Geoarchaeological Assessment Report of land at

ARMADA 1 GALLIONS REACH BECKTON

For Robinson, Kenning and Gallagher

Andrew Dufton MSc

L-P:ARCHÆOLOGY

Geoarchaeological Assessment Report of land at

ARMADA 1 GALLIONS REACH BECKTON

Client:	Robinson, Kenning and Gallagher
Local Authority:	London Borough of Newham
NGR:	543965, 181030
Planning App:	06/00945/LTGDC
Author(s):	A Dufton
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Abstract

Three geoarchaeological boreholes were completed at Armada 1, Gallions Reach, Beckton. All three recorded multiple layers of peat deposits interbedded with alluvial silt and clay. The cores of one representative borehole were then sampled for radiocarbon dating, diatom and pollen analysis.

The results of palaeo-environmental assessment indicate a series of periods of organic sedimentation interspersed with tidal inundation and estuarine conditions. Pollen analysis shows the rapid establishment of alder on site with mixed woodland vegetation further inland. Evidence of deforestation and the spread of grassland and pasture is recorded by c. 790-510BC.

A predictive model of deposits was created for the site at Armada 1 incorporating data from surrounding developments to further elaborate on geoarchaeological conditions.

Given the palaeo-environmental information collected from the boreholes further works are not necessary at the site.

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1. Introduction and Scope of Study

1.1. This report has been prepared by Andrew Dufton of L – P : Archaeology on behalf of Robinson, Kenning and Gallagher.

1.2. The document considers works at Gallions Reach, Beckton, Newham, London. The local authority is The London Borough of Newham. The site is centred at National Grid Reference 543965, 181030 (**FIGURE 1**).

1.3. The geoarchaeological works are a response to an archaeological condition applied to planning application 06/00945/LTGDC. The works consisted of three boreholes targeting areas not examined in past geotechnical works.

1.4. The works were carried out from the 27th of November to the 3rd of December, 2006. The boreholes were completed by Soils Limited under the supervision of Dr. Tom Hill of Birmingham Archaeo-Environmental, University of Birmingham.

1.5. The works followed the methodology laid out in YOUNG 2006 (**APPENDIX 2**).

1.6. This document seeks to draw together results of previous geotechnical work undertaken in the area with the current results in order to create a model of geoarchaeological deposits.

2. Site Background

2.1. PLANNING BACKGROUND

2.1.1. A planning application for a new storage/distribution centre at the site was submitted in June, 2006 (application number 06/00954/LTGDC).

2.1.2. An archaeological condition was attached to the approved planning permission requiring a programme of archaeological work. The reasons for this decision are as follows:

> Important archaeological remains may exist on this site. Accordingly the planning authority wishes to secure the provision of an archaeological investigation and the subsequent recording of the remains prior to development, in accordance with Policy EQ43 of the Unitary Development Plan and PPG16.

2.1.3. The current works have been undertaken by L – P : Archaeology in order to satisfy this condition.

2.2. TOPOGRAPHY

2.2.1. Current plans for development at Gallions Reach, Beckton consist of four sites: Armada 1, Armada 1A, Gallions Roundabout, and Gallions Approach (**FIGURE 2**). The current works are concerned solely with the Armada 1 site.

2.2.2. Armada 1 covers an area of approximately 4.45 hectares to the east of the track of the DLR. Prior to development works the site was disused and did not contain any above ground structures (LOCKE AND PHILLIPS 2003:III).

2.2.3. The site slopes gently from the north to the south, with observed elevation values ranging between 5.5 and 6.2m Above Ordnance Datum (AOD). A depression in the southernmost site area is significantly lower, with elevation values around 4.0m AOD.

2.3. GEOTECHNICAL SUMMARY

2.3.1. Information across the Gallions Reach development area is available from a series of geotechnical investigations dating from 2001. Results from a total of 42 cable percussive boreholes are considered in this report (**FIGURE 2**).

ARMADA 1

2.3.2. Initial geotechnical data for the Armada 1 site was obtained from 10 boreholes, ranging in depths from 20.5m to 26.5m below ground level, and a subsequent ground investigation report of the site completed in 2003 (LOCKE AND PHILLIPS 2003).

2.3.3. An additional 10 boreholes completed in 2006, with depths from 13m to 15.5m below ground level, add further insight to the Armada 1 area (CAMPBELL REITH HILL 2006).

2.3.4. Ground levels are relatively level and fall mostly within the values of 5.3 to 5.8m OD. Made ground is observed at all borehole locations, with thicknesses ranging from 3.2m to 7m and highly variable composition.

2.3.5. Alluvium at the Armada 1 site also shows varied composition both vertically and laterally (LOCKE AND PHILLIPS 2003:17).

2.3.6. Fifteen of the sixteen boreholes completed at Armada 1 also observed peat deposits. These deposits are found at depths of 5.7m to 9m below ground level, and range in thickness from 0.5m to 4.8m (**FIGURE 3**).

2.3.7. River Terrace Deposits are relatively uniform across the site. Consisting primarily of fine to coarse angular gravel, Terrace Deposits are observed from depths of 6.5m to 14m below ground level (**LOCKE AND PHILLIPS 2003:17**). Thanet Sands mark the deepest recorded strata within the sites, with depths ranging from 15m to 18.1m below ground level, and are relatively uniform throughout (LOCKE AND PHILLIPS 2003: 18).

ARMADA 1A

2.3.8. Immediately to the west, Armada 1A shows a similar pattern of deposits. Peat deposits are observed at three of the 1A boreholes, from depths of 5.3m to 7.3m below ground level and ranging in thickness from 0.45m to 1.4m.

GALLIONS ROUNDABOUT

2.3.9. Data for the raised area at Gallions Roundabout site was gained from six boreholes completed as part of a larger report on the site in 2001 (**SYMONDS GROUP 2001**).

2.3.10. A relatively uniform layer of grey silty alluvial clay is observed across the site. Peat deposits are also observed at five of the boreholes, from depths of 4.5m to 8.9m below ground level and thicknesses up to 1.7m.

2.3.11. River Terrace Deposits are found from depths of 7.4m to 11.7m below ground level. Only one borehole, BH1, went below the gravel deposit to record green silty Thanet Sands at 19m below ground level.

GALLIONS APPROACH

2.3.12. Results from 16 boreholes on the Gallions Approach site, completed in 2002, are available for analysis (GREEN AND BRZESKI 2002). Alluvium deposits across the site range from 3.3m to 9.9m in thickness. Although variable throughout, there is a noted tendency toward a composition of grey mottled black clay/silt (GREEN AND BRZESKI 2002:19).

2.3.13. Only two boreholes, BH2 and BH16, record fibrous peat horizons for this area occurring at depths of 11.4m and 10.9m respectively with a thickness of 0.9m. This is a noticeable departure from the other two sites where a majority of the boreholes recorded peat deposits (**FIGURE 3**).

2.3.14. Relatively uniform River Terrace Deposits, consisting of "sandy fine to coarse angular to subrounded chalk and flint gravel", are observed from depths of 6.5m to 13.5m below ground level (GREEN AND BRZESKI 2002:19).

2.4. ARCHAEOLOGICAL BACKGROUND

2.4.1. An archaeological desk based assessment has previously been completed for the site and should be consulted for a detailed description of the potential for survival of archaeological remains (YOUNG 2003).

2.4.2. There is no evidence to suggest any settlement activity on site dating to the Prehistoric period. However the site is considered of significance due to the

geoarchaeology of the area and a there is a high likelihood that palaeo-environmental information is present on site.

2.4.3. During the Roman period the site is close to an area thought to contain a significant Roman settlement (YOUNG 2003). The site was likely used for agricultural purposes during this period.

2.4.4. Documentary and cartographic evidence from the Saxon, Medieval, and Post Medieval periods suggests the site was located close to the settlements of Eastham and Woolich (YOUNG 2003). The site was most likely used as pasture adjacent to these settlements for the duration of these periods.

3. Methodology

3.1. The detailed methodology for the geoarchaeological assessment is reproduced in **APPENDIX 2.**

3.2. The primary aims of the geoarchaeological boreholes were as follows:

- Record the depth and character of the deposits in each borehole;
- Assess the potential of these deposits for palaeo-environmental analyses;
- Recover suitable sub-samples for analysis of sub-fossil pollen and diatoms and material for radiocarbon dating
- Assess the implications of the palaeo-environmental record for landscape development.

3.3. The boreholes were completed by Soils Limited under the observation of Dr. Tom Hill of Birmingham Archaeo-Environmental, University of Birmingham.

3.4. In addition, a predictive model was created using the existing borehole data outlining the depths and thickness of various deposits.

3.5. The model was created using the Kriging method of interpolation in ArcGIS 8.2. This technique uses data from individual boreholes to create a continuous surface model by optimising the weighted average of surrounding observations for any given point (WHEATLEY AND GILLINGS 2002:196).

3.6. Initial calculations produced an error surface indicating the varied reliability of the calculations. Areas of lesser reliability were targeted for investigation in the current works (**FIGURE 4**).

3.7. Results from the current works were then used to update the predictive model.

4. Results

4.1. BOREHOLE RESULTS

4.1.1. The palaeo-environmental assessment of the three boreholes was completed by Dr. Tom Hill of Birmingham Arhaeo-Environmental. For a detailed description of the borehole deposits please consult **APPENDIX 3**.

4.1.2. The observed stratigraphy of the three boreholes was similar to the results of previous geotechnical works. Made ground is observed as deep as -1.59m AOD. All three boreholes contained peat deposits, and gravel levels range from -3.84 - -6.99m AOD.

4.1.3. Initial stratigraphic analysis identified the sequence in borehole 1 as most representative of the site. Three separate peat units were observed interbedded with alluvial deposits. A wood horizon was also identified at -5.74 to -6.11m AOD. The sequence from borehole 1 was subsequently used for palaeo-environmental assessment (HILL AND GEAREY 2007).

4.1.4. Three organic samples from this core were submitted for radiocabon dating. The results illustrate organic sedimentation on the site beginning between approximately 5220-4950 BC. After a period of tidal inundation there is a return to *in situ* organic sedimentation from approximately 4330-4060 BC.

4.1.5. A terrestrial freshwater environment is then dominant until 790-510BC, at which point estuarine conditions are reestablished and dominate the lowlands. A final phase of peat development was contaminated by overlying made ground and thus was unavailable for analysis (HILL AND GEAREY 2007).

4.1.6. Diatom preservation was poor within most of the samples. However most species identified prefer brackish water environments, suggesting the above deposition of silts and clays "occurred within an estuarine environment where tidal inundation was common"(HILL AND GEAREY 2007).

4.1.7. Pollen preservation was good for most of the samples. Pollen analysis shows alder becoming established after the beginning of organic settlement accumulation approximately 5220-4950 BC, possibly forming floodplain carr (HILL AND GEAREY 2007).

4.1.8. Vegetation further inland was mixed woodland. There is some evidence for anthropogenic activity on dryland areas by approximately 790-510BC resulting in deforestation of dryland woodland and the subsequent spread of pastures (HILL AND GEAREY 2007).

4.2. PREDICTIVE MODELING

4.2.1. The above results from the boreholes was then entered into an existing geoarchaeological model using data from Armada 1 and the associated sites of Armada 1A, Gallions Roundabout, and Gallions Approach.

4.2.2. The model creates a continuous surface illustrating the levels of various deposits and helps to provide a general understanding of the geoarchaeology across the study site and the wider area.

4.2.3. The results of the modeling exercise are by no means exhaustive. While the model is by no means perfect, it still serves as a valuable indication of possible trends emerging across the four sites.

4.2.4. An attempt at modeling the levels or thicknesses of alluvial deposits was unsuccessful. The highly varied levels of made ground prevent the creation of a meaningful surface and render any results unreliable.

4.2.5. Peat deposits were not visibly affected by made ground, and as such peat thickness present a smoother and more believable modeled surface (**FIGURE 5**).

4.2.6. Boreholes to the east on the Gallions Approach site show no peat deposits. With a significant concentration of peat to the southwest, the Armada 1 area shows the thickest peat levels. A gradual decline in peat thickness is observed moving to the west of Armada 1.

4.2.7. Perhaps the most interesting results of the predictive modeling exercise are observed in the levels (OD) surface of River Terrace Deposits (**FIGURE 6**).

4.2.8. As expected, gravel levels are lowest to the east directly adjacent to the river. An interesting elevation of the Terrace Deposits appears in the centre of Gallions Approach, followed by a depressed channel running northeast-southwest across the eastern portion of Armada 1.

4.2.9. Concentrated peat deposits observed above are seen to correspond with the lower gravel levels. From this region Terrace Gravels are seen to rise gradually to the west across the Armada 1A and Gallions Roundabout sites.

4.2.10. A hypothetical interpretation of the modeled surfaces could suggest the observed raised gravel levels at Gallions Approach possibly represent an eyot along the banks of the Thames, separated from the mainland by a palaeo-channel.

5. Summary and Conclusions

5.1. Three geoarchaeological boreholes were completed at Armada 1, Gallions Reach from the 27th November to 3rd December, 2006.

5.2. All three of the boreholes revealed organic peat deposits interbedded with alluvial silts and clays.

5.3. Radiocarbon dating reveals initial organic sedimentation around 5220-4950 BC, followed by a period of tidal inundation. A terrestrial freshwater environment dominated to circa 790-510 BC, at which point estuarine conditions were reestablished.

5.4. Diatom analysis reveals a majority of species with a preference for brackish water environments, further suggesting an estuarine environment during the deposition of silts and clays.

5.5. Pollen analysis shows the alder established on site, probably forming floodplain carr. Vegetation further inland was apparently mixed woodland, but by approximately 790-510 BC deforestation and the spread of pastureland is observed.

5.6. The creation of a predictive model of geological deposits for the site and nearby developments adds a further layer of understanding of the geoarchaeological characteristics of the site.

5.7. The current evaluation has provided an increased understanding of the palaeo-environmental conditions on site. As such further works on the site should not be required.

FIGURES

FIGURE 1 // Site Location General

0 1,000 m

CLIENT // Robinson, Kenning and Gallagher

PROJECT // 0278L- Royal Docks Road

DESCRIPTION // Site location general

DOC REF: LP0278L-GAR-v1

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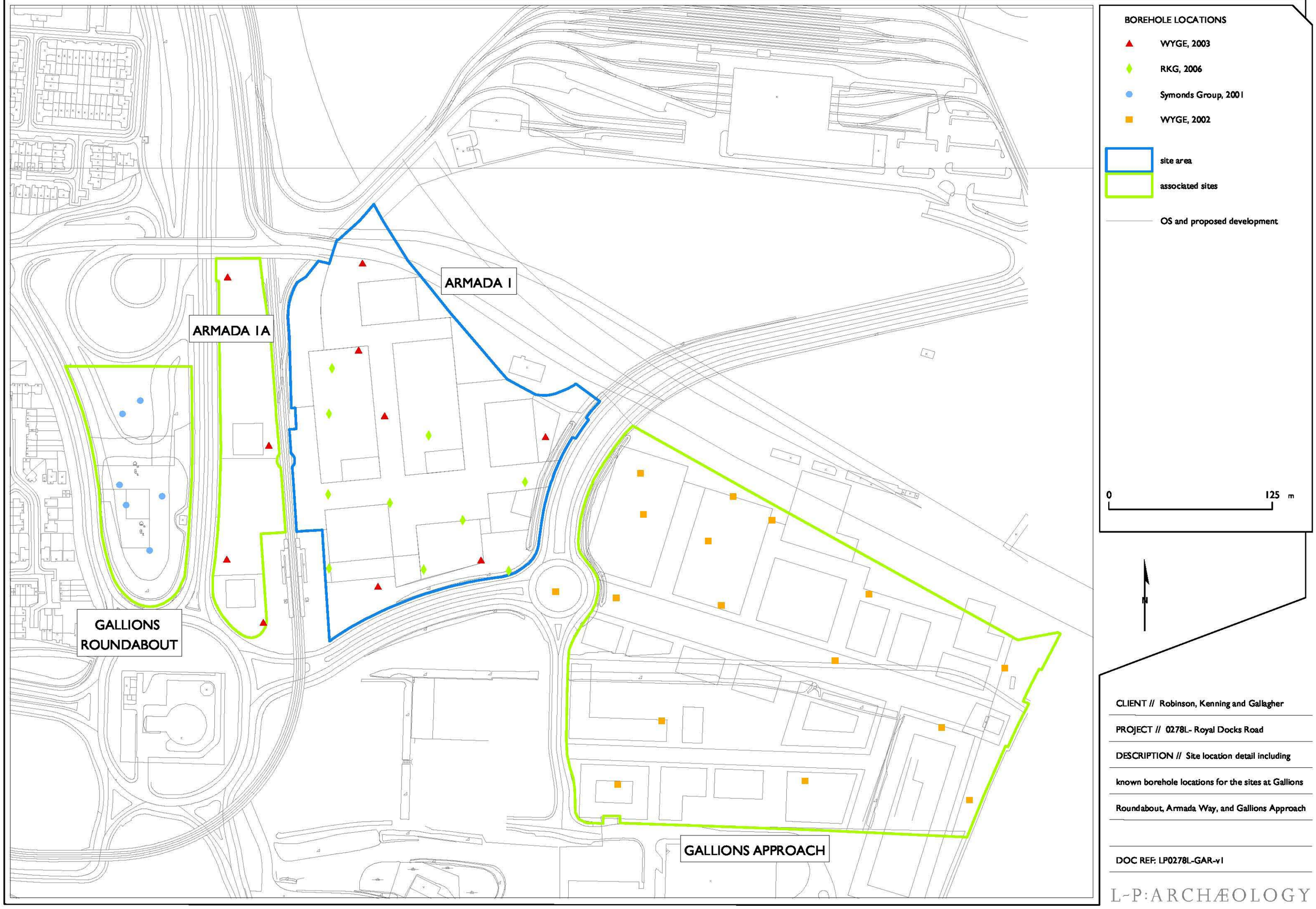
Figure 2 // Site Location Detail



CLIENT // Robinson, Kenning and Gallagher

PROJECT // 0278L- Royal Docks Road

DESCRIPTION // Site location detail including known borehole locations for the sites at Gallions Roundabout, Armada Way, and Gallions Approach

DOC REF. LP0278L-GAR-v1

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Figure 3 // Observed Peat Deposits

observed peat deposits

site area

associated sites

OS and proposed development

0 125 m

N

CLIENT // Robinson, Kenning and Gallagher

PROJECT // 0278L- Royal Docks Road

DESCRIPTION // Borehole locations for the sites at Gallions Roundabout, Armada Way, and Gallions Approach with observed peat deposits.

DOC REF: LP0278L-GAR-v1

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FIGURE 4 // Borehole Locations

0 100 m

CLIENT // Robinson, Kenning and Gallagher

PROJECT // 0278L-Royal Docks Road

DESCRIPTION // Borehole locations in relation to initial model variance

DOC REF: LP0278L-GAR-v1

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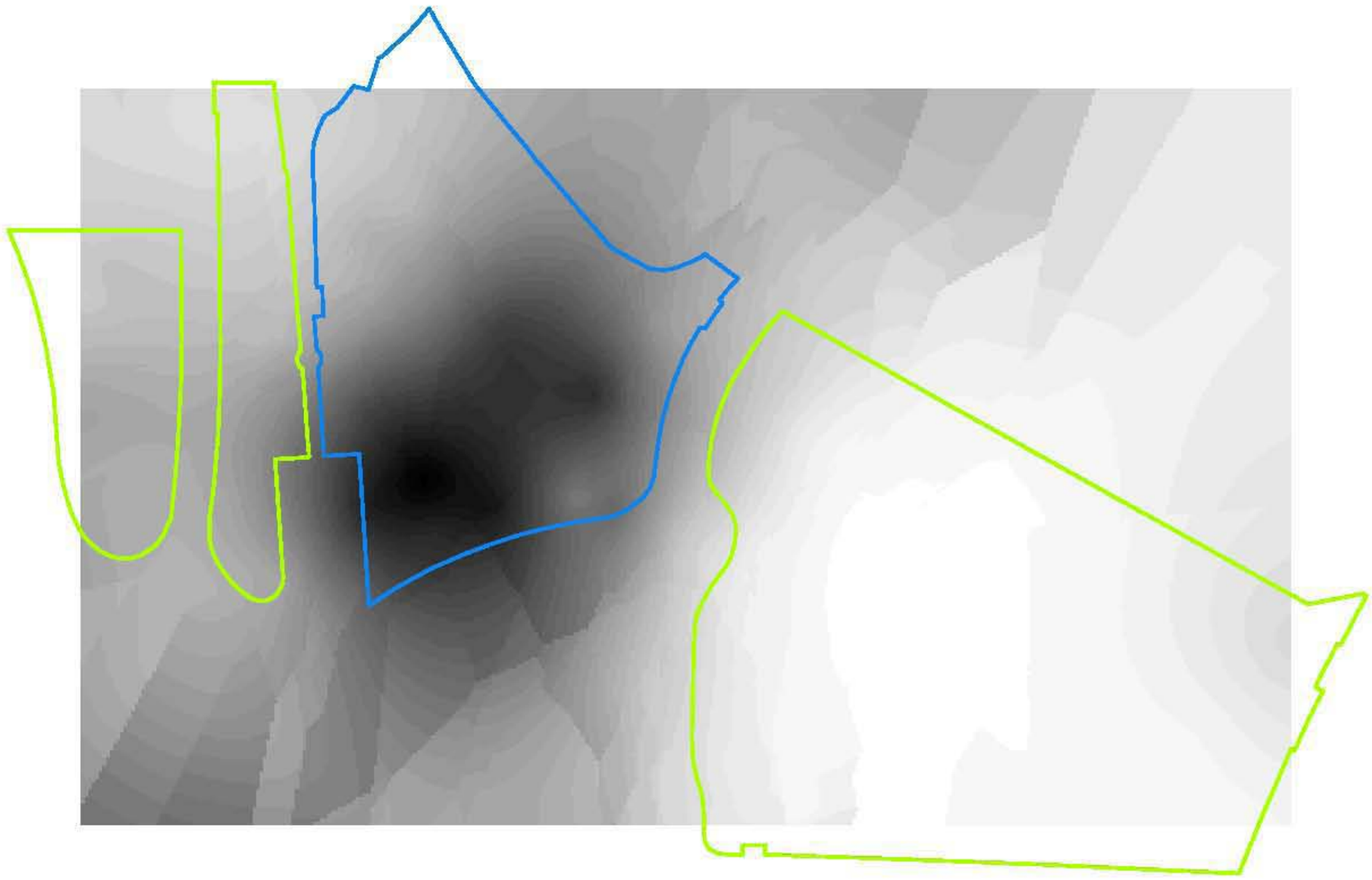
Figure 5 // Peat Deposits



peat thickness

0m (no peat deposits)

3.5 m

site area

associated sites

0 125 m

CLIENT // Robinson, Kenning and Gallagher

PROJECT // 0278L- Royal Docks Road

DESCRIPTION // Thickness of peat deposits across all four sites as modelled in GIS. Darker areas indicate thicker deposits, and the lightest (white) areas are void of peat deposits

DOC REF: LP0278L-GAR-v1

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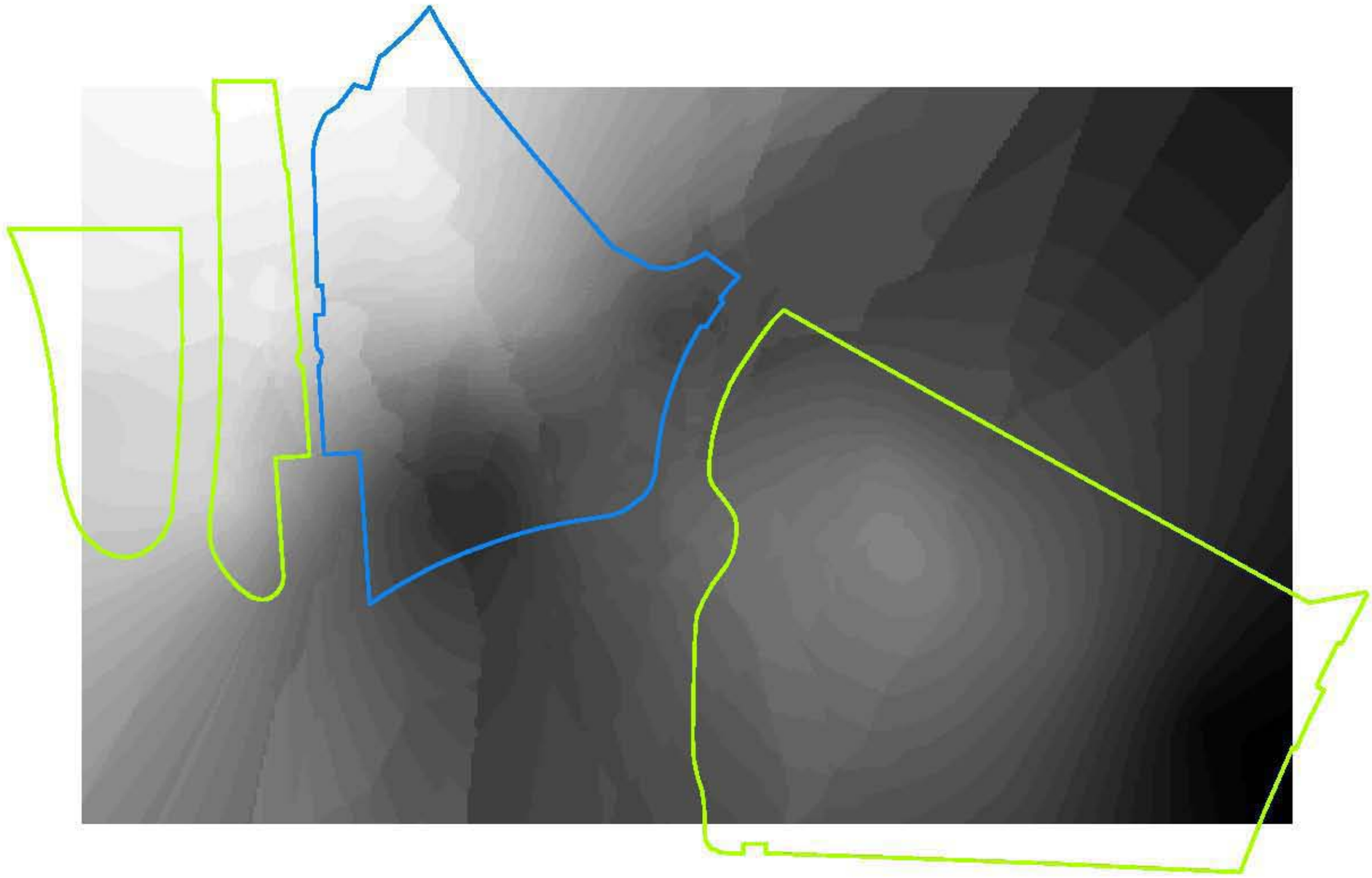
Figure 6 // River Terrace Deposits



river terrace levels

-3.6 m OD

-7.4 m OD

site area

associated sites

0 125 m

CLIENT // Robinson, Kenning and Gallagher

PROJECT // 0278L- Royal Docks Road

DESCRIPTION // Level (mOD) of river terrace deposits across all three sites as modelled in GIS. Darker areas indicate a lower gravel horizon.

DOC REF: LP0278L-GAR-v1

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Figure 7 // Updated Model Variance

model variance

high accuracy

low accuracy

site area

associated sites

0 125 m

N

CLIENT // Robinson, Kenning and Gallagher

PROJECT // 0278L - Royal Docks Road

DESCRIPTION // Updated combined variance of the modelled surfaces as computed in GIS. Darker areas indicate lower model accuracy.

DOC REF: LP0278L-GAR-v1

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SOURCES CONSULTED

APPENDIX 1

BIBLIOGRAPHIC

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SPECIFICATION

APPENDIX 2

Specification for Geoarchaeological Works at

GALLIONS REACH (ARMADA 1)

For Robinson, Kenning and Gallagher

Janine Young MA

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Specification for Geoarchaeological Works at

GALLIONS REACH (ARMADA 1)

Client:	Robinson Kenning and Gallagher
Local Authority:	London Borough of Newham
NGR:	TL86148, 64513
Planning App:	
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1.1. This specification for geoarchaeological works has been prepared by Janine Young and incorporates detailed methodologies from BUAFU and Soils Limited. It has been prepared on behalf of Robinson, Kenning and Gallagher.

1.2. This specification concerns land located at Gallions Reach in the London Borough of Newham. The site is currently undergoing redevelopment as part of a wider development in the area. Previous work on the site has referred to the land as "Armarda 1".

1.3. An Archaeological Desk Based Assessment was carried out on the site in 2002, and whilst this suggested a low archaeological potential it did highlight the strong potential for palaeo-environmental evidence being recovered from the site.

1.4. A subsequent geoarchaeological summary has used borehole data from geotechnical test pits to produce a model of the geology of the site. This has been used to inform the strategy for further works.

1.5. Further works have been agreed with English Heritage on the basis of the results of the geoarchological assessment.

1.6. The works will consist of 3 cable percussion boreholes located across the site. These have been positioned to maximise data recovery whilst taking into consideration the existing conditions on site.

1.7. This document describes the methodologies for retrieving the samples from the site and analysing the samples to assessment level. Further analysis may be required on the samples, depending on the results of the assessment.

2. Site Background

2.1. GEOLOGY

2.1.1. Initial geotechnical data for the Armada 1 site, and the adjacent Armada 1A site to the west, was obtained from 10 boreholes, ranging in depths from 20.5m to 26.5m below ground level, and a subsequent ground investigation report of the site completed in 2003 (LOCKE AND PHILLIPS 2003).

2.1.2. An additional 10 boreholes completed in 2006, with depths from 13m to 15.5m below ground level, add further insight to the Armada 1 area (CAMPBELL REITH HILL 2006).

2.1.3. At Armada 1, ground levels are relatively level and fall mostly within the values of 5.3 to 5.8m OD. Made ground is observed at all borehole locations, with thicknesses ranging from 3.2m to 7m and with highly variable composition.

2.1.4. Alluvium at the Armada 1 site also shows varied composition both vertically and laterally (LOCKE AND PHILLIPS 2003:17).

2.1.5. Fifteen of the sixteen boreholes completed at Armada 1 also observed peat deposits. These deposits are found at depths of 5.7m to 9m below ground level, and range in thickness from 0.5m to 4.8m.

2.1.6. Armada 1A shows similar deposits. Made ground at the site occurs to depths between 3.8m to 6.5m below ground level. Alluvium deposits at Armada 1A also show great variety between the 4 boreholes.

2.1.7. Peat deposits are observed at three of the 1A boreholes, from depths of 5.3m to 7.3m below ground level and ranging in thickness from 0.45m to 1.4m.

2.1.8. River Terrace Deposits are relatively uniform across the Armada 1 and Armada 1A sites. Consisting primarily of fine to coarse angular gravel, Terrace Deposits are observed from depths of 6.5m to 14m below ground level (**LOCKE AND PHILLIPS 2003:17**).

2.1.9. Within the deeper 2003 boreholes, Thanet Sands are found at all locations within the Armada 1/1A sites. Thanet Sands mark the deepest recorded strata within the sites, with depths ranging from 15m to 18.1m below ground level,

and are relatively uniform throughout (LOCKE AND PHILLIPS 2003: 18).

2.2. TOPOGRAPHY AND SITE CONDITIONS

2.2.1. Armada 1 covers an area of approximately 4.45 hectares to the east of the track of the DLR. Prior to development works the site was disused and did not contain any above ground structures (LOCKE AND PHILLIPS 2003:III).

2.2.2. The site surface falls approximately between 5.0m to 6.0m AOD.

2.2.3. The site is currently being developed.

3. Objectives of Archaeological Evaluation

3.1. Given the extent and results of previous works it has been agreed that an additional three boreholes will be carried out in areas which have been located to maximise information recovery whilst taking into consideration the current site conditions.

GENERAL AIMS OF THE EVALUATION

3.2. The main aims of the coring and palaeoenvironmental assessments at Gallions Reach (Armada 1) will be to:

- Record the depth and character of the deposits in each borehole;
- Assess the potential of these deposits for palaeoenvironmental analyses;
- Recover suitable sub-samples for analysis of sub-fossil pollen and diatoms and material for radiocarbon dating
- Assess the implications of the palaeo-environmental record for landscape development.

4. Methodology

4.1. Each borehole will be accurately located using GPS, EDM or accurate measurements depending on site conditions, and tied in to the national grid.

4.2. A cable percussive rig will be used to excavate each borehole. This will be operated by 'Soils Limited' and a suitably qualified member of their staff according to their Method Statement.

4.3. Each borehole will be monitored by a suitably qualified geo-archaeologist.

4.4. U4/100 samples will be recovered from each borehole from the top of the alluvium to the gravel. These samples will be extruded cleaned and logged at the laboratory facilities of the Institute of Archaeology and Antiquity, University of Birminghan.

4.5. Sediments will be recorded on pro-forma sheets in the field using the Troels-Smith (1955) scheme of sediment description. Through the Troels-Smith scheme each separate deposit unit (layer) is characterised according to its components (clay, silt, plant macro remains, *etc.*) and physical properties (colour, boundary characteristics, *etc.*) on a 4-point scale, where 1 point equals 25 % of the layer. The scheme is descriptive and independent of any knowledge of depositional processes, and its structured approach enables direct comparison of results collected by different investigators (LONG *ET AL.*, 1999).

4.6. Should suitable organic sediments be encountered, the following samples will be taken: six pollen samples from each borehole, six diatom samples from each borehole, two radiocarbon samples.

4.7. Samples will be prepared and analysed according to standard techniques (Moore *et al.*, 1991 for pollen and Plater *et al.* 2000 for diatoms) using laboratory facilities in the Institute of Archaeology and Antiquity, University of Birmingham. Pollen samples will be counted on either an Olympus or Nikon microscope at a magnification of x 400 to a sum of 125 TLPS (total land pollen and spores). Diatom samples will also be counted on Olympus or Nikon microscope at a magnification of x 1000 to a sum of 200 TDV (total diatom valves).

4.8. Samples for radiocarbon dating will be submitted to Beta Analytic Inc., Florida, USA.

5. Schedule of Works

5.1. Soils Limited have been contracted to construct and carry out each borehole using a cable percussive drill. A separate method statement for this is included as an appendix.

5.2. Dr Ben Gearey MIFA will be responsible for all aspects of management of the project. He will also be responsible for pollen analyses.

5.3. The fieldwork will be carried out by Dr Tom Hill. He will also carry out the diatom analyses and report production.

5.4. Field archaeological fieldwork, monitoring and sub-sample collection will be carried out in a single phase. It is anticipated that a final report including results of all palaeoenvironmental assessments, will be produced within three months of fieldwork.

6. Access and Safety

6.1. Reasonable access to the site will be arranged for representatives of the Local Planning Authority and the relevant English Heritage Archaeological Advisor who may wish to make site inspections to ensure that the archaeological investigations are progressing satisfactorily.

6.2. The Local Planning Authority and relevant English Heritage Archaeological Advisor should be given at least 24 hours notice of the commencement date.

6.3. Before any site work commences, a full Risk Assessment Document will be produced setting out the site specific health and safety policies that will be enforced in order to reduce to an absolute minimum any risks to health and safety. This will include separate risk assessments by Soils Limited specific to their equipment and machinery. In addition to this risk assessment, the following considerations will also be made: All relevant health and safety regulations will be followed. Barriers, hoardings and warning notices will be installed as appropriate. Safety helmets and visibility jackets will be used by all personnel as necessary.

7. Report

7.1. A report will be produced detailing methods, results, discussion and conclusions of the borehole investigatons and palaeoenvironmental assessment. The report will provide an outline of the nature of the sediments encountered, the processes responsible for sediment deposition, the results of the palaeoenvironmental assessments and the implications of the data for human activity and the archaeological record.

7.2. This initial report will present an assessment of the investigation results and make recommendations as to the significance of the results and suitability for further analysis and publication following the review procedures set out in MAPII.

7.3. The results will also be used to update the existing model of the underlying topography of the site.

7.4. The report will be arranged as follows:

- A non-technical summary of the results
- An introduction outlining circumstances of and background to the project
- A description of the methodologies used
- Results of the borehole survey and palaeoenvironmental assessments
- Discussion of these results within a local and if appropriate national context
- Conclusions and recommendations for further work.
- References
- Appendix of borehole logs
- Illustrations showing the locations of the boreholes and the revised topography model.
- Copy of the OASIS form.

7.5. Following approval, bound copies of the excavation report will be sent to the client. Two copies will be sent to the Greater London Sites and Monument Record.

8. Archive

8.1. The site code will be used to mark all plans, drawings, context and recording sheets, photographs and other site material during excavation.

8.2. The integrity of the site archive will be maintained. All finds and records will properly be curated by the Museum of London and be available for public consumption. Appropriate guidance set out in the MGC "Standards in the Museum Care of Archaeological Collections" (1992), and the SMA's draft "Selection, Retention and Disposal of Archaeological Collections" (1992) will be followed in all circumstances.

8.3. An accession number for the archive will be allocated by the relevant museum prior to the commencement of the fieldwork

8.4. The minimum acceptable standard for the archival report is defined in the "Management of Archaeological Projects" 5.4. It will include all materials recovered (or the comprehensive record of such materials) and all written, drawn and photographic records relating directly to the investigations undertaken. It will be quantified, ordered, indexed and internally consistent. It will also contain a site matrix, a site summary and brief written observations on the artefactual and environmental data.

8.5. United Kingdom Institute for Conservation guidelines for the preparation of excavation archives for long-term storage (1990) will be followed. Arrangements for the curation of the site archive will be agreed with the appropriate Museum.

8.6. Pursuant to these agreements the archive will be presented to the appropriate museum within 6 months of the completion of the fieldwork (unless alternative arrangements have been agreed in writing with the Local Planning Authority or English Heritage). In addition, written confirmation from the client will be provided for the transfer of ownership.

8.7. The project will be registered and regularly updated as part of the OASIS project. A printed copy of the relevant OASIS form will be included as an appendix in the final report.

SOURCES CONSULTED

APPENDIX 1

BIBLIOGRAPHIC

CAMBELL REITH HILL, 2006. *Validation Report for Armada 1 Site.* Campbell Reith Hill LLP, unpublished report.

GREEN C AND BRZESKI J, 2002. *Ground Conditions Assessment of the Site 3, Gallions Approach, Beckton.* White Young Green Environmental, unpublished report.

LOCKE M AND PHILLIPS S, 2003. *Ground Conditions Assessment of the Armada 1/1A Site, Beckton, London.* White Young Green Environmental, unpublished report.

YOUNG J AND DUFTON A, 2006 *Geoarchaeological Summary of land at Galleons Reach, Sites 1, 2 and 3.* L – P : Archaeology unpublished archive report.

PALAEO-ENVIRONMENTAL ASSESSMENT

APPENDIX 3

Gallions Reach, London: Field Report & Palaeoenvironmental Assessment of Borehole Deposits

Client: L~P: Archaeology

March 2007

By

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LPA-28-07

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BIRMINGHAM ARCHAEO-ENVIRONMENTAL BAE

SUMMARY

- L~P Archaeology undertook a desk-based geoarchaeological assessment on behalf of Robinson, Kenning and Gallagher concerning land at Gallions Reach in the London borough of Newham. Due to the abundance of both archaeological and palaeoenvironmental discoveries throughout the Thames Estuary lowlands, the site contained a sedimentary archive with potential to shed light on past environmental changes in this area. Birmingham Archaeo-Environmental were sub-contracted to monitor the drilling of three cable percussive boreholes on the site. Complete sedimentary sequences from each of the cores were extracted for stratigraphic analysis and consideration for subsequent palaeoenvironmental assessment.

- This report presents the results of the fieldwork and palaeoenvironmental assessment undertaken for Gallions Reach, London. Initial stratigraphic analysis identified one core for palaeoenvironmental assessment. Three peat units interbedded with alluvial silts and clays were identified overlying river terrace gravels. The cores were sub-sampled for pollen and diatoms, whilst three suitable organic samples were submitted for radiocarbon dating in order to provide a chronostratigraphic framework.

- Radiocarbon dating of the interbedded peat units indicated that organic sedimentation began *c.* 5,220-4,950BC prior to tidal inundation and the accumulation of estuarine silts and clays. A return to *in-situ* organic sedimentation then occurred *c.* 4,330-4,060BC, with a terrestrial freshwater environment dominating until *c.* 790-510BC. Estuarine conditions then become re-established to dominate the lowlands until a final phase of peat development occurred. Hydrocarbon contamination from the overlying made ground prevented any analyses of the upper peat unit.

- Although diatom preservation was poor within most of the samples, the majority of species encountered thrive in brackish water environments. It is therefore inferred that the development of the interbedded silts and clays occurred within an estuarine environment where tidal inundation was common.

- In contrast, pollen preservation was good within most of the samples and shows that alder rapidly becoming established on the sampling site following the beginning of organic sediment accumulation, probably forming floodplain carr. The vegetation beyond the wetland edge was apparently mixed woodland with lime, oak, hazel and elm. By *c.* 790-510BC, there is evidence for probable anthropogenic activity on these dryland areas, which resulted in the clearance of areas of dryland woodland and the spread of grass/pastureland.

- Whilst further diatom analysis is not recommended, further more detailed pollen assessments (counts of at least 300 TLP at an interval of 0.08-0.04m throughout the organic-rich deposits) should be considered for this sequence, with additional radiocarbon dating to refine the chronology.

1. INTRODUCTION

A specification for geoarchaeological works on land proximal to Gallions Reach, Newham, London (TQ 440 810), was prepared by LP Archaeology (Young, 2006), in order to assess the palaeoenvironmental and archaeological potential of the area. A number of phases of ground investigations had previously been undertaken in and around the site that had identified a stratigraphic archive of palaeoenvironmental potential. The borehole records available enabled an initial assessment to be made by LP Archaeology that demonstrated that early Tertiary Thanet Sands comprise the underlying solid geology; river terrace gravels were found to overlie this deposit between -3.6m O.D and -7.4m O.D. A mixture of alluvium and peat in turn overlay these, with a considerable thickness of Made Ground of between 3.5 and 6.5m. Birmingham Archaeo-Environmental were sub-contracted to undertake the monitoring of borehole drilling and subsequent stratigraphic and palaeoenvironmental analysis, following the specification prepared by Young (2006). This report presents the results of palaeoenvironmental investigations (borehole drilling, recording, sampling and palaeoenvironmental assessment) associated with this scheme of work.

The aim of the work was twofold:

- To identify, record, characterise and sample organic deposits, primarily peats, encountered and described during previous geotechnical surveys. Assess this material for biological preservation (pollen and diatoms) and identify suitable samples for radiocarbon dating.

- To provide a detailed understanding of the subsurface stratigraphy of the peats and fine grained alluvial silts and clays, which might aid in the development of archaeological prospection strategies.

2. METHODOLOGY

2.1 Borehole Survey

At the time of the fieldwork, the area was already in the process of development, with commercial storage units being constructed. Borehole 1 and 3 were located within the buildings under construction, whilst Borehole 2 was located to the north of the units (Figure 1).

Drilling took place during November (27th-30th) and December (1st-3rd) 2006, and was undertaken by Soils Limited, under the supervision of Dr Tom Hill (Birmingham Archaeo-Environmental). Drilling was undertaken using a cable percussive borehole drill with a typical depth penetration of 10-15m. During drilling, 3 boreholes were sunk at pre-arranged locations identified and marked out by L~P: Archaeology (Figure 1). The borehole locations had been chosen to complement the stratigraphic archive believed to be present at the site and to ensure the full palaeoenvironmental potential of the site was utilised. Drilling at each location encountered Made Ground to depths of between 6.10m and 6.50m below ground level (bgl). Subsequent drilling extracted sediment samples in closed 50cm length plastic U100 tubes. Sample bags were used to store samples extracted outside of the main U100 chamber. Sampling within U100 tubes continued until gravels were encountered, believed to be the river

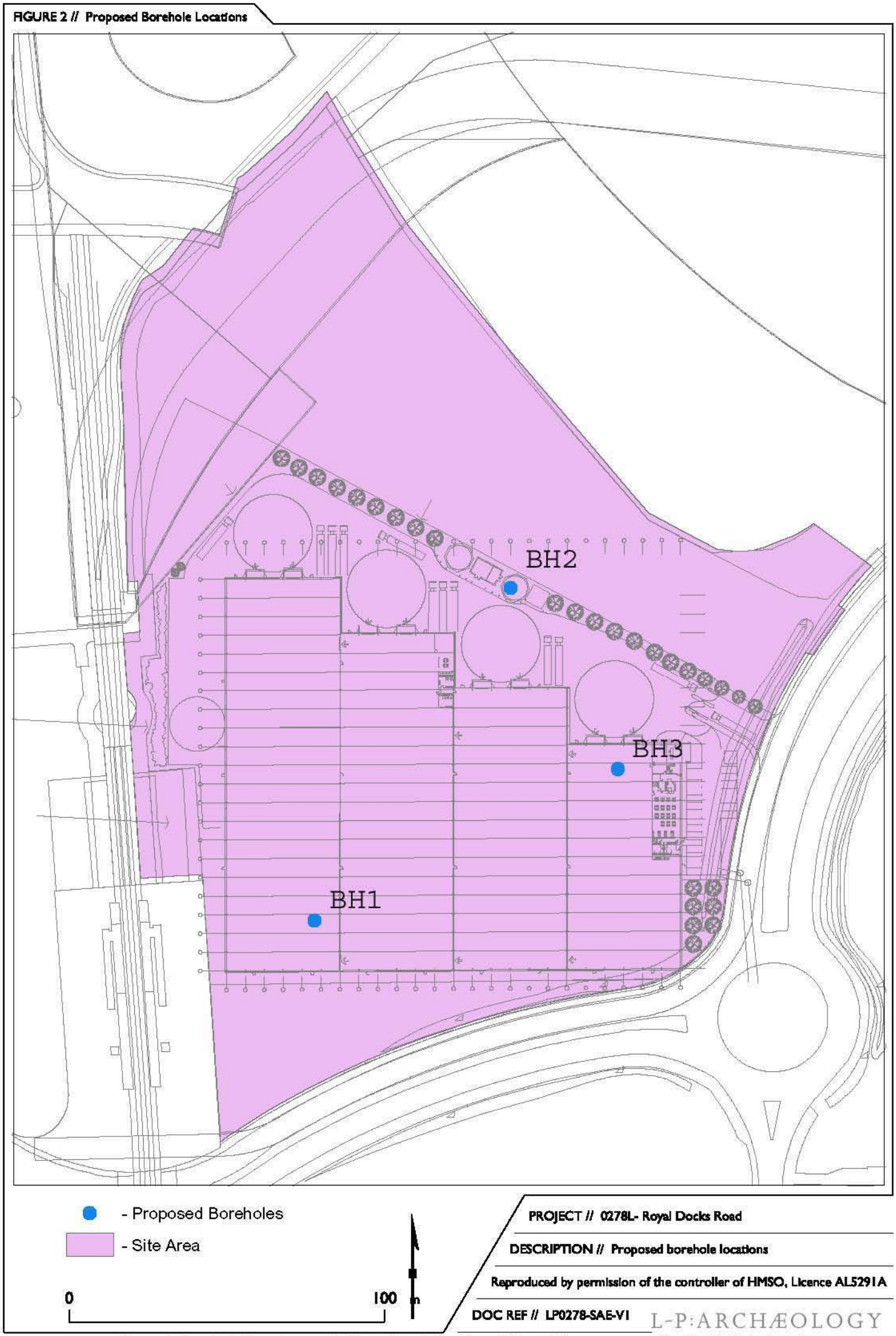

Figure 1: Borehole locations at Gallions Reach, London. Adapted from map provided by L~P:Archaeology.

terrace gravels that underlie the drift deposits. Boreholes 1 and 2 were completed during the first 3 days of drilling. Borehole 3 was completed over the weekend of 2nd-3rd December without the supervision of Birmingham Archaeo-Environmental due to the mechanical failure of the cable percussive drill. Consequently, except for the last c. 4.0m worth of samples from Borehole 3, all samples were immediately returned to the laboratory at the University of Birmingham for analysis. Soils Limited delivered the remaining U100 tubes and samples bags from Borehole 3 to Birmingham Archaeo-Environmental in January 2007.

2.2 Stratigraphic Analysis

Stratigraphic analysis of the sedimentary sequences from Boreholes 1, 2 and 3 were undertaken at the Birmingham Archaeo-Environmental laboratory at the University of Birmingham. Each U100 tube was cut open to ensure the enclosed stratigraphy remained intact prior to recording and sampling. This also enabled the complete stratigraphic sequence of each core to remain intact should further palaeoenvironmental analysis be required. Sediments were recorded using the Troels-Smith (1955) classification scheme. The scheme breaks down a sediment sample into four main components and allows the inclusion of extra components that are also present, but that are not dominant. Key physical properties of the sediment layers are also identified according to darkness (Da), stratification (St), elasticity (El), dryness of the sediment (Dr) and the sharpness of the upper sediment boundary (UB). A summary of the sedimentary and physical properties classified by Troels-Smith (1955) and the nomenclature used is provided in Table 1. A full stratigraphic breakdown of the 3 boreholes is provided in Appendix I.

In order to assess the palaeoenvironmental potential of the archive, pollen and diatom analysis were undertaken, supported by radiocarbon dating of selected horizons. The initial proposals for palaeoenvironmental analysis by L~P: Archaeology suggested a total of eight pollen and eight diatom samples to be assessed from one or more of the boreholes, complemented by two AMS radiocarbon dates to provide a chronostratigraphic framework for the depositional archive. This was based on the assumption that only one peat unit was expected to be present. However, analysis of the borehole stratigraphy identified up to three separate peat units interbedded within alluvial clays and silts. Consequently, through consultation with Janine Young (L~P: Archaeology) and Dr Jane Sidell (English Heritage), the resolution of pollen and diatom analysis was increased to 16 samples each, complemented by three AMS radiocarbon dates.

Degree of Darkness	
nig.4	black
nig.3	
nig.2	
nig.1	
nig.0	white

Degree of Stratification	
strf.4	well stratified
strf.3	
strf.2	
strf.1	
strf.0	no stratification

Degree of Elasticity	
elas.4	very elastic
elas.3	
elas.2	
elas.1	
elas.0	no elasticity

Degree of Dryness	
sicc.4	very dry
sicc.3	
sicc.2	
sicc.1	
sicc.0	water

	Sharpness of Upper Boundary
lim.4	< 0.5mm
lim.3	< 1.0 & > 0.5mm
lim.2	< 2.0 & > 1.0mm
lim.1	< 10.0 & > 2.0mm
lim.0	> 10.0mm

	Sh	*Substantia humosa*	Humous substance, homogeneous microscopic structure
I Turfa	*Tb*	*T. bryophytica*	Mosses +/- humous substance
	Tl	*T. lignosa*	Stumps, roots, intertwined rootlets, of ligneous plants
	Th	*T. herbacea*	Roots, intertwined rootlets, rhizomes of herbaceous plants
II Detritus	*Dl*	*D. lignosus*	Fragments of ligneous plants >2mm
	Dh	*D. herbosus*	Fragments of herbaceous plants >2mm
	Dg	*D. granosus*	Fragments of ligneous and herbaceous plants <2mm >0.1mm
III Limus	*Lf*	*L. ferrugineus*	Rust, non-hardened. Particles <0.1mm
IV Argilla	*As*	*A.steatodes*	Particles of clay
	Ag	*A. granosa*	Particles of silt
V Grana	*Ga*	*G. arenosa*	Mineral particles 0.6 to 0.2mm
	Gs	*G. saburralia*	Mineral particles 2.0 to 0.6mm
	Gg(min)	*G. glareosa minora*	Mineral particles 6.0 to 2.0mm
	Gg(maj)	*G. glareosa majora*	Mineral particles 20.0 to 6.0mm
	Ptm	*Particulae testae molloscorum*	Fragments of calcareous shells

Table 1 Physical and sedimentary properties of deposits according to Troels-Smith (1955)

Depth (m)	*m (O.D.)*	*Stratigraphic summary*
0.00-6.50m	4.91m to -1.59m	MADE GROUND
6.50-6.90m	**-1.59m to -1.99m**	**Dark brown-black very well humified peat. Strong hydrocarbon odour**
6.90-7.40m	-1.99m to -2.49m	Dark grey-brown organic-rich clayey-silt
7.40-8.15m	-2.49m to -3.24m	Dark grey-brown organic-rich silty clay with occasional herbaceous rootlets
8.15-8.62m	**-3.24m to -3.71m**	**Light red-brown minerogenic well humified peat**
8.62-9.53m	**-3.71m to -4.62m**	**Dark red-brown wood-rich well humified peat**
9.53-9.57m	-4.62m to -4.66m	Light grey organic-rich clayey silt
9.57-9.64m	**-4.66m to -4.73m**	**Grey-brown silty well humified peat**
9.64-9.66m	-4.73m to -4.75m	Light grey organic-rich clayey silt
9.66-10.02m	**-4.75m to -5.11m**	**Dark red-brown very well humified peat**
10.02-10.14m	**-5.11m to -5.23m**	**Grey-brown silt-rich well humified peat**
10.14-10.65m	-5.23m to 5.74m	Light grey-brown organic-rich silty clay, with occasional wood and herbaceous fragments
10.65-11.02m	-5.74m to -6.11m	WOOD stump?
11.02-11.40m	-6.11m to -6.49m	Light grey-brown organic-rich clayey silt
11.40-11.68m	**-6.49m to -6.77m**	**Dark brown silt-rich well humified peat**
11.68-11.90m	-6.77m to -6.99m	Grey-brown pebble-rich clayey silt
Below 11.90m	Below -6.99m	Gravel encountered

Table 2: Summary of Borehole 1 stratigraphy

Borehole 1 was identified as having the most representative stratigraphic archive for the site and was consequently chosen for palaeoenvironmental assessment. A full stratigraphic description is provided in Appendix I, with a summary in Table 2. A total of five peat units (highlighted in bold in Table 2) were present within Borehole 1. A 'basal' peat unit was present at -6.49m to -6.77m O.D, overlying pebbly clays and river terrace gravels. An 'upper' peat underlay the Made Ground at -1.59m to -1.99m O.D. The three remaining peat units were interbedded with grey-brown clayey silts with varying organic content. Two very thin (<0.10m) clayey silt units separate the three peat units, and as a consequence, the three units were considered to represent one major phase of peat accumulation. For ease of discussion, these three peat units will be termed the 'intermediate' peat units. A 0.37m thick wood horizon was also encountered above the basal peat unit at -5.74 to -6.11m O.D. The majority of the peat units were found to be very well humified with occasional wood fragments and varying silt content.

The Made Ground that capped the natural deposits was found to have a hydrocarbon odour that increased in strength with depth. This contamination, possibly by diesel or oil, appeared to have affected the upper peat unit (-1.59m to -1.99m O.D). The initial allocation of AMS radiocarbon dates was intended to date upper, middle and lower peat units. However, the presence of these hydrocarbons within the upper peat made contamination with ancient carbon compounds probable, rendering any radiocarbon dating of this unit problematic. Radiocarbon dating was therefore carried out on wood fragments taken from the top of the basal peat unit (-6.50m O.D.) and from the base and top of the intermediate peat unit (-5.22m O.D. and -3.25m O.D. respectively).

2.3 PALAEOENVIRONMENTAL ANALYSIS

2.3.1 Pollen Assessment

A total of 16 samples for pollen analysis were taken from the top, middle and bottom of each peat unit as well as from selected locations in the interbedded minerogenic sequences (Table 3). The upper peat unit was not sampled for pollen assessment due to the contamination discussed above. Pollen preparation followed standard techniques including KOH digestion and acetylation (Moore *et al.*, 1991). At least 125 total land pollen grains (TLP) excluding aquatics and spores were counted for each sample, although this was not attained where concentrations were low or pollen preservation was poor (see below). Pollen nomenclature follows Moore *et al.*, (1991) with the recommendations suggested by Bennett *et al.* (1994).

Depth	Altitude (m O.D.)	Generalised Stratigraphy	Pollen Analysis	Diatom Analysis	Radiocarbon Dating
6.90	-1.99	Grey-brown organic clayey silt		*	
6.92	-2.01			*	
6.94	-2.03			*	
8.10	-3.19		*		
8.12	-3.21			*	
8.14	-3.23			*	
8.16	-3.25	Red-brown well humified peat	*	*	*
8.80	-3.89		*		
9.52	-4.61		*	*	
9.54	-4.63	Light grey organic clayey silt		*	
9.56	-4.65			*	
9.58	-4.67	Grey-brown to red-brown silty humified peat	*	*	
9.63	-4.72		*		
9.68	-4.77		*		
9.90	-4.99		*		
10.13	-5.22		*	*	*
10.15	-5.24	Light grey-brown organic-rich clayey silt	*	*	
10.20	-5.29			*	
10.65	-5.74		*		
10.65-11.02	-5.74 to -6.11	*wood stump*			
11.04	-6.13	Light grey-brown organic-rich clayey silt	*		
11.35	-6.44			*	
11.39	-6.48		*	*	*
11.41	-6.50	Dark brown silt-rich humified peat	*	*	
11.55	-6.64		*		
11.67	-6.76		*		

Table 3: Summary of palaeoenvironmental assessment sampling strategy applied to Borehole 1

2.3.2 Diatom Assessment

Due to the generally good preservation potential of diatom frustules in fine-grained minerogenic sediments, the sampling strategy for diatom assessment concentrated on the silt and clay deposits interbedded between the peat units. Diatom samples were also taken from the upper and lower boundaries of each peat unit. A total of 16 samples (Table 3) were prepared following the standard procedure described by Plater *et al*. (2000). Diatom species identification and ecological classification was achieved with reference to Denys (1991-92), Hendy (1964), van der Werff and Huls (1958-74) and Vos & deWolf (1993).

Vos & deWolf (1993) developed a diatom ecological classification scheme to assist in the reconstruction of past environmental conditions from fossil diatom assemblages. The scheme classifies diatom species into ecological groups from which specific sedimentary environments can be inferred. Species can be divided into groups according to salinity tolerances (freshwater, brackish water, marine or a mix) and lifeform. Planktonic and tychoplanktonic species live predominantly within the water column and commonly rely on wave motion for transport and are consequently easily transported, restricting their use in understanding changes in relative sea level. Other lifeforms are more useful, including Epipelic species that attach themselves to muddy substrates, and epiphytic species that live attached to plants. Finally, aerophilous species require periods of tidal submergence and emergence and are commonly found in abundance within the intertidal and supratidal zones.

3. RESULTS

3.1. Pollen Analysis

Pollen concentrations and preservation was generally high enough to permit a count of 125TLP, although concentrations were low in the basal sample (11.67m) and at 10.13 and 10.15m. In addition, very few palynomorphs were present at 9.90m. The pollen data are presented in Figure 2. The most pronounced feature of the basal part of the diagram (11.67-11.41m) is the rapid increase in *Alnus* (alder) to high values (90%+), which has the effect of initially suppressing the values for the other arboreal taxa. As *Alnus* percentages level out at c.50% above 10.75m, the values for the other trees likewise stabilise with *Quercus* (oak) (20%) and *Corylus avellana*-type (almost certainly referable to hazel in this instance) (10%) being well represented. Other trees in the form of *Tilia* (lime), *Ulmus* (elm) and *Betula* (birch) are present in lower values (up to 5%). *Taxus* (yew) is also recorded in low values at 9.58 and 9.68m depth. Herbaceous plants are poorly represented with Poaceae (wild grasses) (less than 5%) and sporadic records of Cyperaceae (sedges), Chenopodiaceae (fat hen) and *Plantago* spp. Spores of *Polypodium* (common polypody), *Pteridium* (bracken) and Pteropsida (monolete) indet. (ferns) are observed at low values.

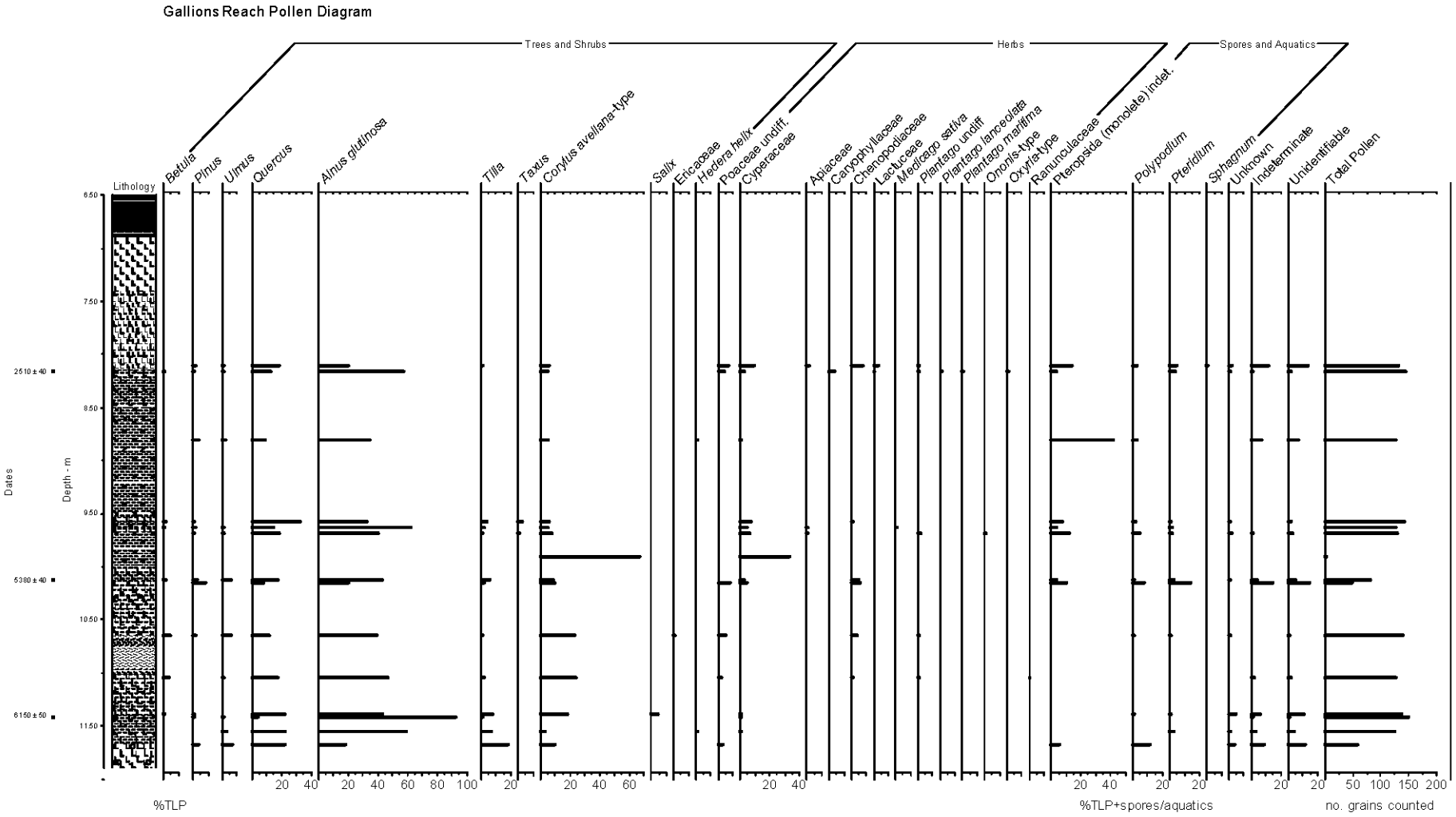

Figure 2: Pollen diagram for Gallions Reach Borehole 1.

The pollen data therefore indicate that alder carr became established on and around the sampling site shortly after organic sediment accumulation began, with mixed oak-hazel-elm woodland in the wider landscape. This is further supported by the wood horizon encountered between 10.65-11.02m depth being identified as *Alnus glutinosa* (alder; Vorst, *pers. comm.*), which suggests the establishment of alder carr on the site. *Tilia* tends to be poorly represented palynologically (eg. Waller 1994) and it is likely that lime was a significant component of this tree cover; perhaps even on damper soils at the wetland-dryland transition (cf. Scaife, 2000). The alder canopy appears to have been dense with little evidence for understorey plants other than ferns and perhaps epiphytes including common polypody. The high silt content of the peat suggests that the sampling site was subject to fluvial inputs and areas of standing water must have been present in the near vicinity, but no aquatic plants are present in the pollen record.

Whilst the record is likely to be heavily biased towards this local vegetation, the dryland woodland was probably also fairly dense, although the precise structure of vegetation beyond the floodplain area is difficult to establish on the basis of these data. Poaceae may well derive from wetland grasses such as *Phragmites* (common reed) rather than open habitats on 'dryland' areas. The appearance of Chenopodiaceae (Fat Hen) after 10.65m could reflect the presence of tall herb communities in the alder carr or might suggest the proximity of salt marsh habitats. This section of the diagram is dated to between 6150±50 BP (10.13m; Beta-226709, cal. BC 5220-4950) and 5380±40 BP (11.41m; Beta-226708, cal. BC 4330 to 4220 and 4210 to 4160, 4130 to 4060), indicating a phase of landscape development during the later Mesolithic.

The spectra from the upper half of the diagram (c.9.00-8.00m) have moderately high *Alnus* (20-40%) values indicating alder carr persisting on the floodplain. However, percentages of other tree/shrub taxa are lower, with *Tilia* values having declined to *c.* 2% by the close of the diagram, suggesting that lime was not as prevalent as in the lower section of the diagram and *Quercus* (10-15%), *Corylus* (5%) and *Ulmus* (1-2%) are also reduced. There is other evidence for more open habitats, with slight increases in Poaceae, Cyperaceae (both 5-10%), a peak in Chenopodiaceae (c.10%) and lower values for Lactuceae (dandelion-type plants) *Plantago lanceolata* (ribwort plantain) and *P. maritima* (sea plantain). The relatively high values for fat hen suggest these plants were in close proximity to the sampling site, which given the presence of *P. maritima* and the stratigraphic context, probably indicate the near presence of salt marsh communities. Ribwort plantain, on the other hand, is a plant of drier conditions and indicates some open, grassy places beyond the wetland edge. Lactuceae includes many plants that might derive from either or both of the previous habitats. *Pteridium* also attains c. 5% TLP+spores, suggesting the presence of open, drier soils where bracken could grow. This phase of landscape development dates to 2510+40 BP (Beta-226707, cal. BC 790-510), very late Bronze Age to early Iron Age.

By the close of the diagram then, the impression is that whilst alder carr continued to dominate locally, the environment was increasingly open. It is probable that this increased openness is a result of a combination of factors, with rising watertables and encroaching saltmarsh habitats evident: the drop in *Alnus* at the very close of the diagram occurs prior to a shift to minerogenic sedimentation reflecting the inundation of the carr. Rising watertables or a shift in channel position relative to the sampling site might also explain the reduced values for the other arboreal taxa, but it seems likely that some disturbance/clearance by human communities of the lime-oak-hazel

woodland on the drier soils is indicated. The precise nature or extent of such activity cannot be established on the basis of the current data.

3.2 Diatom Analysis

Of the 16 samples prepared and assessed for diatoms, most contained few identifiable frustules. When diatoms were encountered, they were highly disarticulated hindering reliable identification. The majority of the identifiable species were either polyhalobous or mesohalobous species, which require predominantly marine and brackish waters (salinity ranging from c. 0.2g l^{-1} to over 30g l^{-1} respectively) for optimal frustule growth. Due to the overall low species abundance and diversity from the samples, diatom species have not been presented as percentages of Total Diatom Valves (%TDV) in Figure 3 but are given as raw counts.

Samples taken from the basal peat unit and the overlying organic-rich clayey silt (11.39m and 11.35m depth respectively) contained few diatom frustules, with the planktonic polyhalobous species *Melosira westii* and *Podosira stelligera* present. In addition, mesohalobous species including *Campylodiscus echeneis*, *Cyclotella striata* and *Nitzschia navicularis* were encountered. Occasional *Epithemia turgida* frustules were also found within the organic-rich clayey silt.

Diatoms were absent within the organic-rich clayey silt until the stratigraphic boundary with the overlying intermediate peat unit (10.15m and 10.13m depth). Very similar diatom assemblages were encountered to those present at the transition from the basal peat unit described above, with occasional frustules of *Melosira westii*, *Campylodiscus echeneis*, *Cyclotella striata* and *Nitzschia navicularis*. In addition, the planktonic polyhalobous species *Paralia sulcata* was present.

Diatoms were also identified within the thin silt horizon in the intermediate peat unit (9.56m and 9.54m depth). Again, diatom abundance was very low and disarticulation was common, preventing a full assessment. Similar assemblages were again observed, although the influence of mesohalobous species (*Nitzschia navicularis* and also *Diploneis didyma*) has increased. The peat immediately overlying the thin minerogenic horizon was also sampled (9.52m depth) but had poor preservation, with only occasional fragments of *Melosire westii* and *Cyclotella striata.*

Samples from the sedimentary boundary between the intermediate peat and upper organic-rich silty clay contained the best-preserved diatom assemblages. Although disarticulation was common, the sample assessed from the top of the intermediate peat unit (8.16m depth) was dominated by *Nitzschia navicularis* and *Cyclotella striata*, with records of *Diploneis didyma*, *Paralia sulcata*, *Melosira westii*, and the mesohalobous species *Nitzschia puncata.* Although there was considerable variation in diatom abundance and preservation, very similar assemblages were present within the overlying organic-rich clays and silts (8.14m and 8.12m depth).

The final sample to contain occasional diatom frustules was from the clays and silts immediately below the contaminated upper peat unit (6.90m depth). Again, preservation was poor and disarticulation was abundant, with only occasional frustules of *Melosira westii*, *Rhaphoneis amphiceros*, *Cyclotella striata* and *Nitzschia navicularis.*

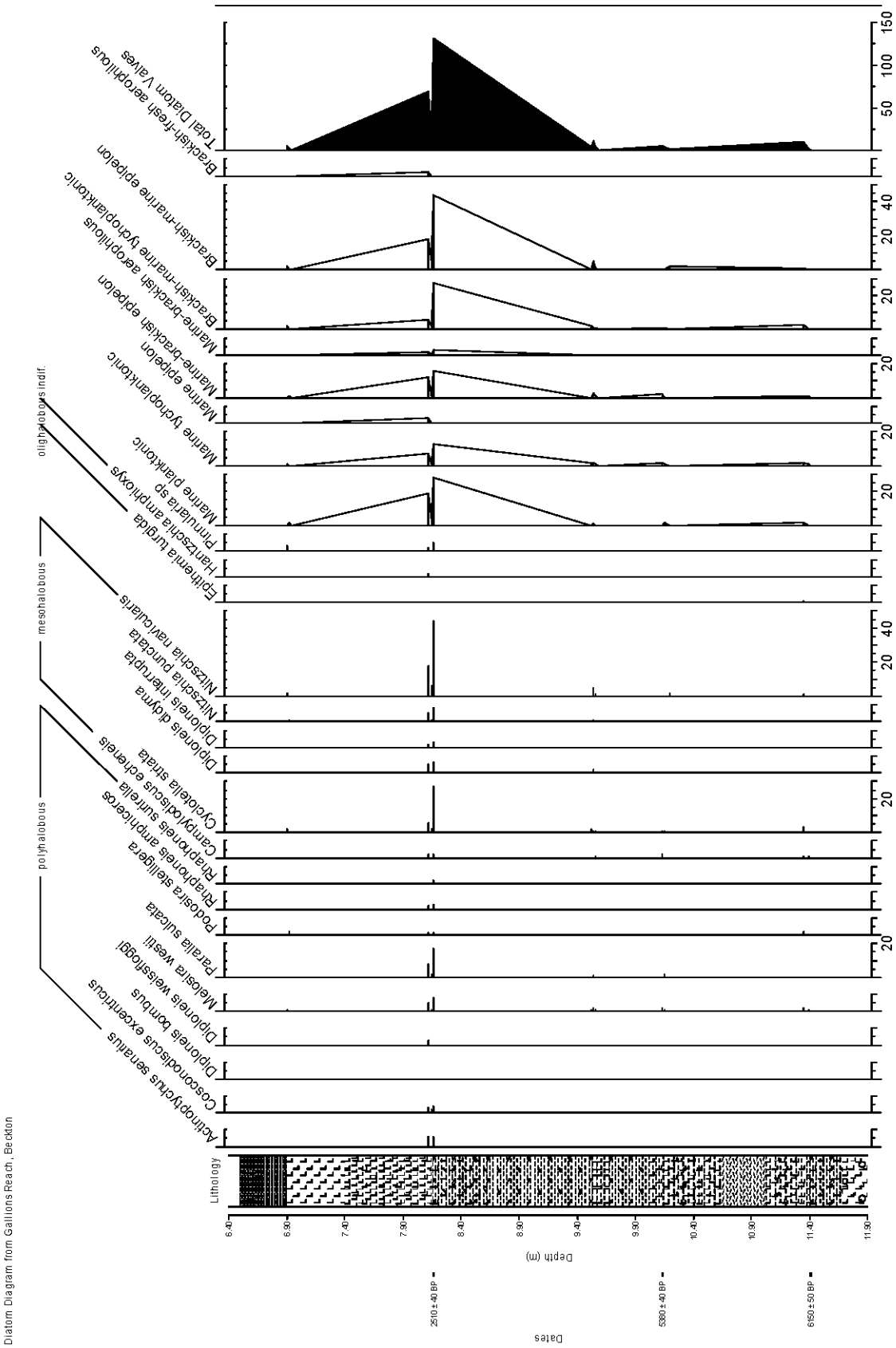

Figure 3: Diatom diagram from Gallions Reach Borehole 1.

The diatom assemblages were found to be very similar throughout the Gallions Reach stratigraphic archive. Although species abundance and diversity was often low, it is likely that all the minerogenic units were deposited under similar conditions, where marine and brackish water environments dominated. The abundance of polyhalobous planktonic species, combined with the mesohalobous species, would suggest outer estuarine conditions at Gallions Reach during the periods of minerogenic sediment accumulation.

3.3 Radiocarbon Dating

Three wood samples were submitted to Beta Analytic, Florida, for AMS radiocarbon dating. The results are set out in Table 3 (see also Appendix II). Calibration was undertaken using INTCAL98 (Stuiver and Van der Pilcht 1998). All samples provided sufficient carbon for accurate measurement and analyses are reported as having proceeded normally.

Sample	Code	Depth (m O.D.)	Sample description	Sample pre-treatment	Conventional radiocarbon age	Calibrated range BC/AD (2 sigma - 95% confidence)
GALL-8.16m	Beta-226707	-3.25	wood	acid/alkali/acid	2,510 +/- 40 BP	790-510 Cal. BC
GALL-10.13m	Beta-226708	-5.22	wood	acid/alkali/acid	5,380 +/- 40 BP	4,330-4,060 Cal. BC
GALL-11.41m	Beta-226709	-6.48	wood	acid/alkali/acid	6,150 +/- 40 BP	5,220-4,950 Cal. BC

Table 3: Results of the radiocarbon dates from

4. INTERPRETATION

The Gallions Reach pollen assessments have demonstrated that organic sedimentation commenced sometime before cal. BC 5220-4950, with alder rapidly becoming established on the sampling site, probably forming floodplain carr. Such vegetation was a common feature of lowland river valleys during the mid-Holocene in England (Brown 1997).

The vegetation beyond the wetland edge was probably mixed woodland with lime, oak, hazel and elm. Alder carr persisted on the sampling site until c. 790-510BC, at which time there is evidence both for probable anthropogenic activity on dryland areas, which resulted in the clearance of areas of dryland woodland and the spread of grass/pastureland, followed shortly afterwards by the end of organic sedimentation as the site was inundated by silt deposits.

The implications of the high representation of local pollen sources and the physical 'screening' effect of such on-site alder carr woodland must be considered here. Recent work has begun to quantify the representation of 'on' and 'off site' vegetation in alder carr sampling sites (Bunting *et al* 2005; Waller *et al* 2005; Binney *et al* 2005).

This work has demonstrated that the palynological signal within alder fen carr is heavily biased towards local vegetation with a limited pollen source area of up to *c.* 130 m from the sampling site. This may indicate that the record of dryland herbs, specifically ribwort plantain, implies that human activity was taking place relatively close to the sampling site.

The inferred vegetation is similar to that evidenced from other palynological studies in Greater London with alder carr on floodplain and mixed woodland in which lime was probably a major constituent (Scaife, 2000). There is no clear evidence for human disturbance to this vegetation until near the close of the diagram, during the later Bronze Age-Iron Age although this may in part at least be a function of relatively low pollen counts and wide sampling intervals. Elsewhere in London, pollen data suggests that following some small scale disturbance during the Neolithic, human impacts increased from the Middle to late Bronze Age with the removal of lime woodland for farming and settlement (Scaife 2000).

Although diatom preservation was poor, the assemblages encountered have confirmed that the periods of minerogenic sedimentation predominantly occurred through episodic tidal inundation of this part of the Thames valley lowlands. Where diatoms were observed in relative abundance (*c.* 8.14m depth), species composition suggests deposition occurred predominantly on mudflats within the intertidal estuarine zone (Vos & deWolf, 1993). The presence of saltmarsh habitats typical of the intertidal zone is also reflected in the pollen record, especially towards the top of the pollen diagram.

The presence of interbedded layers of peat and estuarine silts correlates well with the lithostratigraphic 'Thames-Tilbury' model described by Devoy (1979) for the Thames region. Estuarine ('Thames') units interdigitated within peat are considered to represent periods of relative sea-level (RSL) rise, whilst in contrast, the peat ('Tilbury') units infer of drop in RSL or a reduction in the *rate* of RSL rise (Wilkinson *et al.*, 2000).

Peat accumulation began at the site *c.* 5,220-4,950 BC (7,170-6,900 cal. BP). Rapid sea-level rise is a feature of south-east England between 11,500 cal. BP and 6,850 cal. BP in response to the retreating Devensian ice sheet (Long & Tooley, 1995). It is therefore likely that the initial base of organic deposition on the site occurred in response to rising regional water tables prior to marine inundation. Basal peats are commonly found to overlie early Holocene and Pleistocene sediments and their development appears to be a result of the rising ground water levels which provide saturated depositional conditions suitable for mire formation in coastal and floodplain settings (Petzelberger, 2000).

Estuarine sedimentation continued until *c.* 4,330-4,060 BC (6,280-6,010 cal. BP), after which a return to predominantly freshwater *in-situ* biogenic sedimentation took place. Peat formation under these conditions then dominated until *c.* 790-510 BC (2,740-2,460 cal. BP), although occasional estuarine inundation occurred during this period, depositing thin minerogenic horizons. Sea level is likely to have continued to rise during this period of terrestrial sedimentation, although at a slower rate. This explanation is preferred over an actual drop in RSL, as a rising water table is required firstly to assist the accumulation of organic matter in a fen and also to prevent organic material from decomposing (Streif, 2004). A period of estuarine contraction and peat

development is also evident throughout much of the Thames lowlands between *c.* 6,850 and 3,200 cal. BP. The return to estuarine sedimentation from *c.* 790-510 BC onwards is evidence for a period during which the rate of sea-level rise was greater than that of peat growth.

5 RECOMMENDATIONS FOR FURTHER ANALYSIS

Diatom preservation within the stratigraphic archive was found to be relatively poor. Consequently, further diatom analysis at the site is not recommended. The pollen assessments have demonstrated that preservation of pollen in the Gallions Reach sequence is generally good. The radiocarbon dates indicate that the sequence stretches from just before cal. BC 5220-4950 to cal. BC 790-510. This represents an average accumulation rate of approximately 14 yrs cm^{-1}, and although sediment accumulation between throughout this time has clearly been subject to fluvial influences, there is no evidence for erosional contacts suggesting that no substantial hiatuses are present in the stratigraphy. The vegetation record therefore covers the later Mesolithic through to the early Iron Age. Pollen sequences from Greater London including the Neolithic period are scarce (Scaife 2000) whilst there is also a lack of palynological data from this part of London (Wilkinson *et al.* 2000). It is thus recommended that further more detailed pollen assessments (counts of at least 300 TLP at an interval of 0.08-0.04m throughout the organic-rich deposits) are considered for this sequence, with additional radiocarbon dating to refine the chronology.

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APPENDIX I

Borehole Stratigraphy

Troels-Smith (1955) sedimentary classification scheme used for stratigraphic descriptions. Refer to Table 1 for summary of classification scheme.

Borehole 1
Ground level: 4.91m O.D.

4.91m to -1.59m O.D.	MADE GROUND				
-1.59 to -1.99m O.D.	Da	St	El	Dr	UB
	4	0	0	1	2
	Sh4, As+, Ag+, Th+				
	Black very well humified peat				
	**strong hydrocarbon odour*				
-1.99m to -2.49m O.D.	Da	St	El	Dr	UB
	3	0	0	1	1
	Ag2, As2, Sh++, Th+				
	Dark grey-brown organic-rich clayey silt with occasional rootlets				
-2.49m to -3.24m O.D.	Da	St	El	Dr	UB
	2+	0	0	1	0
	As3, Ag1, Sh+, Th+				
	Dark grey-brown organic-rich silty clay with occasional herbaceous rootlets				
-3.24m to -3.71m O.D.	Da	St	El	Dr	UB
	2+	1	0+	1	1
	Light brown to grey-brown minerogenic well-humified peat				
-3.71m to -4.62m O.D.	Da	St	El	Dr	UB
	3+	2	2	1+	1
	Sh2, Dh1, Dl1, Th+, Dg+, As+				
	Dark brown to red-brown woody well humified peat				
-4.62m to -4.66m O.D.	Da	St	El	Dr	UB
	1+	0	0	1	2
	Ag2, As1, Sh1, Dh+				
	Light grey organic-rich clayey silt				
-4.66m to -4.73m O.D.	Da	St	El	Dr	UB
	2+	0	0	1	3
	Sh2, Ag1, As1, Dh++, Th+				
	Grey-brown silty well humified peat				
-4.73m to -4.75m O.D.	Da	St	El	Dr	UB
	1+	0	0	1	2
	Ag2, As1, Sh1, Dh+				
	Light grey organic-rich clayey silt				
-4.75m to -5.11m O.D.	Da	St	El	Dr	UB
	3+	1	1	1	1
	Sh2, Dh1, Dg1, Dl+, Th+				
	Dark brown to red-brown herbaceous well humified peat				

-5.11m to -5.23m O.D.	Da	St	El	Dr	UB
	3	0	0	1	2
	Sh2, Ag2, Dl+, Dh+, Th+, As+				
	Grey-brown very silty well humified peat				
-5.23m to -5.74m O.D.	Da	St	El	Dr	UB
	2+	0	0	1	1
	As2, Ag1, Sh1, Dl+, Dh+, Th+				
	Light grey-brown organic-rich silty clay, with occasional wood and herbaceous fragments				
-5.74m to -6.11m O.D.	Wood horizon				
-6.11m to -6.49m O.D.	Da	St	El	Dr	UB
	2+	0	0	1	2
	Ag2, As1, Sh1, Dl+, Dh+, Th+				
	Light grey-brown organic-rich clayey silt				
-6.49m to -6.77m O.D	Da	St	El	Dr	UB
	3	1	1	1	1
	Sh2, Sh1, Ag1, As+, Dl+, Th+				
	Dark brown silt well humified peat				
-6.77m to -6.99m O.D.	Da	St	El	Dr	UB
	2+	0	0	0	1
	Ag2, As1, GgMaj1, GgMin+, Sh+				
	Grey-brown pebble-rich clayey silt				
Below -6.99m O.D.	*Gravel encountered*				

Borehole 2
Ground level: 6.01m O.D.

6.01m to -0.15m O.D.	MADE GROUND				
-0.15m to -0.35m O.D.	Da	St	El	Dr	UB
	4	0	0	1	1
	Sh3, Ag1, As++				
	Black silty very well humified peat				
-0.35m to -1.58m O.D.	Da	St	El	Dr	UB
	2+	0	0	1	1
	Ag2, As1, Sh1				
	Light grey-brown organic-rich clayey silt				
-1.58m to -2.09m O.D.	Da	St	El	Dr	UB
	3	1+	1	0	2
	Sh2, Dg1, Dh1, Dl+, Th+				
	Red-brown herbaceous well humified peat				
-2.09m to -2.31m O.D.	Da	St	El	Dr	UB
	2	0	0	1	1
	Ag2, As1, Sh1, Dh++, Th+				
	Grey-brown organic-rich clayey silt				
-2.13m to -2.82m O.D.	Da	St	El	Dr	UB
	3+	1	1+	1	2
	Sh2, Dh1, Ag1, As+, Dl+				
	Red-brown silty well humified peat				
-2.82m to -2.95m O.D.	Da	St	El	Dr	UB
	2	0+	0	0	1
	Ag2, Ga1, As1, Dh+, Sh+				
	Light grey slightly sandy organic clayey silt				
-2.95m to -3.22m O.D.	Da	St	El	Dr	UB
	2+	0	0	1	1
	Ag2, As1, Sh1, Ga+, Dh+				
	Light grey-brown organic clayey silt				
-3.22m to -3.24m O.D.	Da	St	El	Dr	UB
	2	1	0	1	1
	Ag2, As1, Ga1, Sh+, Dl+				
	Light grey-brown slightly sandy clayey silt with fine sand stratification evident				
-3.24m to -3.77m O.D.	Da	St	El	Dr	UB
	“=	0	0	1	1
	Ag2, As1, Sh1, Dh++, Ga+				
	Light grey-brown organic clayey silt				
-3.77m to -3.84m O.D.	Da	St	El	Dr	UB
	3+	0	0	0	1
	Ag1, Ag1, Ga1, GgMaj1, GgMin+, Sh+				
	Dark grey-brown pebbly silty clayey sand				
Below -3.84m O.D.	*Gravel encountered*				

Borehole 3

Ground level: 5.57m O.D.

5.57m to -0.53m O.D.		MADE GROUND				
-0.1m3 to -1.39m O.D.	Da	St	El	Dr	UB	
		3+	0+	1	1	-
		Ag2, As1, Sh1, Ga+, Dh+, Th+				
		Dark brown organic-rich clayey silt				
-1.39m to -1.47m O.D.	Da	St	El	Dr	UB	
		4	1	2	1	2
		Sh3, Dh1, Th+, Dg+, Dl+				
		Black very well humified peat				
-1.47m to -2.79m O.D.	Da	St	El	Dr	UB	
		2	0	0	1	2
		Ag2, As1, Sh1				
		Grey-brown organic-rich clayey silt				
-2.79m to -3.78m O.D.	Da	St	El	Dr	UB	
		3	2	2	1	1
		Sh3, Dh1, Th+, Ag+, Dg+, Dl+				
		Dark brown to red-brown very well humified peat with occasional wood fragments				
-3.78m to -4.01m O.D.	Da	St	El	Dr	UB	
		1+	0	0	1	2
		Ag2, As2, Sh+, Dl++, Dh++				
		Light grey-brown clayey silt with abundant wood and herbaceous fragments				
-4.01m to -4.68m O.D.	Da	St	El	Dr	UB	
		3+	0	2	1	2
		Sh2, Dh1, Ag1, Th+, Dl+				
		Dark brown slightly silty well humified peat				
-4.68m to -4.92m O.D.	Da	St	El	Dr	UB	
		1+	0	0	1	1
		Ag2, As1, Sh1, Dh+, Th+				
		Light grey-brown organic-rich clayey silt				
-4.92m to -4.98m O.D.	Da	St	El	Dr	UB	
		3	1	1	1	1
		Sh2, Dh1, Ag1, Th+, Dl+				
		Dark brown slightly silty well humified peat				
-4.98m to -5.85m O.D.	Da	St	El	Dr	UB	
		2	0	0	1	1
		Ag2, As2, Sh+, Dh+, Dl+, Th+				
		Grey-brown organic clayey silt				
-5.85m to -6.08m O.D.	Da	St	El	Dr	UB	
		3	1	2	1	0
		Sh2, Dh1, Ag1, Th+, Dl+				
		Dark red-brown slightly silty well humified peat				
-6.08m to -6.53m O.D.	Da	St	El	Dr	UB	
		1+	0	0	1	0
		Ag2 As2, Sh+, Ga+				
		Light grey clayey silt				

-6.53m to -6.59m O.D.	Da	St	El	Dr	UB	
		2	0	0	1	1
		Ga2, Ag1, GgMaj1, GgMin+				
		Orange-brown pebbly silt sand				
Below -6.59m O.D.		*Gravels encountered*				

APPENDIX II

Radiocarbon Dating Certificates

FROM: Darden Hood, Director (mailto:mailto:dhood@radiocarbon.com)
(This is a copy of the letter being mailed. Invoices/receipts follow only by mail.)

March 2, 2007

Mr. Thomas Hill
University of Birmingham
Birmingham Archaeology
Edgbaston
Birmingham B15 2TT
UK

RE: Radiocarbon Dating Results For Samples GALL-8.16m, GALL-10.13m, GALL-11.41m

Dear Dr. Hill:

Enclosed are the radiocarbon dating results for three samples recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis proceeded normally. As usual, the method of analysis is listed on the report sheet and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. It was analyzed with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the VISA card provided. A receipt is enclosed. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood

Mr. Thomas Hill

Report Date: 3/2/2007

University of Birmingham

Material Received: 1/29/2007

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 226707 SAMPLE : GALL-8.16m ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 790 to 510 (Cal BP 2740 to 2460)	2580 +/- 40 BP	-29.4 o/oo	2510 +/- 40 BP
Beta - 226708 SAMPLE : GALL-10.13m ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 4330 to 4220 (Cal BP 6280 to 6170) AND Cal BC 4210 to 4160 (Cal BP 6160 to 6110) Cal BC 4130 to 4060 (Cal BP 6080 to 6010)	5440 +/- 40 BP	-28.4 o/oo	5380 +/- 40 BP
Beta - 226709 SAMPLE : GALL-11.41m ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (wood): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 5220 to 4950 (Cal BP 7170 to 6900)	6190 +/- 50 BP	-27.2 o/oo	6150 +/- 50 BP

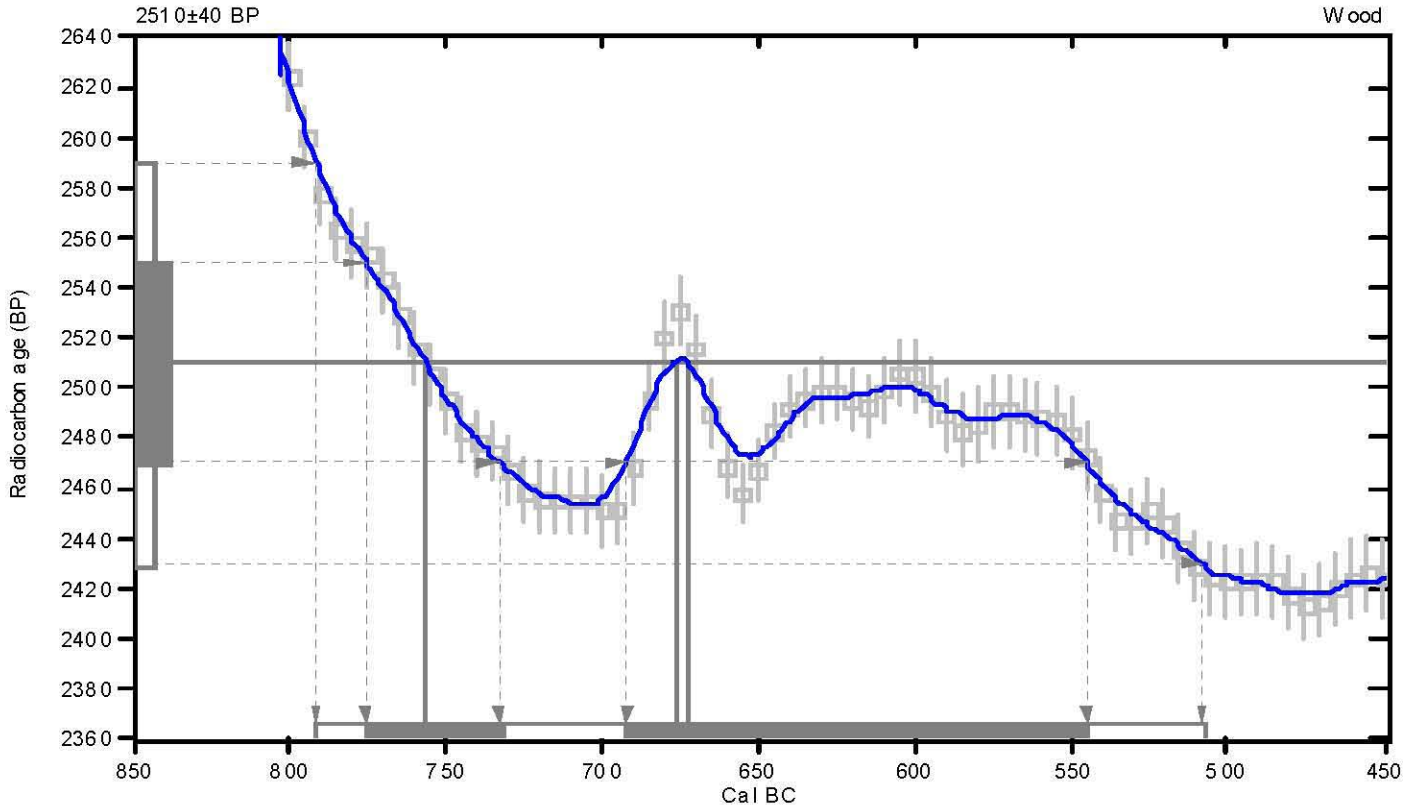
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-29.4:lab. mult=1)

Laboratory number:	**Beta-226707**
Conventional radiocarbon age:	**2510±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 790 to 510 (Cal BP 2740 to 2460)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal BC 760 (Cal BP 2710) and Cal BC 680 (Cal BP 2630) and Cal BC 670 (Cal BP 2620)
1 Sigma calibrated results: (68% probability)	Cal BC 780 to 730 (Cal BP 2730 to 2680) and Cal BC 690 to 540 (Cal BP 2640 to 2500)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35 (2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

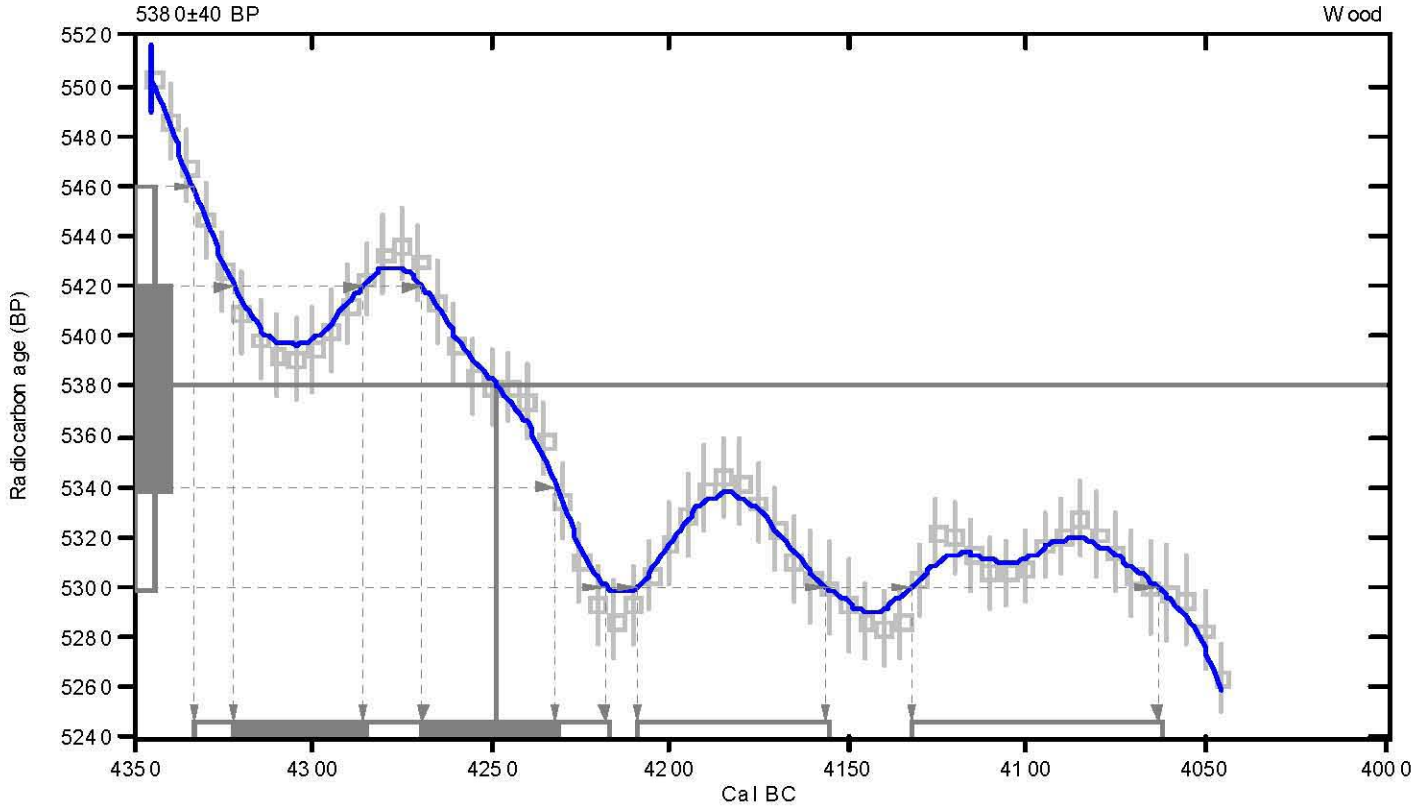
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-28.4:lab. mult=1)

Laboratory number:	**Beta-226708**
Conventional radiocarbon age:	**5380±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 4330 to 4220 (Cal BP 6280 to 6170) and Cal BC 4210 to 4160 (Cal BP 6160 to 6110) and Cal BC 4130 to 4060 (Cal BP 6080 to 6010)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 4250 (Cal BP 6200)
1 Sigma calibrated results: (68% probability)	Cal BC 4320 to 4290 (Cal BP 6270 to 6240) and Cal BC 4270 to 4230 (Cal BP 6220 to 6180)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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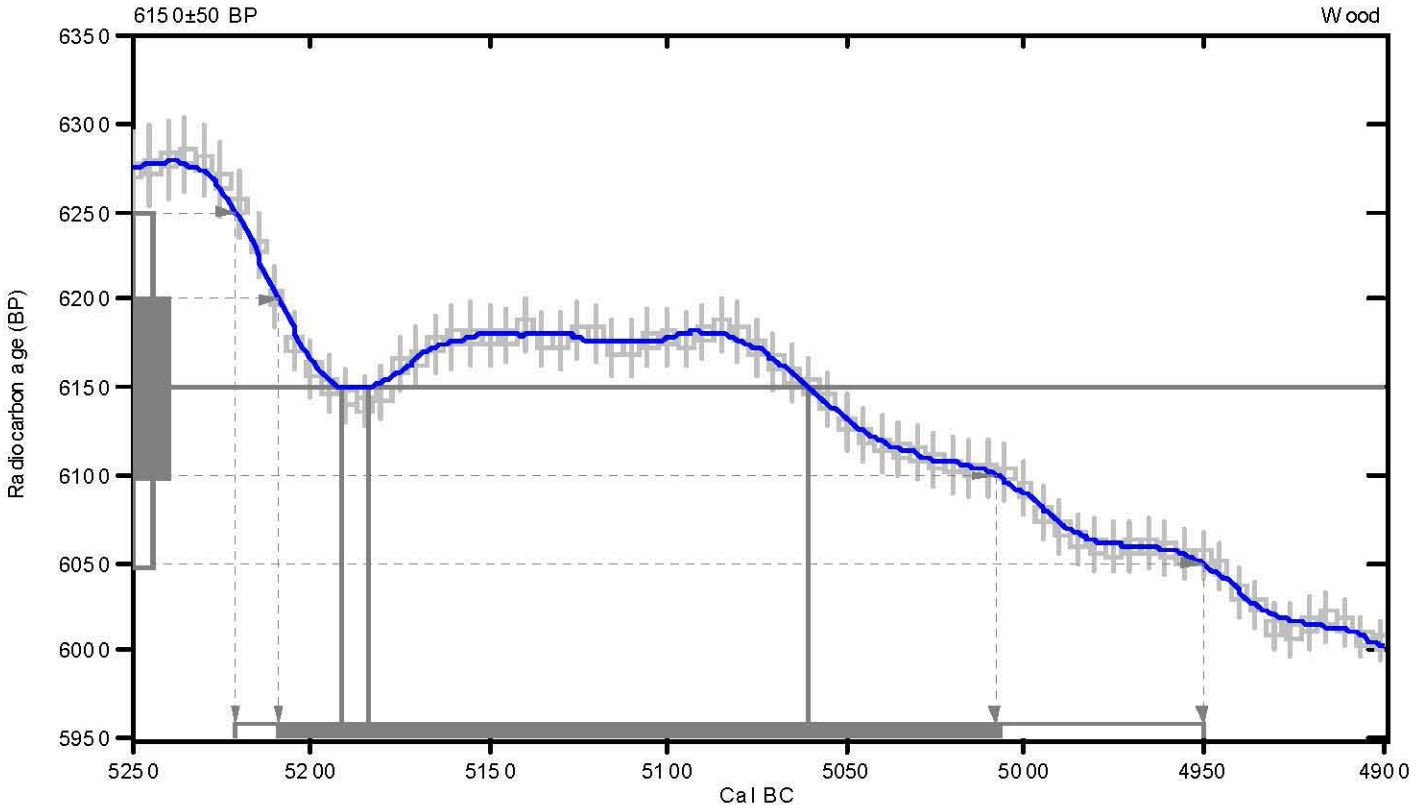
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-27.2:lab. mult=1)

Laboratory number:	**Beta-226709**
Conventional radiocarbon age:	**6150±50 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 5220 to 4950 (Cal BP 7170 to 6900)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal BC 5190 (Cal BP 7140) and Cal BC 5180 (Cal BP 7130) and Cal BC 5060 (Cal BP 7010)
1 Sigma calibrated result: (68% probability)	Cal BC 5210 to 5010 (Cal BP 7160 to 6960)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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OASIS FORM

APPENDIX 4

OASIS DATA COLLECTION FORM:

Printable version

OASIS ID: lparchae1-26337

Project details

Project name	Armada 1, Gallions Reach
Short description of the project	Three geoarchaeological boreholes were carried out to satisfy a planning condition. Sixteen samples were taken for pollen and diatom analysis. Three samples were taken for radiocarbon dating.
Project dates	Start: 27-11-2006 End: 08-12-2006
Previous/future work	No / No
Any associated project reference codes	AMG06 - Sitecode
Type of project	Field evaluation
Site status	None
Current Land use	Industry and Commerce 4 - Storage and warehousing
Methods & techniques	'Augering','Environmental Sampling'
Development type	Urban commercial (e.g. offices, shops, banks, etc.)
Prompt	Direction from Local Planning Authority - PPG16
Position in the planning process	After full determination (eg. As a condition)

Project location

Country	
Site location	GREATER LONDON NEWHAM NEWHAM
Postcode	E6 7FB
Study area	4.45 Hectares
Site coordinates	TQ 543960 181045 50.9411065727 0.197868711460 50 56 27 N 000 11 52 E Polygon
Height OD	Min: -4.22m Max: 0.21m

Project creators

Name of Organisation	L - P : Archaeology
Project brief originator	English Heritage/Department of Environment
Project design originator	L - P : Archaeology
Project director/manager	Janine Young
Project supervisor	Tom Hill

Project archives

Physical Archive Exists?	No
Physical Archive recipient	Museum of London
Digital Archive Exists?	No
Paper Archive recipient	Museum of London
Paper Contents	'Environmental'
Paper Media available	'Report','Unspecified Archive'

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	Geoarchaeological Assessment Report of land at Armada 1, Gallions Reach, Beckton
Author(s)/Editor(s)	Dufton, A.
Date	2007
Issuer or publisher	L - P : Archaeology
Place of issue or publication	London

Entered by	Andy Dufton (a.dufton@lparchaeology.com)
Entered on	20 April 2007

OASIS:

Please e-mail English Heritage for OASIS help and advice