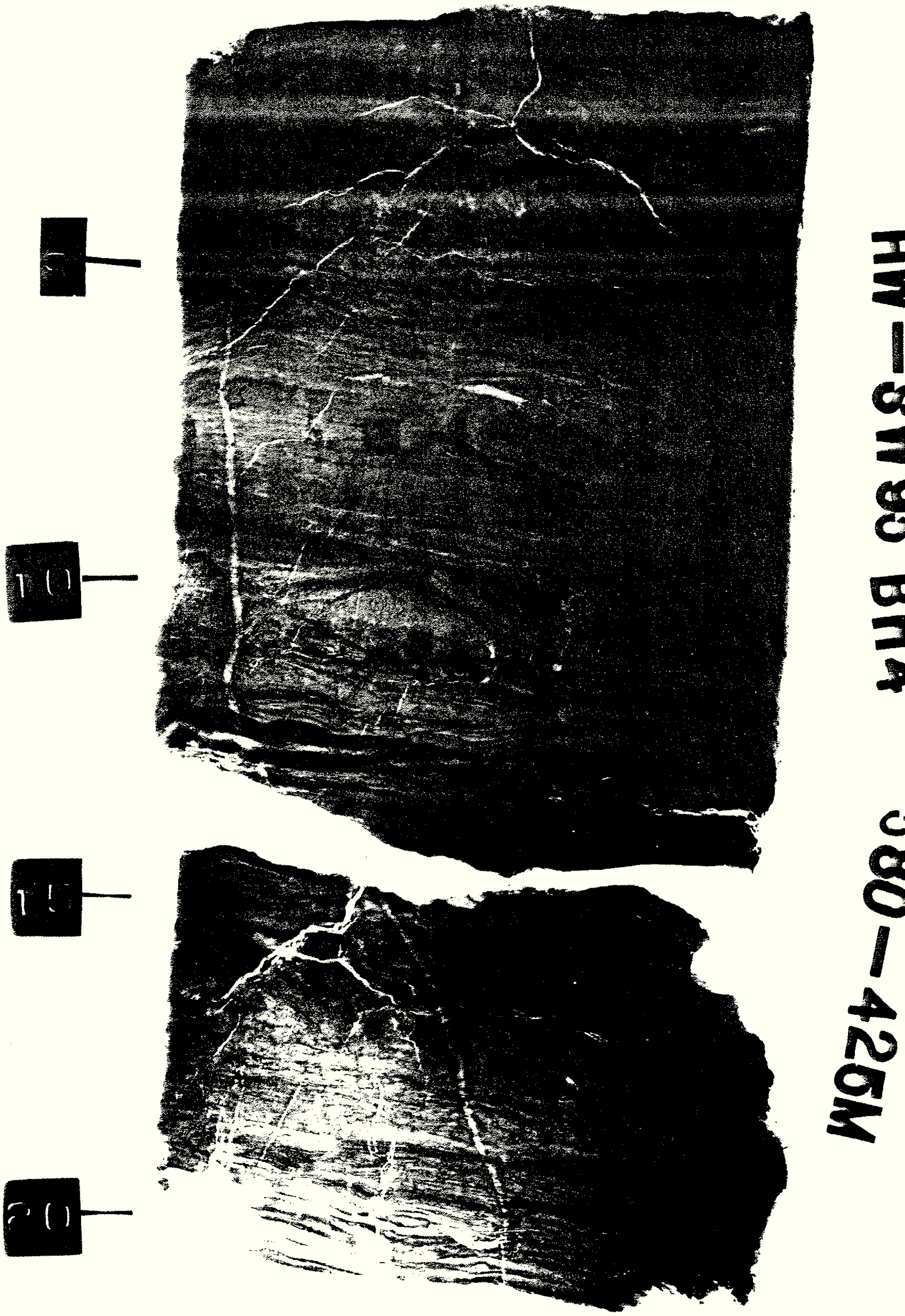


Plate 2. X-radiograph of core 3.80-4.25m, borehole 4.

5.0 DISCUSSION

The data presented in Section 4.0 above indicates that well stratified sequences are preserved at the site and that considerable complexity is likely to have accompanied sequence generation. Table 2 shows the main identified units, inferred environments of deposition and archaeological and biostratigraphic potential of the sequence. The topographic basement is formed by the morphology of the underlying gravel body. Within the area of investigation the surface of the gravel undulates considerably (Figure 2) and is likely to have exerted a considerable influence on later patterns of sedimentation. Gravel deposition is likely to have occurred in the late-Devensian (15-10ka B.P.) under high energy braided channel conditions. Archaeological material may be incorporated within the sequence but will be reworked and not *in situ*.

Organic sedimentation of peat and organic silts in the vicinity of trench 1 and borehole 1 will have taken place under terrestrial conditions in areas of damp or wet ground. In places the deposits are wood rich and large timbers were observed and sampled in trench 1 (see Appendix V). Given the common occurrence elsewhere in SE England of archaeological material within such contexts (e.g. at Nor Marsh in the Medway Estuary - Bates and Barham, in prep) it is possible that this unit represents an area of considerable significance to earlier inhabitants of the area. The well stratified nature of the sequences suggests an important and well preserved palaeoenvironmental sequence might be recovered from these deposits. The peats observed in the trench (Appendix V) shows extensive evidence for erosion and appears to represent a formerly more extensive unit. Close study of the trench sequences show that a compact brown silt is present in voids in the peat. This detail would be difficult to extract from drill cores alone.

Units 2 and 4 may well represent sub-units of a single lithostratigraphic unit. This represents the onset of fluvial activity in the area. A gradual decrease in energy levels, possibly due to increasing water depth or distance from source of sediment led to a fining upwards into silts and clay-silts in unit 4. This appears to have taken place on both sides of the gravel high of borehole 2. The predominantly environment of deposition may have changed during the deposition of units 2 and 4. A shift from fluvial deposition to sub-tidal deposition may be present within the sequence. This will be detected by analysis of the diatom flora within the sediments. Clearly the shift is environment of deposition will have ramifications from the archaeological significance of the sequence.

Sedimentation subsequent to the deposition of unit 4 appears to have differed on either side of the gravel island. To the south sediments appear to indicate deposition, perhaps rapidly, in low energy conditions. To the north the sediments appear denser, with indications of terrestrial mollusc activity and probable active pedogenesis and weathering.

In order to fully understand the nature of the sequences it is clear that further laboratory work is required. The data presented appears to suggest that the gravel 'bedrock' topography has played an important role in influencing the nature of sediment deposition in the area. Depositional patterns either side of the gravel high varied considerably, except during the deposition of unit 4. This implies that the sequences generated may be significantly influenced by local rather than regional processes. It is likely that the preserved sediments indicate shifts in palaeoenvironmental conditions from terrestrial wetland in which peat formation predominated towards increasing fluvial activity (responsible for minerogenic sediment input noted within the peats present in shafts 1 and 2). Erosion under fluvial conditions was followed by fluvial sand deposition and a gradual decrease in energy conditions indicated by a decrease in sediment grain size up-profile. Estuarine or brackish water conditions are probably recorded within this profile prior to a return to freshwater and/or subareial conditions noted in boreholes 5 and 6 at the top of the profile. This model implies that channel edge marginal situations (peats), that may have been utilised by humans, gave way to deeper, probably brackish water conditions unlikely to have been utilised by humans. Finally channel marginal conditions were re-established and human occupation/exploitation of the area would have been possible.

Local archaeological significance appears three fold. The presence of the peat or organic silts at the base of borehole 1 and in trench 1 indicate possible sequences in which human activity in the area may be preserved. Such environments are often favourable for human exploitation and the recovery of archaeological finds in such circumstances are often enhanced by the preservation of material types rare or absent in dry-land sites. Secondly unit 6 appears to represent sediments formed under sub-aerial conditions and it is likely that a palaeolandsurface, of admittedly unknown age but probably prehistoric, is present at the top of the sequence. This landsurface may represent a surface of exploitation. Finally the stratigraphic record contains abundant evidence for well preserved biostratigraphic material that represents an important, off-site, palaeoenvironmental sequence.

At the present time it is difficult to determine the age of the sequence beyond that with the exception of the deposition of the gravels the sediments are of Holocene age.

Stratigraphic unit	Inferred environment of deposition	Biostratigraphic potential	Archaeological potential
7. Made ground		Low to nil	Medium to low
6. Fine mid-grey clay-silt	?	Moderate	High
5. Soft black silt-clay	Low energy wet ground or slow/still water	Moderate - primary stratification possibly disturbed by sediment loading	Medium
4. Silts/silt-clay	Low energy slow or still water with periodic higher energy events	High	Low
3. Organic silts/ peats	Terrestrial wet ground	High	High
2. Coarse (organic) sands	High energy fluvial	Medium to low	Low
1. Angular flint gravels	High energy fluvial braided channel	Low	Low - predominantly reworked artefacts

Table 2. Main stratigraphic unit identified, inferred environments of deposition and biostratigraphic and archaeological potential.

It is now possible to consider the degree to which the assessment has been able to address the questions formulated prior to the commencement of fieldwork. The key points listed in section 1.0 will now be discussed.

i. Are the sequences well stratified?
It is clear from both the careful cleaning of the cores and from the study of the X-radiographs (Plates 1 and 2) that in places the sequences are very well laminated or stratified and that minimal post-depositional disturbance has affected the sediments. The lamination intervals suggest that sub-sampling at 0.5cm or less may be productive in parts of the sequence.

ii. Are they likely to contain biostratigraphic material suitable to formulate high resolution palaeoenvironmental sequences?
Some biostratigraphic material has been noted, e.g. molluscs and plant macrofossils (including wood, stem and root tissue). It has not been possible to determine whether or not pollen, diatoms and ostracods are present but experience of such sequences suggests this type of material is likely to be present.

iii. Are there indications within the sequences of palaeolandsurfaces and palaeotopography?
Palaeotopography is clearly indicated by the surface of the gravels (probably forming a long lasting influence on sedimentation patterns) and a possible palaeolandsurface has been identified towards the top of boreholes 5 and 6, at the top of unit 6.

iv. Is there suitable material within the samples for dating (e.g. ^{14}C and OL dating)?
Sufficient wood is present in the samples to provide material for both conventional and AMS ^{14}C dating. Other organic fractions including peat, plant stem tissue (excluding wood) and molluscs may be considered for dating. Optical Luminescence Dating (OL Dating) should be possible in certain areas due to the presence of a sand fraction, these samples have been taken and stored in light tight containers.

v. Are the sequences similar to others observed in the area?
While certain elements of the sequence appear similar to those recorded elsewhere (e.g. the presence of peat below clay in the vicinity of the Royal Albert Docks - Whitaker, 1889) the sequence appears to differ from that recently discussed to the west at Blackwall (Bates and Barham, 1992). The differences observed may be a result of the importance of local factors associated with the river Lea and the presence of the gravel high.

vi. What is the likely archaeological potential and significance of the sequences?
While no archaeological material was located during the drilling or the excavation of the trench it is clear that the presence of the peat represents an important resource within which archaeological material may be present. Buried archaeological structures within similar sequences and at similar datums are present to the east in the vicinity of Beckton (Ken Whitaker, pers.comm.) and it should be considered that similar material may occur in the area of the ground works. The identification of the palaeolandsurface to the north (boreholes 5 and 6) is of importance as it represents a surface (as yet of unknown age) on which a record of human activity may be preserved. The palaeoenvironmental record likely to be present within much of the sequence is of archaeological significance and represents an off-site palaeoenvironmental record for human activity in the area. Few detailed palaeoenvironmental records have been examined from an archaeological perspective in the London area, despite an abundance of archaeological artefacts of all periods, hence this sequence represents an important resource.

vii. What are the major environments of deposition of the sediments?
These have been discussed above and range from high energy fluvial environments to terrestrial wet ground and possible subtidal conditions. Detailed information regarding the precise environments will only be elucidated after further, detailed, analysis.

viii. Is the sequence of local (i.e. Lea Valley) or regional (i.e. Thames) significance?
It is been suggested that considerable control over sedimentation has been exerted by the topography of the gravel 'bedrock'. This morphology has influenced sedimentation patterns throughout much of the history of sequence development. It is not possible to determine within which system these deposits were developed.

ix. What are the problems relating to topographic setting, disturbance of sediments, discontinuous nature of the sequences, and lack of spatial data?
The topographic setting has influenced sedimentation and therefore comparisons with sequences elsewhere in the Thames should be treated with caution. Little disturbance appears to have occurred in the sequence examined in detail but major unconformities/erosion episodes have been noted, e.g. within the peat/organic silts and immediately above this sequence. A lack or three-dimensional data for the sediment architecture makes it difficult to determine the distribution of the sediments and the nature of the contemporary landscape.

6.0 RECOMMENDATIONS FOR FUTURE WORK

The assessment of the data recovered has fulfilled, at least in part, the main objectives set out in the project brief and has confirmed that an important stratigraphic sequence is preserved at the site. Further work is considered necessary for a more complete understanding of the development of the site and perhaps of greater significance, to aid in the understanding the palaeogeography and palaeoenvironment of man in this part of the Thames system during the Holocene. A series of recommendations are listed below:

1. Dating. At present no clear understanding of the age of sequence development is available. Suitable samples for both ^{14}C and OL dating have been taken. Initially a comparison of the age of the peat and wood rooted into the peat would be useful to provide a date for the onset of sediment accumulation in the Holocene at the site. Sufficient material is available from the trench excavation to use conventional ^{14}C techniques. Additional dates from the upper part of the sequence, units 5 and 6, would be useful to provide dates for the cessation of sedimentation at the site.

2. Sedimentology. Further work on both the core material and the monolith and bulk sample material recovered from the trenches is necessary. Archiving of all trench material is necessary in order to achieve a full descriptive and photographic record. Selected cores/monoliths should subsequently be selected for further analysis including X-radiography (to assess primary structure), limited particle size, loss-on-ignition and total Phosphate analysis. Careful selection of the samples should aid in the characterisation of the sediment types present and the formulation of a facies model.

3. Biostratigraphy. An initial assessment of presence/absence and preservational status of pollen, diatoms, ostracods and molluscs should be undertaken. As a first stage this work will not provide detailed palaeoenvironmental data suitable for habitat reconstruction's or comparison with other sequences elsewhere in the catchment. More detailed studies of key parts of the sequence will be necessary should this be considered desirable. Clearly the significance of the peat, in both archaeological and palaeoenvironmental terms, may indicate that resources should be focused on a detailed examination of this unit and the transition into the overlying sequence.

Future work at the site should be considered with respect to other sites (further sites?) within the Jubilee Line Extension Project and the broader themes of interest (research) emergent from this work. At the scale of the site priorities for future work may well differ from those themes that may be prioritised at a level of integration along the route corridor.

It is suggested that the following program is adopted:-

Phase I Archiving of all material from trench excavation including description and photography. Sub-sampling of selected cores, X-radiography and preliminary sedimentological analysis. Preliminary assessment of plant macrofossil, molluscan, pollen and diatom content.

Phase II Detailed study of core material leading to the development of a full sedimentological facies model. Construction of detailed pollen and diatom diagrams. Further ^{14}C dates may be required in order to calibrate sequence development.

It is important that project work moves rapidly into Phase I of the recommended work. Considerable fungal growth has already been noted on the surface of many of the cores described despite attempts to retard growth through storage under optimal conditions. Further deterioration of core material may prejudice future analysis.

7.0 SUMMARY AND CONCLUSIONS

The preliminary study and assessment of the stratigraphic sequences at the site indicate that sequence development appears to have occurred through a complex interaction of site specific topographic controls and local sedimentation factors integrated with regional processes operating at a Thames wide scale. The interaction of these factors render precise conclusions and correlations with other sites and areas difficult. Within the sequence areas of possible archaeological significance have been identified and discussed.

The stratigraphic sequences are well preserved and contain abundant biostratigraphic data. They are likely to yield a detailed palaeoenvironmental record that should be relatively easily dated by ^{14}C dating techniques.

The investigation has been successful and all objectives set out in the project brief have been examined and discussed. Clearly it has not been possible to comment in detail on all aims however the emergent problems have been identified and ways of resolving them outlined. Further work is recommended commencing with dating of key parts of the sequence and archiving of all remaining sediment monoliths and samples from the trench excavation. This assessment must also include preliminary sedimentological analysis and assessment of the micro/macro-floral/faunal content. A final stage of detailed sedimentological and biostratigraphic analysis may then commence. This work must be based on the an integrated data set drawn from both the borehole and trench samples.

ACKNOWLEDGEMENTS

The authors would like to thank Mr.Dave Wilkinson and Mr.Rob Early for help on site and the subsequent production of surveying data. Mr. A.J.Barham provided useful comments on an earlier draft of this report.

BIBLIOGRAPHY.

AITKEN, M.J. 1992 Optical Dating. **Quaternary Science Reviews 11**, 127-132.

ALLEN, J.R.L., & RAE, J.E. 1987 Late-Flandrian shoreline oscillations in the Severn Estuary: a geomorphological and stratigraphical reconnaissance. **Philosophical Transactions of the Royal Society of London B315**, 185-230.

BATES, M.R. and BARHAM, A.J. 1992 Blackwall Tunnel Third Bore: stratigraphic and palaeoenvironmental assessment. **Geoarchaeological Service Facility Site Assessment Report 92/06**. 52pp.

BENNETT, K.D. 1984 The post-glacial history of *Pinus sylvestris* in the British Isles. **Quaternary Science Reviews 3**, 133-155.

BENNETT, K.D. 1989 A provisional map of forest types for the British Isles 5000 years ago. **Journal of Quaternary Science 4**, 141-145.

BRIDGLAND, D.R. 1994 **The Quaternary of the Thames**. Chapman and Hall: London. 441pp.

BRIDGLAND, D.R., GIBBARD, P.L., HARDING, P. et.al., 1985 New information and results from recent excavations at Barnfield PIt, Swanscombe. **Quaternary Newsetter 46**, 25-39.

BRIDGLAND, D.R. and HARDING, P. 1993 Middle Pleistocene terrace deposits at Globe Pit, Little Thurrock, and their contained Clactonian industry. **Proceedings of the Geologist Association 104**, 263-284.

BROMEHEAD, C.E.N. 1925 The Geology of North London **Memoir Geological Survey of Great Britain.**

CHURCHILL, D.M. 1965 The displacement of deposits formed at sea-level 6500 years ago in Southern Britain. **Quaternaria 7**, 239-248.

DEVOY, R.J.N. 1979 Flandrian sea-level changes and vegetational history of the lower Thames Estuary. **Philosophical Transactions of the Royal Society of London B285**, 355-407.

DEVOY, R.J.N. 1982 Analysis of the geological evidence for Holocene sea level movements in Southeast England. **Proceedings of the Geologist Association 93**, 65-90.

DEWEY, H., & BROMEHEAD, C.E.N. 1921 The geology of south London. **Memoir of the Geological Survey of Great Britain.**

FAEGRI, K. & IVERSEN, J. 1964 **Textbook of Pollen Analysis.** New York.

GIBBARD, P.L. 1985 **Pleistocene history of the Middle Thames Valley.** Cambridge University Press. 155pp.

GODWIN, H.H. 1940 Pollen analysis and forest history in England and Wales. **New Phytologist 39**, 370-400.

GREENSMITH, J.T., & TUCKER, E.V. 1980 Evidence for differential subsidence on the Essex Coast. **Proceedings of the Geologist Association 91**, 169-175.

KELSEY, J. 1972 Geodetic aspects concerning possible subsidence in South-Eastern England. **Philosophical Transactions of the Royal Society of London A272**, 141-149.

KING, W.B.R., & OAKLEY, K.P. 1936 The Pleistocene succession in the lower parts of the Thames Valley. **Proceedings Prehistoric Society 1**, 52-76.

MIALL, A.D. (ed.) 1978 **Fluvial Sedimentology.** Calgary, Canadian Soc. of Petroleum Geologists, Mem. 5. 859pp.

MIDDLETON, G.V. 1973 Johannes Walther's Law of the correlation of facies. **Geological Society of America Bulletin 84**, 979-988.

MUNSELL 1975 **Munsell Soil Color Charts**. Munsell Color, Macbeth: Baltimore

SHENNAN, I. 1983 Flandrian and Late-Devensian sea-level changes and crustal movements in England and Wales. Pp 255-283, In: **Shorelines and Isostasy.** D.E.Smith and A.G.Dawson (eds.). Academic Press, London.

SHENNAN, I. 1987 Holocene sea-level changes in the North Sea. Pp. 109-151. In: **Sea-Level Changes.** M.J. Tooley and I.Shennan (eds.). Blackwell: Oxford.

SHENNAN, I. 1989a Holocene crustal movements and sea-level changes in Great Britain. **Journal of Quaternary Science 4**, 77-89.

SHENNAN, I. 1989b Holocene sea-level changes and crustal movements in the North Sea Region: an experiment with regional eustasy. In: **Late Quaternary Sea-Level Correlations and Applications:** NATO ASI Series c256. D.B.Scott, P.A.Pirazzoli and C.A. Honig (eds.). Kluwer:Dordrecht.

WHITAKER, W. 1889 The geology of London. **Memoir of the Geological Survey of Great Britain**. 556pp.

WYMER, J.J 1968 **Lower Palaeolithic archaeology in Britain as represented by the Thames Valley.** John Baker, London. 429pp.

APPENDIX I. BOREHOLE LOGS SUPPLIED BY CONTRACTORS

Soil Mechanics

BOREHOLE No.923

Sheet 1 of 6

Equipment & Methods

Cable percussive boring using 200mm casing to a depth of 34.30m and 150mm casing to 37.10m.

Location No. 7669

Location

JUBILEE LINE EXTENSION
(CANNING TOWN TO STRATFORD)

Carried out for

London Underground Limited (JLE 015)

Ground Level 2.36 m A.O.D.

Coordinates 539477.95 E, 181289.62 N

Date 07.11.90 to 09.11.90

Description	Reduced Level	Legend	Depth (Thick)	Samples/Tests Depth	Sample Type	Sample No.	Test	Field Records
Soft grey brown and orange brown mottled very sandy CLAY with occasional to much angular fine to medium gravel sized fragments of ash, coal, flint and metal. (MADE GROUND).	2.36		(1.10)	0.40 - 0.80	B	1		
	1.26		1.10					
Soft grey and orange brown extremely closely fissured CLAY. Fissures randomly orientated, ironstained (orange brown) and planar. (Weathered ALLUVIUM)				1.10 - 1.55	U	2		20 blows for 430mm recovery.
				1.60	D	3		
			(1.40)	1.70 - 2.30	B	4		
	-0.14		2.50	2.50 - 2.95	D	5		
Soft to firm grey and grey brown mottled black locally very silty organic CLAY with some to much decaying vegetation and decaying wood debris (<50mm). (ALLUVIUM).				2.50 - 3.00	B	6		
			(1.30)					
				3.30 - 3.80	B	7		
	-1.44		3.80					
Soft to firm grey, grey brown mottled black organic CLAY with much to coarse sand and angular to subrounded fine to medium flint gravel. (ALLUVIUM)				4.00 - 4.45			C N=15	2,2/3,4,4,4
			(0.70)	4.00 - 4.50	B	8		
	-2.14		4.50					
5.00-5.50m, occasional subangular flint cobbles.				5.00 - 5.50	B	9		
Very dense becoming dense grey and brown angular to rounded fine to coarse flint GRAVEL with some medium to coarse sand. (THAMES GRAVEL)				5.60 - 6.05			C N=52	1,3/6,14,17,15
				5.60 - 6.10	B	10		
			(3.30)					
				6.30 - 6.80	B	11		
				7.10 - 7.55			C N=33	1,1/4,8,9,12
				7.10 - 7.60	B	12		
	-5.44		7.80	7.80	D	13		
8.20-8.35m, grey brown fine grained slightly weathered calcareous CLAYSTONE strong.				8.20	D	14		
As sheet 1 (LONDON CLAY)				8.40 - 8.85	U	15		75 blows for 430mm recovered.
			(9.00)	8.90	D	16		
				9.30 - 9.70	B	17		
				9.90 - 10.35	D	18	S N=23	3,4/5,5,6,7
				9.90 - 10.30	B	19		

Remarks

1. Water added to hold head of water at 4.00m.
2. 8.20m to 8.35m , 20 minutes chiselling through claystone.

Logged by SD

Scale 1:50

Notes:

Materials are described in accordance with Appendices. For explanation of symbols and abbreviations see Fig. 1.
All depths and reduced levels in metres. Thicknesses given in brackets in depth column.

11.04.91/11.03 (Ver 4.1.28)

Fig. 24

APPENDIX II. BOREHOLE LOGS OBTAINED DURING THIS STUDY

Borehole 1.

Depth below ground surface (metres)	
0.00-0.30	Recent fill.
0.30 - 1.50	Mid/light grey soft silty clay - generally unconsolidated. Lower 0.20m transitional to underlying unit.
1.50 - 2.40	Soft black silty organic clay.
2.40 - 2.80	Dark grey clay with occasional plant fragments and occasional sub-rounded flint (<2cm). Becoming more silty with depth.
2.80 - 3.90	Soft light grey-blue silty-clay with occasional wood fragments and stem material (*Phragmities* sp.)
3.90 - 5.40	Soft light grey clay with abundant wood stem plant material increasing in frequency towards the base. Silt content increases with depth. Peaty in places towards the base.
5.40 - 6.00	Dense sandy gravel. Coarse, angular/sub-rounded gravel with brown sandy matrix. Some organic material at top of unit.

Borehole 2.

Depth below ground surface (metres)	
0.00 - 0.40	Modern fill.
0.40 - 1.20	Brick fill.
1.20 - 2.50	Soft, dark grey-blue silty clay with an increase in silt content towards base.
2.50 - 3.00	Medium dense dark grey-brown sandy gravel.

Borehole 3.

Depth below ground surface (metres)	
0.00 - 0.50	Topsoil.
0.50 - 2.70	Brick rubble.
2.70 - 4.30	Soft dark grey-blue silty clay. Silt content increases with depth.
4.30 - 6.00	Medium dense dark grey-brown sandy gravel.

Borehole 4.

Depth below ground surface (metres)	
0.00 - 0.60	Topsoil.
0.60 - 1.20	Modern fill - brick rubble.
1.20 - 2.60	Very soft and unconsolidated dark grey silt with abundant organic fragments including *Phragmities* sp. between 1.20 and 1.70m. Silt content increases with depth.
2.60 - 4.00	Silt content increases, unit becomes denser and organic content decreases with depth.
4.00 - 4.60	Light grey silty-clay with low organic content.
4.60 - 5.00	Coarse poorly sorted flint gravels. Clast are sub-angular. Coarse brown sand matrix.

Borehole 5.

Depth below ground surface (metres)	
0.00 - 0.40	Top soil.
0.40 - 0.90	Made ground - brick fill.
0.90 - 2.00	Firm mid grey clay with some silt, silt content increases with depth. Possible ped-like features noted. Rooting and terrestrial molluscs present. Becomes more compact with depth. Very fine root tubules noted at c.2.00m. Some evidence of iron staining.
2.00 - 2.60	Silty-clay with some organics including *Phragmities* sp.
2.60 - 3.00	As above but some sand, shell fragments present.
3.00 - 4.20	Medium silt becoming denser with depth. Sand content also increasing.
4.20 - 5.00	Coarse angular flint gravels with patches of organics. Sandy matrix.

Borehole 6.

Depth below ground surface (metres)	
0.00 - 0.40	Topsoil.
0.40 - 1.20	Compact brick and concrete fill.
1.20 - 2.60	Structureless mid to dark grey clay. Some silt present increasing with depth. Rooting and organic material present. Terrestrial molluscs present. Becomes denser and more compact with depth.
2.60 - 3.60	Dark grey silty clay - moderately compact.
3.60 - 4.00	Coarse silt - drier than above.
4.00 - 5.00	Finely bedded coarse to medium sand with some organics and shell material. Possible rapid transition to poorly sorted sub-angular brown coarse sandy gravel.

APPENDIX III. CORE DESCRIPTIONS

BOREHOLE 1 3.00-3.45m

0-42cm	The unit is mottled with 2.5Y 3/2 very dark greyish brown and 10YR 2/2 very dark brown, very fine silty clay. Woody fragments (up to 6mm mean diameter and 35mm long) and fine grained organic material are abundant throughout the unit. The majority of the woody fragments show a preferred orientation perpendicular to the sides of the core.

BOREHOLE 1 4.50-4.95m

0-26cm

This is a highly complex mixture of large woody fragments and patches of humified organic material within a 2.5Y 2.5/1 black to 2.5Y 3/1 very dark grey slightly sandy silt. The silt contains sand grains which decrease in abundance up through the unit and are concentrated on the lower boundary. Also towards the lower boundary there are coarse sand to fine gravel clasts up to 3mm mean diameter, sub-rounded. The wood fragments are up to 40mm long and 20mm thick. Most of these wood fragments show a preferred orientation perpendicular to the sides of the core. Also within the core there are 5YR 2.5/2 dark reddish brown well humified organic material with sharp outlines.

____________________sharp contact____________________

26-38cm

The unit is laminated and shows a mixture of 2.5Y 3/1 very dark grey and 2.5Y 2.5/1 black silt with coarse rounded-well rounded quartz grains sand grains at the top of the unit. The difference in the colour within the silts picks out the laminations. The silt contains fine grained organic material (the darker silt having a slightly higher concentration of fine organic material), as well as larger woody organic fragments up to 60mm long and 20mm wide. Within the smaller degraded woody organic material it is possible to see pyrite nodules. The larger organic fragments show a preferred orientation parallel to the laminations.

BOREHOLE 1 5.00-5.45m

0-7cm	VOID
7-11cm	Thinly bedded/ banded unit with a 2.5Y 3/1 very dark grey silt and a 10YR 2/1 black silt. The black silt has a higher fine grained organic content. The unit contains woody organic fragments, the largest of these (15mm x 35mm) shows visible growth rings and is seen at the top of the unit.

____________sharp contact____________

11-20cm	10YR 2/1 black organic rich silt. The unit is rich in both fine grained organic material and woody fragments. There are bands of the silt towards the base of the unit which contain no woody fragments.

____________sharp contact____________

20-23cm	2.5YR 3/1 very dark grey silt mottled with a 10YR 2/1 black organic rich silt containing woody fragments. The fine grained organic material is confined to the black silt.

BOREHOLE 3 3.00-3.45m

0-29cm	3/N3/ very dark grey. Oxidises quickly to 10YR 4/2 dark greyish brown slightly sandy clay. Clasts are present throughout the unit. These consist of pottery and mortar. They are up to 24mm mean diameter. The unit also contains rare sand sized particles and a small amount of fine grained organic material.

---diffuse contact---

29-40cm	3/N3/ very dark grey silt. Oxidises quickly to 10YR 4/2 dark greyish brown. The unit contains clasts of up to 34mm mean diameter. These are angular to sub-rounded of unknown origin. The unit also contains moderate to abundant fine grained organic material.

BOREHOLE 3 4.00-4.45m

0-4/3cm	2.5Y 4/1 dark grey clay. The unit contains a large reed fragment at the top of the core and a piece of tile at 2 to 4cm.

_______________sharp contact_______________

4/3-20cm	2.5Y 3/1 very dark grey sandy clayey silt. The sand has an uneven distribution throughout the unit. The unit contains a high organic content including both fine grained organic material and woody fragments (up to 40mm long). At the base of the unit there a few fine gravel sized clasts up to 5mm mean diameter sub-rounded to sub-angular.

---------------diffuse contact---------------

20-25cm	7.5R N2.5/0 black slightly sandy silt matrix within a gravel. The gravel is a mixture of matrix and clast supported. The gravel clasts are up to 20mm mean diameter and sub-angular. The silt contains fine grained organic particles.

BOREHOLE 4 3.80-4.25m

0-1cm	VOID
1-14/15cm	2.5Y 3/1 dark grey clay silt with small patches of sand. There are some darker 2.5Y 2.5/1 black areas and a gradual transition down through the unit to 2.5Y 4/1 dark grey. Organic rich laminations and bands perpendicular to the sides of the core are present at around 6cm. The bottom of the unit below 12cm shows the presence of coarse silt-fine sand lenses.

__________sharp contact__________

14/15-17/18cm	2.5Y 4/1 dark grey silt clay with abundant discontinuous wavy fine sand laminations perpendicular to the sides of the core.

__________sharp contact__________

17/18-21cm	2.5Y 3/1 very dark grey slightly sandy silt.

__________sharp contact__________

21-22cm	2.5Y 4/1 dark grey clay silt

__________sharp contact__________

22-30cm	2.5Y 4/1 dark grey clay silt with 2.5Y 3/1 very dark grey patches. Sand is found in pockets, lenses at 30cm and possibly beds at 26-26.5cm. Fine grained organic material is also present as streaks up to 30mm long.

__________sharp contact__________

30-35cm	2.5Y 4/1 dark grey silt with sand lenses.

__________sharp contact__________

35-37cm	2.5Y 4/3 olive brown silt with a flint pebble approximately 13mm mean diameter.

----------diffuse contact----------

37-45cm	2.5Y 3/1 very dark grey silt with very little organic material.

BOREHOLE 4 4.25-4.70m

0-16/15cm	10YR 3/2 very dark greyish brown slightly sandy silt with sandy laminations within the top 1cm and irregular patches of very fine to fine sand (2.5Y 4/3 olive brown), below. These sandy patches are abundant above 16cm and are then confined to small less than 10mm long laminations below 16cm. The unit contains abundant fine grained organic particles some of which show a preferred orientation perpendicular to the sides of the core.

---diffuse contact---

16/15-20cm	10YR 3/2 very dark greyish brown fine silt/clay. The unit contains small, less than 10mm long, fine sand laminations. At the base of the core there are two flint clasts up to 4mm long, sub-angular. The unit contains abundant fine grained organic particles some of which are concentrated into bands parallel to the upper boundary of this unit.

BOREHOLE 5 1.20-1.65m

0-44cm	Mottled clay unit. 10YR 4/3 brown is the dominant colour throughout most of the core. This changes slightly down through the core to 10YR 4/2 dark greyish brown. There is also a strong 5YR 3/3 dark reddish brown colour throughout the core which is seen to be associated with fine roots at the top of the core. There is also a dark/black mottling within the top 20cm of the core.

BOREHOLE 5 3.20-3.65m

0-3/9cm	This unit is mixed with patches of 2.5Y 3/2 very dark greyish brown sandy clayey silt within a 2.5Y 4/3 olive brown coarse sand. The sand is moderately well to well sorted and dominated by quartz grains with rare chalk grains. The sand grains are sub-rounded to well-rounded. The unit also contains a small amount of organic material.

sharp/irregular contact

3/9-31cm	2.5Y 4/1 dark grey clay with N2.5/ black patches which quickly oxidise to 2.5Y 4/2 dark greyish brown. The unit contains two small sandy patches at 6 and 8.5cm. These patches may show that the boundary is inclined or represent ball and pillow type structures formed during soft sediment deformation. The unit also contains a very small amount of fine grained organic material.

BOREHOLE 5 3.90-4.35m

0-11cm	2.5Y 5/4 light olive brown coarse sand. The unit has poorly sorted patches within a generally well sorted unit. The colour darkens with an increasing amount of fine silt/clay. The sand is dominated by rounded to well-rounded quartz grains. The sand also contains fine gravel sized flint clasts up to 3mm mean diameter sub-angular. These clasts increase in frequency up through the unit.
	sharp contact
11-15/14cm	2.5Y 3/2 very dark greyish brown sandy fine silt with abundant fine grained organic material.
	sharp contact
15/14-18/20cm	2.5Y 5/4 light olive brown coarse sand. The sand is dominated by rounded to well-rounded quartz grains with rare chalk grains and a shell fragment. There are also fine gravel clasts of chalk, flint and quartz.
	sharp contact
18/20-21/21.5cm	2.5Y 3/2 very dark greyish brown sandy fine silt with abundant fine grained organic material and fine gravel sized clasts. These clasts are sub-rounded to sub-angular, up to 3mm mean diameter and are composed of chalk, flint and quartz. A mollusc shell is also present at 20cm.
	sharp contact
21/21.5-22/21.5cm	2.5Y 5/4 light olive brown coarse sand dominated by rounded to well-rounded quartz grains with rare chalk grains and fine gravel clasts of chalk, flint and quartz.
	sharp contact
22/21.5-23/24cm	2.5Y 3/2 very dark greyish brown sandy fine silt with abundant fine grained organic material.

sharp contact

23/24-24/25cm	2.5Y 5/4 light olive brown coarse sand dominated by rounded to well-rounded quartz grains with rare chalk grains with no gravel clasts. The sand also contains laminations of fine silt.

sharp contact

24/25-27cm	2.5Y 3/2 very dark greyish brown slightly sandy fine silt. The coarse sand forms laminations at the top of the unit.

BOREHOLE 6   2.50-2.95m

0-26cm	2.5Y 4/1 dark grey clay. The unit is slightly mottled down to 14cm, with a 2.5Y 3/2 very dark greyish brown staining. The unit contains fine grained organic material which increases in abundance to 26cm. There are fine roots visible at the top of the core above 4cm. Small patches of coarse silt/fine sand are also present throughout the unit. These increase to 26cm where they begin to form laminations.

--diffuse contact--

26-41cm	2.5Y 4/1 dark grey clay with thin discontinuous wavy laminations of coarse silt and very fine sand. These laminations are also picked out by concentrations in fine grained organic material. Rare larger organic fragments are also present, these are 1 to 2mm in diameter.

BOREHOLE 6 4.00-4.45m

0-10cm	Very poorly sorted gravel with a sandy, silty, clay matrix. Colour varies with clast colour. But the sand is 2.5Y 4/2 dark greyish brown, dominated by rounded to well rounded quartz grains with rare chalk grains. The sand is mixed with a sandy silty clay 2.5Y 3/2 very dark greyish brown. The flint gravel clasts are clast supported and up to 25mm mean diameter sub-angular to angular.

---diffuse contact--

10-32/37cm	This unit is a mixture of coarse sand (2.5Y 5/4 light olive brown) and frequent patches of clay/silt. The coarse sand is well sorted and composed of rounded to well rounded quartz grains. The sand varies in colour with the amount of silt/clay present, from 2.5Y 5/4 light olive brown (pure well sorted coarse sand) to 2.5Y 3/2 very dark greyish brown where there is a high silt/clay content. At the top of the unit there is a pocket of peat. It has a sharp but irregular outline and is well humified and compact. It contains a small amount of woody organic material and small patches of clay. At 24-27cm the sand contains a patch of clay which is well sorted, contains no sand grains and a small amount of fine grained organic material.

---diffuse contact--

32/37-40cm	2.5Y 3/2 very dark greyish brown coarse sandy silt. The unit is poorly sorted with a high percentage of sand which is dominated by rounded to well rounded quartz grains.

APPENDIX IV. LIST OF ALL SAMPLES TAKEN FROM TRENCH EXCAVATION

Trench/Section Number	**Monoliths**	**OL samples**	**Bulk samples**
Trench 2, Shaft 1	M 4 M 5 M 6 M 7 M 8 M 9 M 10 M 11 M 12	Ol samples 1 - 5	GSF 1 4x bulk peat samples
Trench 2, Shaft 2	M 13 M14	-	GSF 2 GSF 3 GSF 4 Block of peat
North sloping section	M 1 M 2 M 3	-	3x bulk sediment samples

APPENDIX V. SUMMARY OF STRATIGRAPHIC INFORMATION FROM TRENCH TR2

NW Sloping section 45.

Section size: 1m high x 2m wide.

Samples taken: Monoliths 1, 2, 3
Bulk samples 3 x bulk sediment samples

The top 10cm of this section comprised a dark grey layer containing wood, slag and brick rubble. The upper 'fill' unit was underlain by a thick mid grey (becoming darker grey towards the base of profile) clay unit that continued to the base of the profile. Mottling was noted throughout the unit consisting of small pockets of organic material (fibrous stems fragments) that appeared to decrease in frequency towards the base of the profile. This unit was cut by a clay-silt. The contact between the two units was sharp. This unit contained abundant molluscs and plant material including *Phragmites* sp. Some rooting was also noted in this unit.

This sequence appears similar to unit 6 recorded in boreholes 5 and 6.

Trench 2, Shaft 1 (east facing section).

Samples taken: Monoliths 4, 5, 6, 7, 8, 9, 10, 11, 12
Bulk samples GSF 1 plus 4 x peat samples

The top 1m of this section comprised of a mid grey clay that was well bedded in the top 1.0m to 1.25m. Individual beds were approximately 5cm wide and light grey in colour. Bedding intervals were regular and bedding dipped towards the north at an approximate angle of 5° (due to the limited extent of the exposure this figure is an approximation). Sand appeared below 1.5m depth and increased in quantity towards the base of the profile (i.e. indicating a coarsening downwards sequence). At a depth of 1.75m from the top of profile sand and organic lenses appeared. The lenses dipped towards the north at an approximate angle of 25° from the horizontal. Individual lenses were commonly less than 0.5cm thick and less than 10cm in length. Bedding disappeared at c. 1.5m depth. Charcoal was noted at a depth of 2m. Peat was encountered at a depth of 3m. The peat was compact, contained woody root material showing evidence of compaction. A maximum thickness of 1.5m for this unit was recorded. The surface of the peat was eroded, truncated and in places peat was absent entirely from the profile. Within the peat voids between the roots were seen to be filled with a compact mid-brown clay-silt. Coarse sand lenses were also noted in profile associated with the roots. A poorly sorted, angular flint gravel was recorded at a depth of 3.75m from the upper surface.

Trench 2, Shaft 2.

Samples taken: Monoliths 13, 14
Bulk samples GSF 2, 3, 4 plus a block of peat

The top 2.75m was similar to that described in the upper 2.75m of profile recorded in Shaft 1. Sand lenses were noted between 1.75m and 2.00m depth. Sand and silt content increased towards base confirming the coarsening downwards trends noted in Shaft 1. No charcoal was noted in this section. Peat was encountered at 2.75m depth and the upper surface dipped towards the north at approximately 15°. In contrast to the root wood described in Shaft 1 large trunk wood fragments were recorded from this section.

The stratigraphic sequences recovered from Shafts 1 and 2 confirm the observations made on the basis of the borehole log from BH 1. Sampling of the Shafts has enabled larger samples to be taken, in particular of the peat. Additionally a continuos column of sediment was recovered from the trench. It was not possible to achieve this in the borehole without drilling a second hole adjacent to the first.

APPENDIX VI. STRATIGRAPHIC CORRELATION TABLE OF MAJOR GRAVEL UNITS IN THE THAMES VALLEY (from Bridgland, 1994).

Age (in thousands of years)	Upper Thames	Middle Thames	Lower Thames	Essex	Stage	^{18}O
	Recent floodplain and channel deposits: Holocene alluvium of floodplain and coast					
10					Holocene	1
	Northmoor Gravel	Shepperton Gravel	Submerged	Submerged	late Devensian	2-4
71	*Rejuvenation event*					
		Temperate climate deposits at South Kensington (Ismaili centre), Isleworth and Kempton Park	Submerged	Submerged	early/mid-Devensian? interstadial(s)	5a &/or 5c?
?						
	Cold climate gravels above Eynsham Gravel	**Reading area** U. levels of Taplow Gravel; **Slough area** Kempton Park Gravel	East Tilbury Marshes Gravel	Submerged	early-mid-Devensian	5d–2
122						
	Eynsham Gravel	Within Taplow Formation; Trafalgar Square and Brentford deposits	Below floodplain	Submerged	Ipswichian (*sensu* Trafalgar Square)	5e
128						
	Stanton Harcourt Gravel	Taplow Gravel; Basal Kempton Pk Gravel - incl. Spring Gardens Gravel of Gibbard (1985)	Basal East Tilbury Marshes Gravel	Submerged	late Saalian	6
		Rejuvenation event				
		Taplow Gravel	Mucking Gravel			
186						
	Stanton Harcourt Channel Deposits, interglacial Magdalen Grove, Summertown etc.	Interglacial deposits at Redlands Pit, Reading	Interglacial deposits at Aveley, Ilford (Uphall Pit), West Thurrock, Crayford and Northfleet	Submerged	Intra-Saalian temperate episode	7
245						
	Basal Summertown-Radley Formation at some sites?	Basal Taplow Gravel?	Basal Mucking Gravel	Submerged		
	Rejuvenation event				mid-Saalian	8
	Wolvercote Gravel at some sites?	Lynch Hill Gravel	Corbets Tey Gravel	Barling Gravel		
303						
	Wolvercote Channel Deposits		Interglacial deposits at Ilford (Cauliflower Pit), Belhus Park, Purfleet and Grays	Shoeburyness Channel interglacial deposits	Intra-Saalian temperate episode	9
339						
	Basal Wolvercote Gravel	Basal Lynch Hill Gravel?	Basal Corbets Tey Gravel	Shoeburyness Channel - basal gravel		
	Rejuvenation event				early Saalian	10
	? Moreton Drift (Arkell, 1947a)					
	Hanborough Gravel	Boyn Hill Gravel	Orsett Heath Gravel	Southchurch/Asheldham/Mersea Island/Wigborough Gravel		
?						
	Reworked mammalian fauna in Hanborough Gravel		Swanscombe deposits	Southend/Asheldham/Cudmore Grove/Clacton Channel Deposits	Hoxnian (*sensu* Swanscombe)	11
423						
	Basal Hanborough Gravel?	Basal Boyn Hill Gravel?	Basal Orsett Heath Gravel (incl. Basal Gravel at Swanscombe)	Southend/Asheldham/Cudmore Grove/Clacton Channel - basal gravel		
	Rejuvenation event					
	Freeland Formation	Black Park gravel				
	Moreton Drift?	Anglian glacial deposits	Hornchurch Till	U.St Osyth/U. Holland Gravel	Anglian	12
	Freeland Formation	Winter Hill/Westmill Gravel	Valley did not exist as a Thames course prior to this	St Osyth/Holland Formation		
478						
	Sugworth Channel Deposits	Rassler Gravel?		Wivenhoe/Cooks Green Fm Ardleigh/St Osyth Formation Waldringfield Gravel	Cromerian Complex	21–13
?						
	Combe Formation	Gerrards Cross Gravel		Bures Gravel*		
	Higher divisions of the Northern Drift Group	Beaconsfield Gravel; Satwell Gravel; ?gravel at Chorleywood; Westland Green Gravels; Stoke Row Gravel; Nettlebed Gravel; Nettlebed interglacial deposits		Moreton Gravel*; Stebbing Gravel*	Early Pleistocene	pre–21

* Nomenclature for High-level Kesgrave Subgroup in Essex follows Whiteman (1990).

Appendix 2 Summary of context information

	Type of context	Depth (m)	Top level (m TD)	Comments
200	ground surface	0.20	102.65	present surface
201	make-up layer	0.58	102.59	
202	make-up layer	0.38	102.05	
203	make-up layer	1.6	?	
204	make-up layer	0.3	102.13	
205	ground surface	0.84	102.81	associated with Iron Works?
206	black alluvium	0.42	101.6	marshland deposit
207	fill of ?ditch	1.1	101.32	
208	?ditch	1.1	?	
209	make-up layer	1.3	101.58	
210	fill of trench	1.7	?	
211	service trench	1.7	?	
212	alluvium	0.6	101.52	
213	group of alluvial deposits	1	100.66	fine bands of alluvium
214	band of sand	0.01	99.93	higher energy transportation?
215	alluvium	0.08	99.92	
216	alluvium	0.01	99.9	
217	alluvium	0.1	99.82	
218	alluvium	0.08	99.74	
219	alluvium	0.16	?	
220	alluvium	0.07	?	
221	alluvium	0.08	?	
222	alluvium	0.12	99.45	
223	alluvium	0.06	99.43	

224	alluvium	0.05	99.3	
225	alluvium	0.09	99.29	
226	alluvium	0.01	99.25	
227	sandy alluvium	0.07	?	higher energy transportation?
228	alluvium	0.1	?	
229	alluvium	0.04	?	
230	alluvium	0.01	99.12	
231	alluvium	0.44	98.44	
232	sandy alluvium	0.01	98.36	higher energy transportation?
233	alluvium	0.36	98.36	
234	sandy alluvium	0.02	98.16	higher energy transportation?
235	alluvium	0.45	98.14	
236	peaty alluvium	0.2	97.70	weathered peat
237	alluvium	0.4	?	contains pebbles, high energy transportation?
238	peat	?	?	
239	alluvium	0.1	100.41	
240	alluvium	0.06	100.3	
241	alluvium	0.05	100.24	
242	alluvium	0.08	100.18	
243	alluvium	0.07	100.08	
244	alluvium	0.04	100.01	
245	alluvium	0.06	100.22	
246	alluvium	0.08	100.06	
247	alluvium	0.04	?	
248	alluvium	0.1	99.65	
249	alluvium	0.1	99.59	

250	alluvium	0.08	99.48	
251	alluvium	0.12	99.42	
252	alluvium	0.08	99.32	
253	alluvium	0.22	99.25	
254	sandy alluvium	0.02	98.95	higher energy transportation?
255	alluvium	0.16	98.88	
256	alluvium	0.01	98.72	
257	alluvium	0.06	?	
258	alluvium	0.1	98.68	
259	alluvium	0.1	98.48	
260	alluvium	0.12	98.27	
261	alluvium	0.08	98.17	
262	peat	0.3	98.42	contained well-preserved wood.
263	sandy alluvium	0.01	?	higher energy transportation?
264	alluvium	0.15	?	
265	alluvium	>0.6	?	
266	?channel	?	?	later sequence may fill channel?
267	peaty clay	0.6 m	98.15	well-formed peat
268	alluvium	0.18	96.87	initial alluviation
269	Thames Gravel	?	96.80	

Appendix 3 Jubilee Line Extension Project: archaeological evaluation specification for sites east of the River Lea

This specification is to be read in conjunction with the Jubilee Line Assessment Report of Desk Study, the Archaeological Agreement and the site specific Scope of Works which includes trench design and attendances. The evaluation has been designed, within the technical constraints of the site, to achieve a sample of the area of proposed groundwork.

Evaluation Techniques

1 The trenches will be opened by mechanical excavators, with removal of undifferentiated topsoil or modern overburden, down to the first significant archaeological horizon. The machine will remove level spits moving along the length of the trench creating a stepped profile where required. On reaching the first significant horizon that level will be cleaned in plan using a ditch bucket and /or hand cleaning if the deposits merit it. All machine works will be under archaeological supervision and will cease immediately significant evidence is revealed.

2 All archaeological assessment is by hand with cleaning, examination and recording both in plan and section. The objective is to define remains rather than totally remove them. Full excavation will be confined to the least significant remains (eg dumped layers) which may allow underlying stratigraphy and features to be exposed and recorded. Within significant levels partial excavation, half-sectioning, the recovery of dating evidence and the cleaning and recording of structures is preferable to full excavation.

3 Archaeological excavation may require work by pick and shovel or occasionally further use of the machine. Such techniques are only appropriate for the removal of homogeneous or low grade deposits which may give a "window" into underlying levels. They will not be used on complex stratigraphy and the deposits to be removed will have been properly recorded first.

4 Particular care will be taken not to damage any areas containing significant remains which might merit preservation in situ. Such evidence would normally include deep or complex stratification, settlement evidence and structures. Such areas will be protected and not left to weather.

5 Any human remains must also be left in situ, covered and protected. Removal will only take place under appropriate Home Office and environmental regulations.

Excavation and Recording

6 Evaluation involves selective excavation and recording of the ancient remains by hand, with individual features and layers (contexts) being recorded to scale on plan, pro-formas and by photography. A recording system compatible with that used by the Passmore Edwards Museum will be utilised. Context sheets will include all relevant Stratigraphic relationships and for complex stratigraphy a separate matrix diagram will be employed. A trench plan will be drawn up and located on the OS grid. Context plans will record the full extent of all archaeological deposits.

7 Sections containing significant deposits, including half-sections, will be drawn as appropriate. Upon completion of the evaluation trench at least one long section will be drawn, including a profile of the top of natural deposits.

8 All archaeological plans and sections will be on drawing film at a scale of 1:10 or 1:20 and will be include context numbers and OD spot heights for all principle strata and features.

9 An adequate photographic record of any significant archaeological remains will be made, in both plan and section.

Finds and Samples

10 A high priority will be given to dating remains and so all artifacts and finds will be retained. This could include pottery, tile, bone, building material, wooden artifacts, stone tools and textiles. Similarly high priority will be the recovery of specialist samples for scientific analysis, particularly samples for the absolute dating, structural materials and cultural/environmental evidence including dendrochronological, diatom, plant, seed and pollen analysis. A comprehensive sampling strategy will form part of further archaeological works if they are required, with visits from environmental specialists.

11 All finds and samples will be treated in a proper manner to prevent deterioration. They will be treated according to the Passmore Edwards Museum specifications. Arrangements will be made for conservation of organic and metal artifacts and other fragile finds. This will involve cleaning, labelling, cataloguing and secure, stable storage in appropriate containers. Arrangements for on-site conservation work will be made if any significant fragile finds are discovered that need specialist lifting or treatment.

Off-site post-excavation

12 A summary report on the results of the evaluation will be prepared. This will include recommendations for further action, identifying any areas suitable for either preservation in situ or rescue excavation in advance of construction.

13 The results of the evaluation will be kept in an easily accessible archive at the Passmore Edwards Museum. This will contain the desk study/documentary survey, the ordered records (written, drawn, photographic), the environmental and finds information. To prepare the archive the finds will be cleaned, catalogued, quantified and dated in a manner compatible with that used by the Passmore Edwards Museum. The archive will need to contain a sequence diagram, evidence for phasing, a summary by phase, an introduction, text and conclusions. Lists of context, drawings, photographs and finds will be required.

14 All original records, finds and samples will subsequently be given long-term storage and curation at the Passmore Edwards Museum.

John Dillon
JLE Archaeological Project Co-ordinator
22nd October 1991

Notes on the archaeological specification

No 6 Overall trench plans, and multi-feature/deposit phase plans were also prepared on site.

A series of meetings was held with PEM representatives to ensure recording system compatibility. A context sheet containing elements of both PEM and OAU recording systems was prepared (copy attached).

No 8 Plans at 1:50 and 1:100 were also used

Bibliography

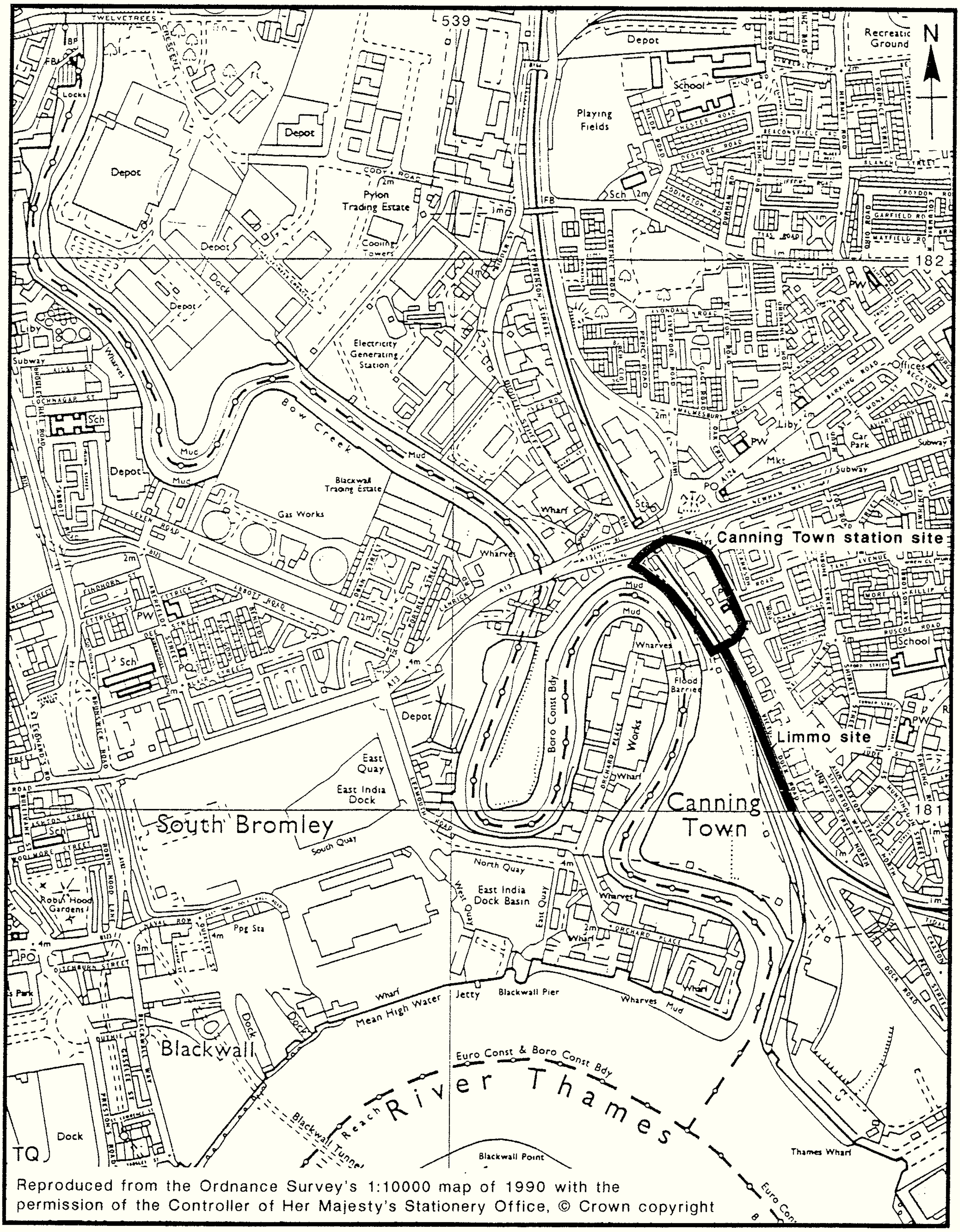
Devoy 1979 Flandrian sea level changes and vegetational history of the Lower Thames estuary, *Philosophical Transactions of the Royal Society of London*, B285; 355-407.

ERL 1990 *Jubilee Line Extension archaeological assessment: report of desk study*, Environmental Resources Limited, June 1990.

OAU 1991 *Canning Town Station: archaeological field evaluation 1991*, Oxford Archaeological Unit.

OAU 1993 *The Jubilee Line Extension (corridor and worksites) from Stratford Station to Canning Town: industrial history and possible ground contamination sources*, Oxford Archaeological Unit.

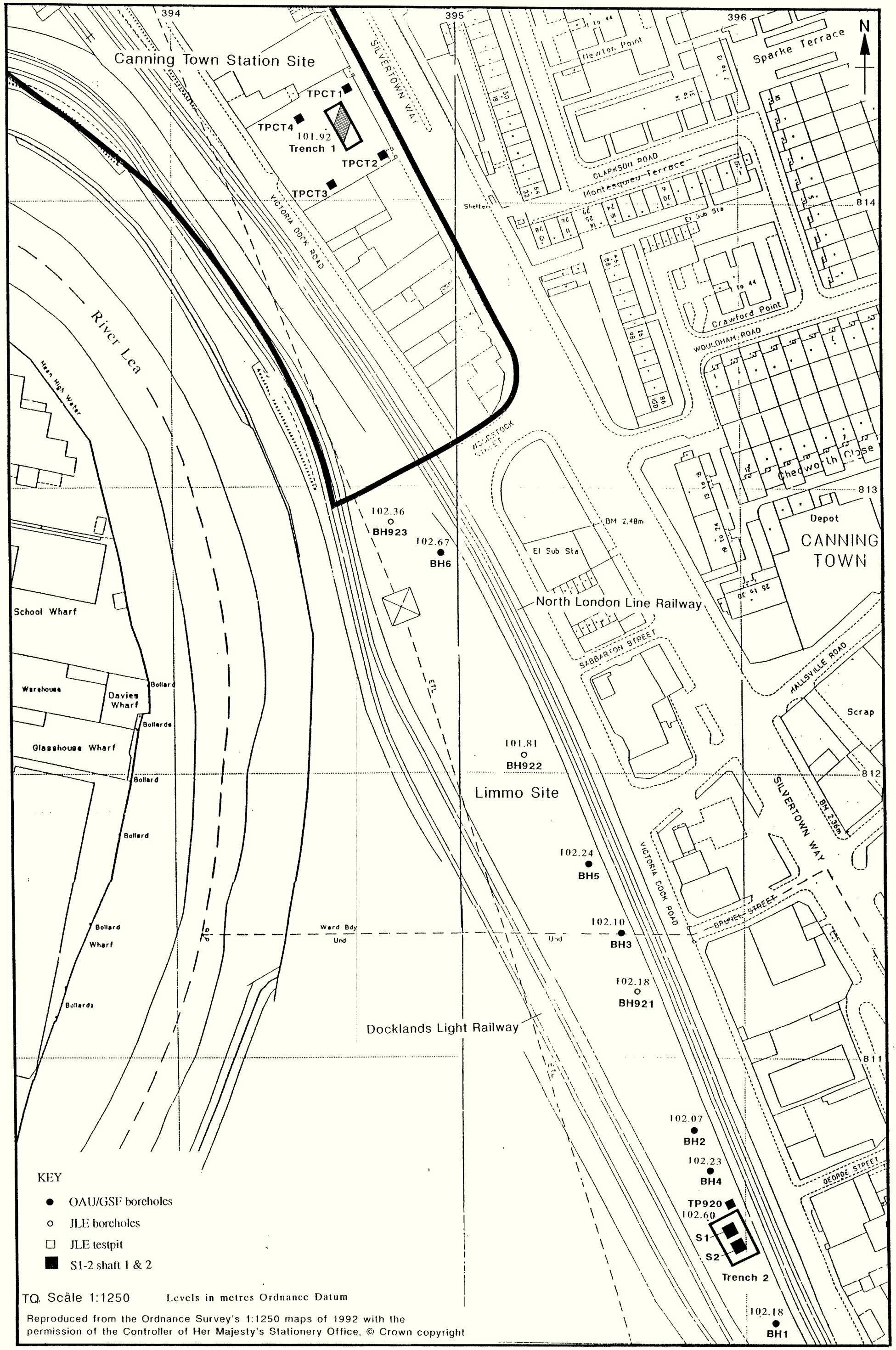
Tyers 1988 The prehistoric peat layers (Tilbury IV), in Hinton, P (ed) *Excavations in Southwark 1973-76, Lambeth 1973-79*, London.



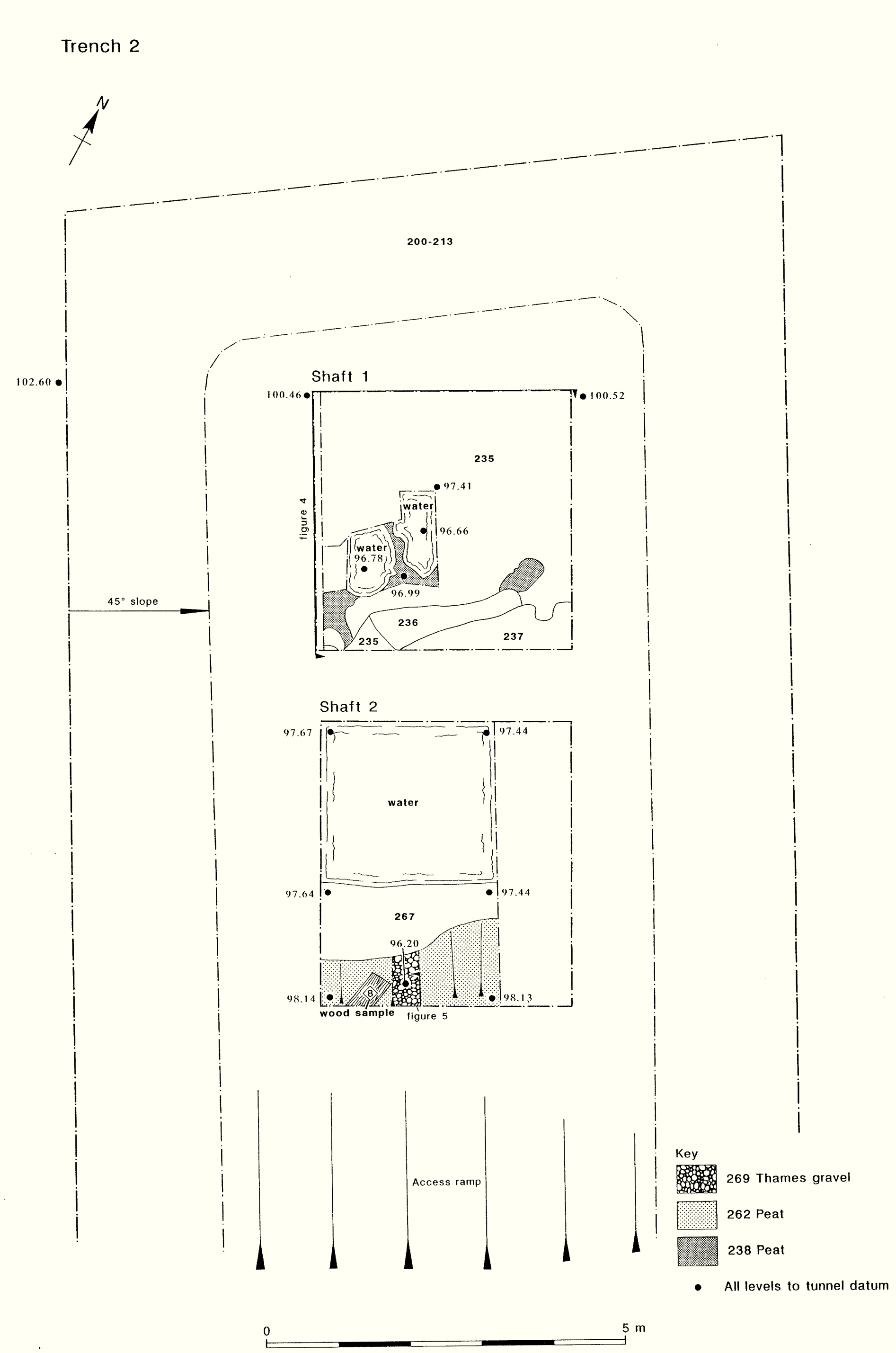
Scale 1:10000

Location map - extent of site

figure 1

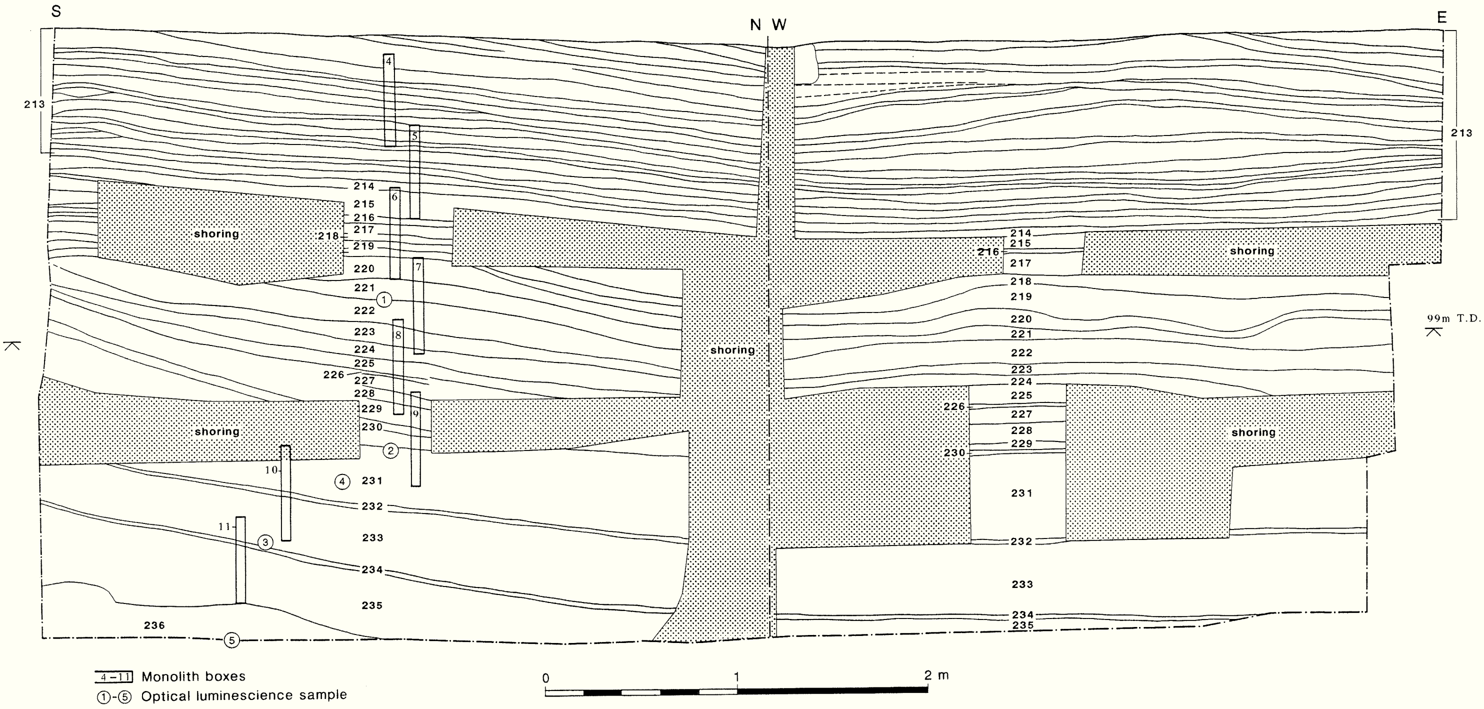


Trench and borehole location figure 2



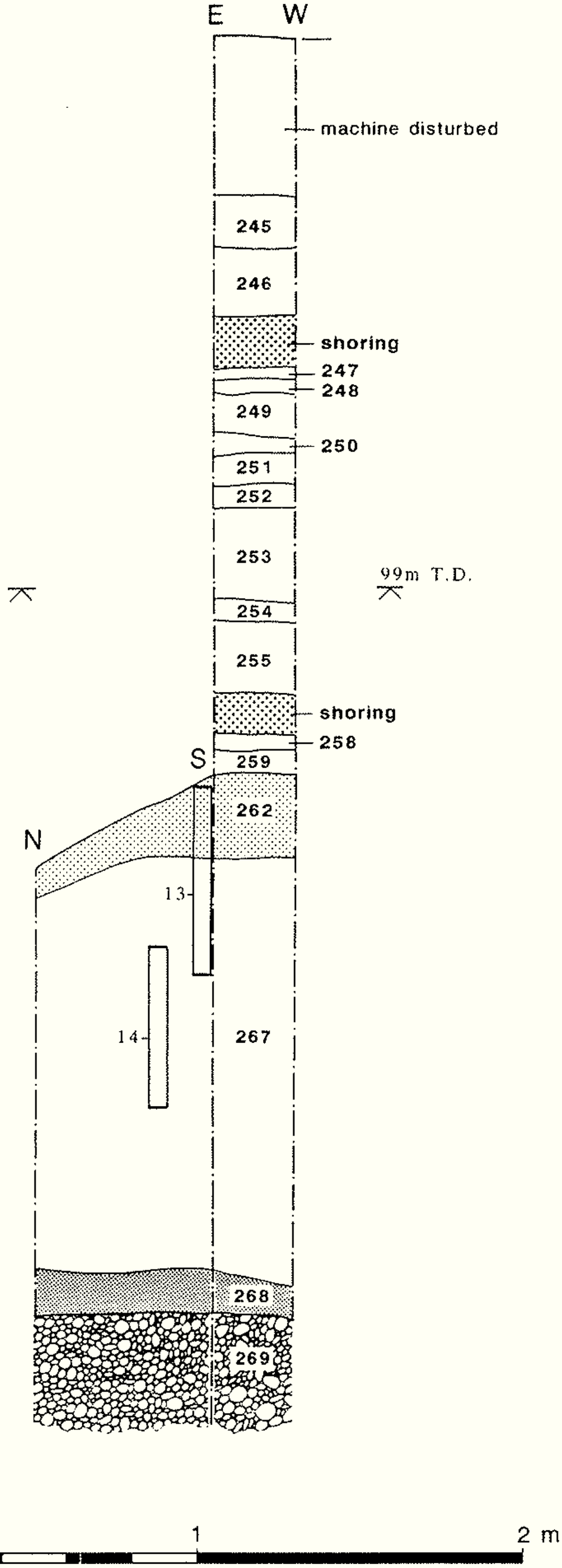
Canning Town Limmo Site Trench 2 figure 3

Shaft 1



Shaft 1 N/S, W/E composite section figure 4

Shaft 2



Shaft 2 N/S, E/W composite section figure 5

Oxford Archaeological Unit
46 Hythe Bridge Street
Oxford OX1 2EP

Tel: 0865 243888 Fax: 0865 793496

Registered Charity No. 285627
Private Limited Company No. 1618597