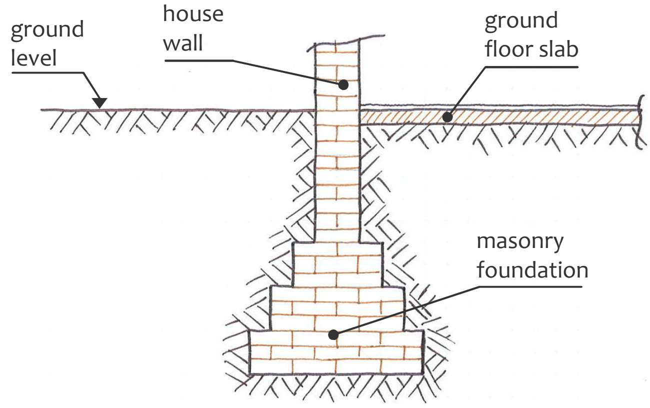
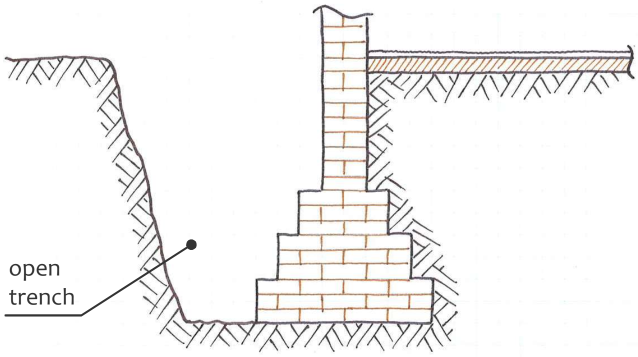
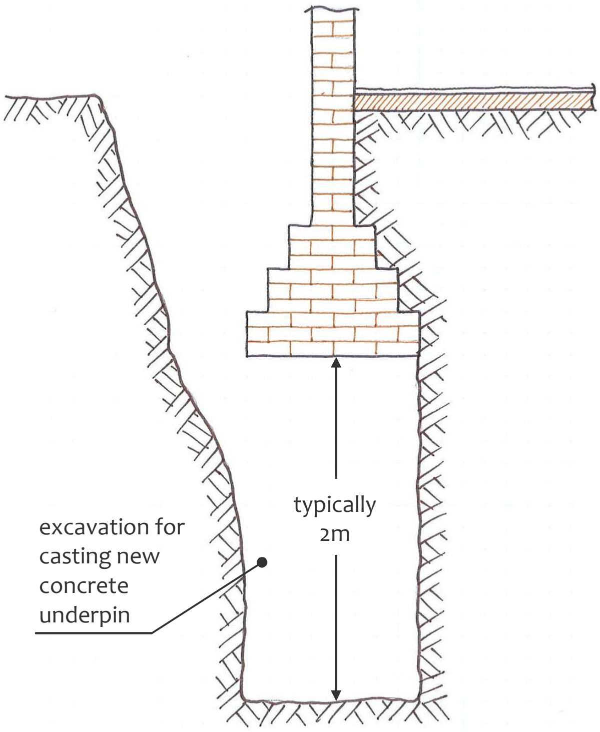
Stage 0: original foundation, typical of houses



Stage 1: exposure of original foundation by digging a short trench along a section of the wall to be underpinned



Stage 2: excavation of pit to form underpin: see Fig. 2.1b for details



Indicative, schematic sketches only.
Actual dimensions are likely to vary.
Not to scale.

Camden Geological, Hydrogeological and Hydrological Study
Typical underpinning construction sequence

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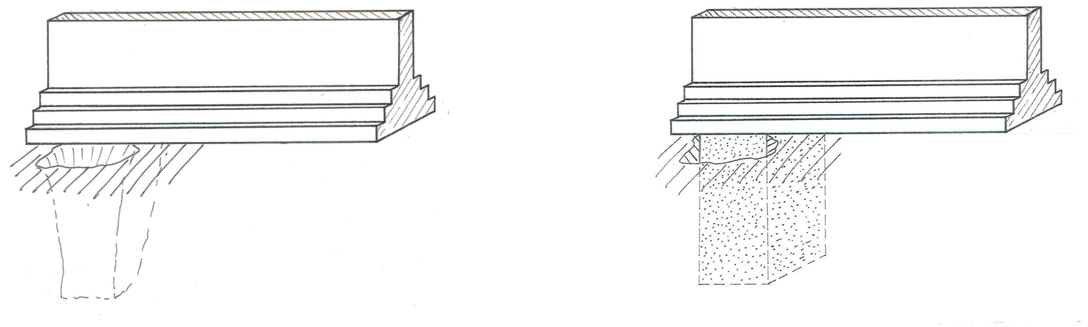
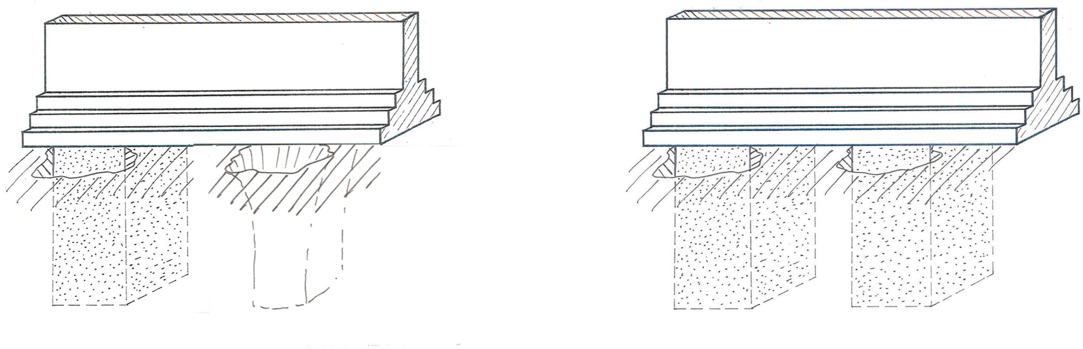
FIGURE 19

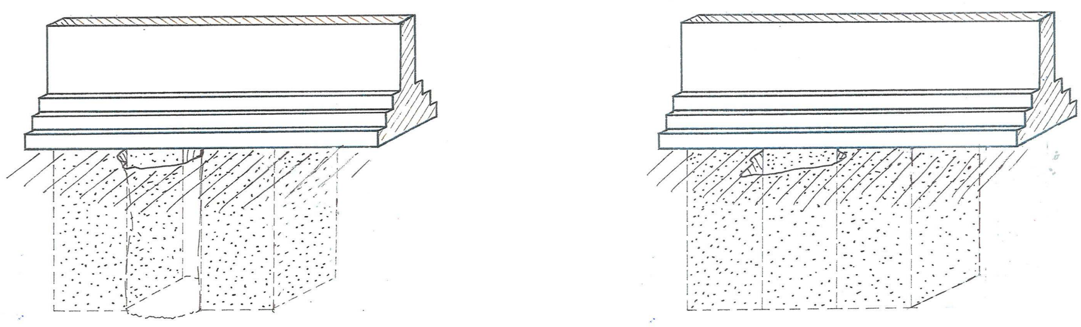
Stage 2a: excavation and concreting of initial section



Stage 2b: excavation and concreting of another section, not adjacent to first one



Stage 2c: excavation and concreting of an intermediate section, to form contiguous rows of underpin



Indicative, schematic sketches only.
Actual dimensions are likely to vary.
Not to scale.

Camden Geological, Hydrogeological and Hydrological Study

Underpinning construction sequence with 'hit and miss' pattern

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FIGURE 20

Appendix B

Envirocheck Report

HEYNE TILLETT STEEL

Appendix C

GEA Site Investigations

HEYNE
TILLETT
STEEL

Desk Study and Ground Investigation Report

Client Deroda Investments Limited

Engineer Price & Myers

J10229

December 2010

Document Control

Project title	75 Avenue Road, London, NW8 6JD	Project ref	J10229
Report prepared by	Mark Kentish BSc MSc FGS		
Report checked and approved for issue by	Steve Branch BSc MSc CGeol FGS FRGS MIEnvSc		

Issue No	Status	Date	Approved for Issue
1	Final	23 December 2010	SU

This report has been issued by the GEA office indicated below. Any enquiries regarding the report should be directed to the office indicated or to Steve Branch in our Herts office.

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CONTENTS

EXECUTIVE SUMMARY

This executive summary contains an overview of the key findings and conclusions. No reliance should be placed on any part of the executive summary until the whole of the report has been read. Other sections of the report may contain information that puts into context the findings that are summarised in the executive summary.

BRIEF

This report describes the findings of a site investigation carried out by Geotechnical and Environmental Associates Limited (GEA) on the instructions of Price and Myers, on behalf of Deroda Investments Ltd, with respect to the redevelopment of the site through the construction of a three storey house with a two storey 8 m deep basement beneath the entire footprint of the house and extending into the rear garden. The purpose of the investigation has been to research the history of the site with respect to possible contaminative uses, to investigate the ground conditions, to assess the extent of any contamination and to provide information to assist with the design of suitable foundations and retaining walls..

DESK STUDY FINDINGS

The earliest map studied, dated 1872, shows the site to be developed with two houses with associated rear gardens, a detached house occupying the southern part of the site and the existing linked detached house occupying the northern part of the site. Queens Road, (later renamed Queens Grove Road) and Avenue Road were present at this time. The site remained in the same layout until some time between 1951 and 1953, by which time the house occupying the eastern part of the site had been removed and the site was occupied by the existing house in the north with the remainder of site forming a large L-shaped garden. At some point between 1953 and the present day the existing swimming pool was constructed in the south-eastern corner, although this is not shown on any of the historical maps. The site has remained in the same layout through to the present day.

GROUND CONDITIONS

Beneath a moderate thickness of made ground, comprising brown silty gravelly clay with brick fragments, which extended to depths of between 0.90 m and 1.40 m, London Clay was encountered and proved to the full depth investigated of 25.45 m. The London Clay initially comprised a naturally reworked layer of brown gravelly clay, extending to depths of 2.9 m and 4.30 m in Borehole Nos 1 and 2 respectively, whereupon firm becoming stiff mottled brown clay was encountered to depths of 7.40 m and 9.40 m respectively. Stiff becoming very stiff grey fissured clay was encountered below the brown clay and extended to the full depth investigated of 25.45 m. A claystone was encountered in Borehole No 1 at 7.40 m.

Groundwater was not encountered during the investigation and both standpipes were found to be dry on a subsequent groundwater monitoring visit. Elevated concentrations of arsenic and lead were encountered within the made ground samples tested.

RECOMMENDATIONS

The London Clay at basement level should provide a suitable bearing stratum for spread foundations and these may be designed to apply a net allowable bearing pressure of 250 kN/m^2 in the stiff fissured clay at a depth of about 8.0 m below existing ground level. Given the anticipated moderate loads and the need to form retaining walls, piled foundations may be a more suitable option. Alternatively consideration could be given to the use of a basement raft foundation, although this will be governed by the applied load from the new development and the amount of tolerable settlement / heave, and will need to be considered in more detail once loads are known.

The majority of the made ground at this site will be removed by the extent of the basement excavation with hard covered areas patio areas around the perimeter of the new building on completion. The existing mature garden that covers the south-western third of the site will remain and form the garden area. Upon completion of the development, direct contact with the soil will be restricted to areas where the existing mature garden is present. It is considered that the critical pathways for exposure to these contaminants will not be realised following the completion of the development and thus remedial action would not be required in this respect.

Part 1: INVESTIGATION REPORT

This section of the report details the objectives of the investigation, the work that has been carried out to meet these objectives and the results of the investigation. Interpretation of the findings is presented in Part 2.

1.0 INTRODUCTION

Geotechnical and Environmental Associates (GEA) has been commissioned by Price and Myers on behalf of Deroda Investments Ltd, to carry out a desk study and ground investigation at 75 Avenue Road, London, NW8 6JD.

1.1 Proposed Development

It is proposed to demolish the existing building and construct a three-storey house with a two-storey basement extending to a depth of about 8 m, which will extend beneath the entire footprint of the house and into the rear garden. It is understood the garden above the basement will be reinstated with a hard covered terrace and part of the existing mature garden and lawn area will remain in the south-western third of the site.

This report is specific to the proposed development and the advice herein should be reviewed once the development proposals have been finalised.

1.2 Purpose of Work

The principal technical objectives of the work carried out were as follows.

- to check the history of the site with respect to previous contaminative uses;
- to determine the ground conditions and their engineering properties;
- to provide advice with respect to the design of suitable foundations and retaining walls;
- to provide an indication of the degree of soil contamination present; and
- to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment.

1.3 Scope of Work

In order to meet the above objectives, a desk study was carried out, followed by a ground investigation. The desk study comprised:

- a review of readily available geological maps;
- a review of historical Ordnance Survey (OS) maps and environmental searches sourced from the Landmark database; and
- a walkover survey of the site.

In the light of this desk study an intrusive ground investigation was carried out which

comprised, in summary, the following activities:

- two cable percussion boreholes, advanced to a maximum depth of 25.45 m below existing garden level;
- standard penetration tests (SPTs), carried out at regular intervals in the boreholes, to provide additional quantitative data on the strength of the soils;
- laboratory testing of selected soil samples for geotechnical purposes and for the presence of contamination; and
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

The report includes a contaminated land assessment which has been undertaken in accordance with the methodology presented in Contaminated Land Report (CLR) 11[1] and involves identifying, making decisions on, and taking appropriate action to deal with land contamination in a way that is consistent with government policies and legislation within the United Kingdom. The risk assessment is thus divided into three stages comprising Preliminary Risk Assessment, Generic Quantitative Risk Assessment, and Site-Specific Risk Assessment.

1.4 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, gas or groundwater samples tested; no liability can be accepted for information in other data sources or conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate; no independent validation of such information has been made by GEA.

2.0 THE SITE

2.1 Site Description

The site is located approximately 250 m to the northeast of St John's Wood Barracks and fronts onto Avenue Road to the northeast. It is bounded to the northwest by a house, to the south by Queens Grove Road and to the west by detached houses and their associated gardens. Its location in respect to Avenue Road and Queens Grove Road can be seen on the map below. It may be additionally located by National Grid Reference 526920, 183820.

1 *Model Procedures for the Management of Land Contamination* issued jointly by the Environment Agency and the Department for Environment, Food and Rural Affairs (DEFRA) Sept 2004

The site is rectangular in shape and measures approximately 40 m by 25 m. A two-storey house occupies the northern part of the site with a tarmac driveway in the northeast. To the south of the house is a swimming pool which has a textile arched roof structure which shows signs of disrepair.

The garden area occupying the eastern and western part of the site is sensibly level, but for a rectangular patio area directly to the rear of the house; the house itself and the front driveway are elevated relative to the garden by approximately 0.4 m.

Vegetation at the site includes a large number of semi-mature and mature deciduous trees of various species, located on all boundaries.

2.2 Site History

The site history has been researched by historical Ordnance Survey Maps (OS) provided by the Landmark database.

The earliest map studied, dated 1872, shows the site to be developed with two houses with associated rear gardens, a detached house occupying the southern part of the site and the existing linked detached house occupying the northern part of the site. Queens Road, (later renamed Queens Grove Road) and Avenue Road were present at this time. The site remained in the same layout until some time between 1951 and 1953 by which time the house occupying the eastern part of the site had been removed and the site occupied by the existing house in the north with the remainder of site forming a large L-shaped garden. At some point between 1953 and the present day the swimming pool was constructed in the south-eastern corner, although this is not shown on any of the historical maps. The site has remained in the same layout through to the present day.

2.3 Other Information

A search of public registers and databases has been made via the Envirocheck database and extracts from the results of the search are appended. More detailed information on the search can be provided if required.

The search has indicated that there are no landfills, waste transfer, treatment or disposal sites within 500 m of the site.

The search has indicated that the site is located in an area where less than 1% of homes are affected by radon emissions; which is the lowest classification given by the Health Protection Agency (HPA) and therefore no radon protective measures will be necessary.

The site is shown to be within a Source II Protection Zones as defined by the environment agency. The site is not at direct risk of flooding.

2.4 Geology and Hydrogeology

The Geological Survey map of the area (BGS Sheet 256) indicates that the site is underlain by London Clay.

The former National Rivers Authority (NRA) Ground Water Vulnerability map suggests that the site is underlain by a non aquifer with soils of negligible permeability. The nearest surface water feature is a pond located approximately 440 m to the north of the site. However, reference to The Lost Rivers of London[2] indicates that the site lies immediately to the west of a tributary of the former River Tyburn, which joined the River Tyburn approximately 100 m to the south of the site. It is understood the River Tyburn has been culverted into the sewage system which runs along Avenue Road.

A figure provided in the BGS memoir showing groundwater contours in 1965 indicates groundwater beneath the site to be at a level of -60 m OD (i.e. approximately 100 m below ground level). This reflects the level of groundwater within the chalk aquifer at depth; the London Clay effectively acts as a barrier to flow between the lower (chalk) aquifer and superficial groundwater. However a more recent contour map of groundwater levels provided by the Environment Agency[3] indicates that by 2009, groundwater in the London area had risen by approximately 30 m and is more likely to be at around -30 m OD, currently 70 m below ground level. Groundwater is unlikely to be present within the London Clay, although groundwater may be present within fissures.

Due to the cohesive nature of the soils, the groundwater flow rate is likely to be negligible. Published data for the permeability of the London Clay indicates the horizontal permeability to generally range between 1×10^{-10} m/s and 1×10^{-8} m/s, with an even lower vertical permeability.

2.5 Preliminary Risk Assessment

Part IIA of the Environmental Protection Act 1990, which was inserted into that Act by Section 57 of the Environment Act 1995, provides the main regulatory regime for the identification and remediation of contaminated land. The determination of contaminated sites is based on a "suitable for use" approach which involves managing the risks posed by contaminated land by making risk-based decisions. This risk assessment is carried out on the basis of a source-pathway-receptor approach.

2.5.1 Source

The historical usage of the site that has been established by the desk study and the site walkover indicates that the site does not have a potentially contaminative history by virtue of it having been developed with two semi detached houses from at least 1872 and with the existing house since some time between 1951 and 1953. However, as with any previously developed site localised areas of dumping or spillages could be present which could provide an isolated contaminant source.

2 Barton, N (1992). *The Lost Rivers of London*, Historical Publications Ltd
3 Environment Agency Status Report (2009) *Management of the London Basin Chalk Aquifer*

2.5.2 Receptor

The use of the site as a residential property with an area of soft landscaping in the west of the site would potentially result in exposure to the soil for residents and thus represents a relatively high sensitivity end-use. The site being underlain by a non-aquifer groundwater is unlikely to be considered as a sensitive target.

2.5.3 Pathway

The development will include the retention of an area of soft landscaping in the south-western part of the site so there is a potential for end users to come into direct contact with contaminated soil in this area. There will be a limited potential for contaminants to move onto or off the site, except horizontally within any made ground or topsoil layer, or upon the interface with the underlying London Clay, possibly in association with perched water movements. However, the area to remain soft landscaped has been soft landscaped for the sites entire developed history and as such any leachable contaminants are likely to have already been mobilised. There is thus considered to be limited potential for a significant contaminant pathway to be present between any potential contaminant source and a target for the particular contaminant.

2.5.4 Preliminary Risk Appraisal

On the basis of the above it is considered that there is a very low risk of there being a significant contaminant linkage at this site which would result in a requirement for major remediation work. Furthermore as there is no evidence of filled ground within the vicinity and as it is anticipated to be underlain by cohesive soils at shallow depth there is not considered to be a significant potential for hazardous soil gas to be present on or migrating towards the site: there should thus be no need to consider soil gas exclusion systems.

3.0 EXPLORATORY WORK

In order to meet the objectives described in Section 1.2, two cable percussion boreholes were advanced to a depth of 25.45 m below ground level by means of a dismantlable cable percussion drilling rig. Standard Penetration Tests (SPTs) were carried out at regular intervals in the boreholes and disturbed and undisturbed samples were recovered for subsequent laboratory examination and testing.

Groundwater monitoring standpipes were installed within Borehole Nos 1 and 2 to a depth of 8 m in each borehole and have been monitored on a single occasion, approximately four weeks after installation.

All of the work was carried out under the part time supervision of a geotechnical engineer from GEA.

The borehole records and results of the laboratory analyses are appended together with a site plan indicating the exploratory positions.

3.1 Sampling Strategy

The locations of the boreholes and trial pits were specified by the consulting engineers and were confirmed on site by GEA to be away from underground services.

Two samples recovered from the made ground were subjected to analysis for a range of common industrial contaminants and contamination indicative parameters. For this investigation the analytical suite for the soil included a range of metals, speciation of total

petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols.

The soil samples were selected to provide a general view of the chemical conditions of the soils that are likely to be involved in a human exposure or groundwater pathway and to provide advice in respect of re-use or for waste disposal classification. The samples are considered to represent the general fill material that may be encountered across the site. The contamination analyses were carried out at an MCERTs accredited laboratory with the majority of the testing suite accredited to MCERTS standards. Details of the MCERTs accreditation and test methods are included in the Appendix together with the analytical results.

4.0 GROUND CONDITIONS

The investigation has confirmed the expected ground conditions in that, below moderate thicknesses of made ground, London Clay was encountered and proved to the full depth of the investigation.

4.1 Made Ground

The made ground was encountered in both boreholes and extended to depths of 1.4 m and 0.9 m in Borehole Nos 1 and 2 respectively. It comprised brown silty gravelly clay with occasional brick, stone and ash fragments.

No evidence of significant contamination was observed within these soils. Samples of the made ground were analysed for a range of contaminants and the results are summarised in section 4.4.

4.2 London Clay

The London Clay initially comprised naturally reworked firm brown mottled silty sandy slightly gravelly clay which extended to depths of 2.9 m and 4.3 m in Borehole Nos 1 and 2 respectively.

The upper zone was underlain by a weathered zone, comprising firm becoming stiff brown mottled grey silty fissured clay with traces of selenite crystals which extended to depths of 8.2 m and 9.4 m. Typical unweathered London Clay was then encountered and comprised stiff becoming very stiff dark brownish grey and grey silty fissured clay with traces of pyrites which was proved to the full depth investigated of to 25.45 m in each borehole.

The results of laboratory undrained triaxial compression tests do not correlate well with the SPT N values for the London Clay. The triaxial results are probably reflective of sample disturbance and a similar lack of correlation has been found previously on a nearby site, although not to such a marked degree.

A claystone was encountered in Borehole No 1 at a depth of 7.4 m.

Laboratory plasticity index tests indicate the London Clay to be of high shrinkability.

4.3 Groundwater

Groundwater was not encountered within either of the boreholes during drilling.

Subsequent monitoring of the standpipes installed in Borehole Nos 1 and 2, approximately four weeks after installation, measured groundwater at a depth of 7.7 m in Borehole No 1 whilst the standpipe in Borehole No 2 was found to be dry. It is possible that the groundwater encountered in Borehole No 1 represents a pocket or seepage of perched water associated with the claystone that was encountered within the borehole at a similar depth. In any case it is not believed to represent a significant quantity of water, but monitoring of the standpipes should be continued to check this assumption.

4.4 Soil Contamination

The table below sets out the values measured within two samples analysed; all concentrations are in mg/kg unless otherwise stated.

Determinant	BH No 1 @ 0.5 m	BH No 2 @ 0.5 m
pH	8.2	8.1
Arsenic	21	**35**
Cadmium	0.12	0.31
Chromium	68	86
Copper	49	86
Mercury	0.82	2.9
Nickel	43	58
Lead	400	**1300**
Selenium	<0.2	<0.2
Zinc	96	220
Total Cyanide	<0.5	<0.5
Total Phenols	<0.3	<0.3
Total Sulphate	1100	700
Sulphide	3.6	10
Extractable Chloride (g/l)	0.018	<0.01
TPH C5–C35	<10	16
Benzo(a)Pyrene	0.27	0.8
Total PAH	2.4	**7.1**
Total Organic Carbon %	1.3	2.6

Note: Figure in bold indicates concentration in excess of risk-based soil guideline values, as discussed below

4.4.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. To this end the table below indicates those contaminants of concern that have values in excess of a generic human health risk based guideline values which are either that of the CLEA[4] Soil Guideline Value where available, or is a Generic Guideline Value calculated using the CLEA UK Version 1.06 software assuming a residential end use. The key generic assumptions for this end use are as follows:

- that groundwater will not be a critical risk receptor;
- that the critical receptor for human health will be a young female child (zero to six years old);
- that the exposure duration will be 6 years;
- that the critical exposure pathways will be direct soil and indoor dust ingestion, skin contact with soils and dust, and inhalation of dust and vapours; and
- that the building type equates to a two storey small terraced house.

It is considered that these assumptions are acceptable for this generic assessment of this site. The tables of generic screening values derived by GEA and an explanation of how each value has been derived are included in the Appendix.

Where contaminant concentrations are measured at concentrations below the generic screening value it is considered that they pose an acceptable level of risk and thus further consideration of these contaminant concentrations is not required. However where concentrations are measured in excess of these generic screening values there is considered to be a potential that they could pose an unacceptable risk and thus further action will be required which could include;

- additional testing to zone the extent of the contaminated material and thus reduce the uncertainty with regard to its potential risk;
- site specific risk assessment to refine the assessment criteria and allow an assessment to be made as to whether the concentration present would pose an unacceptable risk at this site; or
- soil remediation or risk management to mitigate the risk posed by the contaminant to a degree that it poses an acceptable risk.

The concentration ranges of the contaminants of concern highlighted by a comparison of the measured concentrations against the generic screening values are tabulated below. This assessment is based upon the potential for risk to human health, which as this site is underlain by a non-aquifer is considered to be the critical risk receptor.

4 *Updated Technical Background to the CLEA Model (Science Report SC050021/SR3) Jan 2009* and Soil Guideline Value reports for specific contaminants; all DEFRA and Environment Agency.

Contaminant of Concern	Maximum concentration recorded (mg/kg)	Location(s) where elevated concentration recorded	Generic Risk-Based Screening Value
Lead	1300	BH 2	450
Arsenic	35	BH 2	32
Total PAH	7.1	BH 1	6.3

**Threshold values marked thus are for compounds with a limited human toxicity hence the threshold values adopted are not derived on a risk based methodology. Justification for all of the values quoted is provided in the appended table of Generic Risk Based Threshold Soil Guideline Values*

The significance of these results is considered further in Part 2 of the report.

Part 2: DESIGN BASIS REPORT

This section of the report provides an interpretation of the findings detailed in Part 1, in the form of a ground model, and then provides advice and recommendations with respect to foundation options and contamination issues.

5.0 INTRODUCTION

It is proposed to demolish the existing building and construct a three-storey house with a two storey basement extending to a depth of 8 m, which will extend beneath the entire footprint of the house and into the rear garden. It is understood the garden above the basement will be reinstated with a hard covered terrace and part of the existing mature garden and lawn area will remain in the south-western third of the site. Proposed loads have not been provided but are expected to moderate and thus typical of this type of development.

6.0 GROUND MODEL

The desk study has indicated the site was originally developed with two semi detached houses prior to being redeveloped with the existing house in the early 1950s. On the basis of the fieldwork, the ground conditions at this site can be characterised as follows.

- A moderate thickness of made ground overlies London Clay which was proved to the full depth of the investigation of 25.45 m;
- the made ground generally comprises dark brown silty gravelly silt/clay with fragments of ash, brick and stone and extended to depths of 1.4 m and 0.9 m in Borehole Nos 1 and 2 respectively;
- the London Clay generally initially comprises a naturally reworked layer of brown silty sandy gravelly clay to depths of 2.9 m and 42 m respectively;
- whereupon a weathered zone was encountered, comprising firm becoming stiff brown mottled grey silty fissured clay with traces of selenite crystals which extended to depths of 8.2 m and 9.4 m in each borehole respectively;
- this weathered zone is underlain by typical unweathered London Clay which comprises stiff becoming very stiff dark brownish grey and grey silty fissured clay with traces of pyrites and was proved to the full depth investigated of to 25.45 m in each borehole;
- groundwater was not encountered within either of the boreholes during drilling;
- subsequent monitoring of the standpipes installed in the boreholes, approximately four weeks after installation, measured the groundwater at a depth of 7.7 m within Borehole No 1 and found Borehole No 2 to be dry;
- the contamination analyses have indicated that there are elevated concentrations of arsenic, lead and Total PAH within the sample of made ground tested from Borehole No 2 which could pose a risk to human health. No elevated concentrations were recorded in Borehole No 1.

7.0 ADVICE AND RECOMMENDATIONS

It is proposed to demolish the existing buildings and construct a three storey house with a two storey basement extending to a depth of 8 m, which will extend beneath the entire footprint of the house and into the rear garden

The basement is anticipated to extend to a depth of about 8.0 m below existing ground level and loads are expected to be moderate and thus typical of this type of development. The London Clay at basement level should provide a suitable bearing stratum for spread foundations. In view of the anticipated columns loads there are a number of suitable foundation options. With the reduction in load at basement formation level as a result of the removal of overburden, the use of a basement raft foundation bearing on the clay may be a suitable foundation solution. The viability of a raft will be governed by the net load from the new structure and the amount of ground movement that arises; this will need to be the subject of additional analysis once proposals have been finalised if this option is preferred. A bored pile retaining wall may be a suitable means of temporary support for the basement excavation and it may therefore be appropriate to also consider the use of piles to support structural loads.

7.1 Basement Construction

7.1.1 Basement Excavation

Groundwater was not encountered during the investigation; however, subsequent monitoring of the standpipes found groundwater to be present at a depth of 7.7 m in one of the boreholes which may represent a relatively minor seepage associated with the claystone at the similar depth. Monitoring should be continued, but it is not possible to draw wholly meaningful conclusions from the measurements made in the standpipe, as the level of the water table is not as significant as the volume of water that may flow into the excavation. For example, a high level of water measured in a standpipe may not be significant if this represents only a small volume of water. It would therefore be prudent to carry out a number of trial excavations, to depths as close to the full basement depth as possible, to provide an indication of the likely ground water conditions. Monitoring of the standpipe should be continued in any case.

There are a number of methods by which the sides of the basement excavation could be supported in the temporary and permanent conditions. The choice of wall may be governed to a large extent by whether it is to be incorporated into the permanent works and have a load bearing function.

Consideration will need to be given to a retention system that maintains the stability at all times of the neighbouring properties to the northwest and southwest, and of surrounding roads and services. Due to the extent of the proposed basement there is insufficient space on the northern, eastern and southern sides of the site to excavate the basement in an open cut but sheet piling would probably be a cost effective alternative. Sheet piling would also prevent any limited groundwater inflows, although the noise and vibrations associated with some techniques may be undesirable, given the close proximity of the adjacent buildings to the east. Consideration could be given to using pressing techniques, although pressing techniques that use water jetting should be treated with caution in view of the risk of causing heave or settlement of the surrounding structures.

For the south-western extent of the basement it may be possible to construct insitu retaining walls within an open cut excavation with the sides battered to a safe angle. Slopes within the made ground should be excavated at 1 in 2, and slopes within the London Clay could

theoretically be cut at 1 in ½, although this would not eliminate the risk of minor slips, which is unlikely to be acceptable in view of the proximity of existing structures. It would therefore be prudent to cut the London Clay at an angle 1 in 2, although in any case any cut slopes should be subject to daily inspections and it is assumed that surface loads, for example from heavy plant, will not be applied to the top of the cut slopes.

Alternatively it may be preferable to adopt a contiguous bored pile wall and deal with inflows through the wall by means of sump pumping, as this would have the benefit of providing support for structural loads.

The ground movements associated with the basement excavation will depend on the method of excavation and support, and the overall stiffness of the basement structure in the temporary condition. Thus, a suitable amount of propping will be required to provide the necessary rigidity. In this respect the timing of the provision of support to the wall will have an important effect on movements. The stability of the foundations of the neighbouring building to the northwest and southwest and the roads to the northeast and south will need to be ensured at all times.

7.1.2 Basement Retaining Walls

The following parameters are suggested for the design of the permanent basement retaining walls.

Stratum	Bulk Density (kg/m^3)	Effective Cohesion (c' – kN/m^2)	Effective Friction Angle (Φ' – degrees)
Made ground	1800	Zero	25
London Clay	2000	Zero	25

The investigation has indicated that ground water is likely to be present within the 8 m deep basement excavation. Reference to Clause 3.4 of BS BS8102:1990 "Protection of Structures Against Water from the Ground" indicates that, for basements which extend below a depth of 4 m, the water table should be taken as being 1 m below ground level.

In addition reference should be made to BS 8002:1994 "Code of Practice for Earth Retaining Structures" which states that an obligatory minimum surcharge of 10 kN/m^2 should be applied to the surface of retained soils in the design of all retaining walls. Additional surcharge loading should be used in the design to take account of incidental loading arising from construction plant, stacking of materials and movement of traffic both during construction and subsequently unless the nature of the layout of the site precludes the need for such additional surcharge.

7.1.3 Basement Heave

It has been estimated that the excavation of an 8.0 m depth of soil will lead to an unloading of approximately 160 kN/m^2 over the new basement area. This will result in short term elastic heave and long term swelling of the London Clay, although long term movements will be mitigated to some extent by the loads applied by the new development. A heave analysis should be carried out once final loads and levels are known.

7.2 Basement Raft Foundation

Consideration could also be given to the use of a basement raft foundation for the entire building. The weight of the soil removed is unlikely to be balanced by the applied loads from the proposed three storey house so there is likely to be a net unloading, resulting in potential uplift. Therefore, the use of a raft foundation will be governed by the applied load from the new development, the amount of settlement and / or heave and the extent to which the movement can be tolerated or resisted by the structure. A detailed ground movement analysis should therefore be carried out once final dimensions and loadings are known.

7.3 Spread Foundations

It should be possible to use spread foundations bearing within the stiff London Clay below basement level. Moderate width pad or strip foundations bearing on the firm or stiff clay at this depth may be designed to apply a net allowable bearing pressure of 250 kN/m^2. This value incorporates an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits.

Given the need to form retaining walls piled foundations may need to be considered.

7.4 Piled Foundations

For the ground conditions at this site consideration could be given to the use of a driven or bored pile, although the noise and vibrations associated with the use of driven piles may render them unsuitable due to the close proximity of the neighbouring buildings and roads on all sides of the site. Conventional rotary augered piles may be considered as only nominal amounts of casing will be required through the made ground; alternatively, piles installed by continuous flight auger (cfa) techniques may be considered.

The following table of ultimate coefficients may be used for the preliminary design of cfa piles, based on the SPT / cohesion depth graph in the appendix. Greater reliance should be placed on the results of the insitu SPTs as the laboratory test results are not considered to accurately represent the strength of the clay. All depths are shown relative to existing ground floor level.

Ultimate Skin Friction		*kN/m^2*
Basement Excavation	GL to 8.0 m	Ignore
London Clay ($\alpha = 0.5$)	8.0 m to 25.0 m	Increasing linearly from 45 to 110
Ultimate End Bearing		*kN/m^2*
London Clay	20.0 m to 25.0 m	Increasing linearly from 1665 to 1980

In the absence of pile tests, guidance from the London District Surveyors Association[5] (LDSA) suggests that a factor of safety of 2.6 should be applied to the above coefficients in the computation of safe theoretical working loads and that the average ultimate skin friction within the clay should be limted to 110 kN/m^2.

5 LDSA (2009) *Foundations No 1 – Guidance notes for the design of straight shafted bored piles in London Clay*. LDSA Publications

On the basis of the above coefficients and a factor of safety of 2.6 it has been estimated that a 450 mm diameter pile founding at a depth of 25 m below existing ground level should provide a safe working load of about 850 kN and a 450 mm diameter pile founding at a depth of 20 m should provide a safe working load of about 550 kN. A 600 mm diameter pile founding at depths of 25 m and 20 m should provide a safe working load of about 1175 kN and 775 kN respectively.

These examples are not intended to constitute any form of recommendation with regard to pile size or type, but merely serve to illustrate the use of the above coefficients. Specialist piling contractors should be consulted with regard to the design of an appropriate piling scheme. Consideration will need to be given to the possible effects of heave on the piles and this should be considered further once the layout has been finalised.

7.5 Excavations

On the basis of the borehole findings it is considered likely that it will be feasible to form relatively shallow excavations within the made ground and London Clay without the requirement for lateral support, however small scale instabilities may occur within the made ground. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

Inflows of groundwater are unlikely to be encountered; however perched water may be encountered within the vicinity of existing foundations and other buried structures, although any such inflows should be suitably dealt with by sump pumping.

7.6 Basement Floor Slab

Following the excavation of the basement it should be possible to adopt a ground bearing floor slab on the London Clay. The formation level should be proof rolled in any case and any soft spots should be replaced with compacted granular fill. Further consideration will however need to be given to the need to design the slab to take account of heave due to unloading and to the possible requirement to design with respect to a ground water table at a theoretical depth of 1 m below ground level. A void or layer of compressible material is likely to be required below the slab to accommodate the heave.

7.7 Hydrogeological Assessment

The current development proposal includes the construction of a two storey basement beneath the entire footprint of the new house, which will extend into the rear garden and to a depth of approximately 8.0 m below present garden ground level.

The desk study research has indicated that significant movement of groundwater is unlikely to be occurring within the soils of the London Clay beneath the site, except for relatively minor movements associated with fissures or claystones within the clay. This has been confirmed by the investigation, in which groundwater was not encountered during drilling and subsequent monitoring of the standpipes found one standpipe to be dry and the other to have a water level at 7.7 m within an 8 m standpipe. This level is relatively consistent with the presence of a claystone and is likely to represent a seepage of perched water associated with the claystone.

The basement construction and underlying foundations are unlikely to encounter groundwater and in any case the basement will not provide a barrier to any shallow water moving through the London Clay. The construction of the basement should therefore have no affect on the local groundwater regime.

7.8 Effect of Sulphates

Chemical analyses of selected soil samples have indicated low to moderate concentrations of soluble sulphate, corresponding to Class DS-1, ACEC class AC1s and Class DS-3, ACEC class AC2s of Table C2 of BRE Special Digest 1: Part C (2005). The guidelines contained in the above digest should be followed in the design of any new foundation concrete.

The guidelines contained in the above digest should be followed in the design of foundation concrete.

7.9 Site Specific Risk Assessment

The chemical analyses have highlighted the presence of arsenic, lead and total PAH concentrations within the made ground sample tested from Borehole No 2 at 0.5 m. These concentrations could thus pose a potentially unacceptable risk to human health through direct contact, accidental ingestion or inhalation of soil or soil derived dust.

The majority of the made ground at this site will be removed by the extent of the basement excavation with hard covered patio areas around the perimeter of the new building on completion.

The existing mature garden that covers the south-western third of the site will remain and form the garden area. Upon completion of the development, direct contact with the soil will be restricted to areas where the existing mature garden is present. It is considered that the critical pathways for exposure to these contaminants will not be realised following the completion of the development and thus remedial action would not be required in this respect.

However, these contaminants could pose a potential risk to ground workers in the short term. In addition where the made ground is not removed, ie in the far eastern part of the site, which is likely to be the entry point of buried services for the proposed house, there is the potential for the presence of pockets of contamination to be present. If ashy material is found within the proposed service trenches during the site works it could affect the integrity of plastic services and it would be prudent to carry out further testing of the soils within the service trenches in order to eliminate the need for protective measures for buried plastic services.

7.9.1 Site Workers

Concentrations of potentially toxic lead and carcinogenic PAH have been measured in the made ground soils. Site workers should be made aware of the contamination and a programme of working should be identified to protect workers handling any soil. The method of site working should be in accordance with guidelines set out by HSE[6] and CIRIA[7] and the requirements of the Local Authority Environmental Health Officer.

6 HSE (1992) HS(G)66 *Protection of workers and the general public during the development of contaminated land* HMSO

7 CIRIA (1996) *A guide for safe working on contaminated sites* Report 132, Construction Industry Research and Information Association

75 Avenue Road, London, NW8 6JD
Deroda Investments Ltd
Desk Study and Ground Investigation Report

7.10 Waste Disposal

Any spoil arising from excavations or landscaping works will need to be disposed of to a licensed tip. Under the European Waste Directive landfills are classified as accepting inert, non-hazardous or hazardous wastes in accordance with the EU waste Directive.

Based upon the results of the analyses carried out and the technical guidance provided by the Environment Agency[8] it is considered likely that the made ground will be classified as a Non-Hazardous waste and the natural soils may be classified as an Inert waste. However, this classification should be confirmed by the receiving landfill once the soils to be discarded have been identified. In order to finalise this classification it will probably be necessary to carry out further analyses including WAC CEN method bulk leaching tests if a classification of Inert waste is to be considered for the made ground. Such tests should be carried out upon representative samples from the waste stream once the extent of the materials to be discarded has been established.

Under the European Waste Directive all waste going to landfill requires pre-treatment. The pre-treatment process must be physical, thermal, chemical or biological, including sorting. It must change the characteristics of the waste in order to reduce its volume, hazardous nature, facilitate handling or enhance recovery. The only exceptions to this requirement are for inert waste where it is technically not feasible to do so, or for any other waste where the quantity or hazardous nature of the waste cannot be reduced. The waste producer can carry out the treatment but they will need to provide documentation to prove that this has been carried out. Alternatively, the treatment can be carried out by an approved contractor. The Environment Agency has issued a position paper[9] which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be "segregated" onsite prior to excavation by sufficiently characterising the soils insitu prior to excavation.

The local waste regulation department of the Environment Agency (EA) should be contacted to obtain details of tips that are licensed to accept the soil represented by the test results. The tips will be able to provide costs for disposing of this material and may require testing to be carried out.

8.0 FURTHER WORK

It would be prudent to carry out a ground movement analysis for the basement excavation and basement raft foundation once final loads and levels have been determined.

8 Environment Agency 2008. *Hazardous Waste: Interpretation of the definition and classification of hazardous waste.* Technical Guidance WM2 Version 2.2

9 Regulatory Position Statement *'Treating non-hazardous waste for landfill - Enforcing the new requirement'* Environment Agency 23 Oct 2007

APPENDIX

GEA Geotechnical & Environmental Associates
Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Site 75 Avenue Road, London, NW8 6JD				**Borehole Number** BH1
Boring Method Cable Percussion	**Casing Diameter** 150mm cased to 1.00m	**Ground Level (mOD)**	**Client** Deroda Investments Ltd	**Job Number** J10229
	Location	**Dates** 04/11/2010-05/11/2010	**Engineer** Price and Myers	**Sheet** 1/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
							Made Ground (brown silty gravelly clay with occasional brick, stone and ash fragments)		
0.50	D1					(1.40)			
1.20-1.65	CPT N=11	1.00	DRY	1,3/2,3,3,3		1.40			
1.50	D2						Firm becoming stiff brown silty sandy gravelly CLAY		
2.00-2.45	U3					(1.50)			
2.45-2.50	D4								
						2.90			
3.00-3.45	U5						Stiff dark brown mottled grey silty fissured CLAY with traces of selenite crystals. Claystone encountered 7.4 m		
3.45-3.50	D6								
4.00-4.45 4.00	SPT N=16 D7	1.00	DRY	2,3/3,4,4,5					
4.50	D8								
5.00-5.45	U9								
5.45-5.50	D10					(5.30)			
6.00-6.45 6.00	SPT N=19 D11	1.00	DRY	3,3/4,4,5,6					
7.00-7.45 7.00	SPT N=40 D12	1.00	DRY	5,7/9,9,11,11					
8.00	D13								
						8.20	Stiff becoming very stiff from 10 m dark brown and grey silty fissured CLAY with traces of pyrites		
9.00-9.45	U14								
9.45-9.50	D15								

Remarks
Groundwater not encountered
Service inspection pit excavated to 1.2 m - 1hr
19 mm groundwater monitoring standpipe installed to 8.0 m - Groundwater subsequently monitored at a depth of 7.7 m below ground level on 16/12/10

Scale (approx)	Logged By
1:50	MK

Figure No. J10229.BH1

GEA Geotechnical & Environmental Associates
Tyttenhanger House, Coursers Road, St Albans, AL4 0PG

Site	Borehole Number
75 Avenue Road, London, NW8 6JD	BH1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 1.00m		Deroda Investments Ltd	J10229
	Location	**Dates**	**Engineer**	**Sheet**
		04/11/2010-05/11/2010	Price and Myers	2/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.50-10.95 10.50	SPT N=32 D16	1.00	DRY	6,7/7,8,8,9					
11.50	D17								
12.00-12.45	U18								
12.45-12.50	D19								
13.50-13.95 13.50	SPT N=40 D20	1.00	DRY	6,8/9,9,10,12					
14.00	D21								
15.00-15.45	U22								
15.45-15.50	D23								
16.50-16.94 16.50	SPT 50/290 D24	1.00	DRY	8,11/12,13,13,12					
17.50	D25					(17.25)			
18.00-18.45	U26								
18.45-18.50	D27								
19.50-19.91 19.50	SPT 50/255 D28	1.00	DRY	9,13/14,14,15,7					

Remarks	Scale (approx)	Logged By
	1:50	MK
	Figure No. J10229.BH1	

GEA Geotechnical & Environmental Associates
Tyttenhanger House, Coursers Road, St Albans, AL4 0PG

Site	Borehole Number
75 Avenue Road, London, NW8 6JD	BH1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 1.00m		Deroda Investments Ltd	J10229
	Location	**Dates**	**Engineer**	**Sheet**
		04/11/2010-05/11/2010	Price and Myers	3/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
20.50	D29								
21.00-21.45	U30								
21.45-21.50	D31								
22.50-22.89 22.50	SPT 50/240 D32	1.00	DRY	11,13/15,15,16,4		(17.25)			
23.00	D33								
24.00	D34								
24.45-24.77 24.50	SPT 25*/90 50/227 D35	1.00	DRY	12,13/15,16,18,1					
25.00-25.33 25.00	SPT 25*/125 50/200 D36	1.00	DRY	13,12/17,19,14					
						25.45	Complete at 25.45m		

Remarks	Scale (approx)	Logged By
	1:50	MK
	Figure No. J10229.BH1	

D8
D9

GEA Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Site	Borehole Number
75 Avenue Road, London, NW8 6JD	BH2

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	200mm cased to 1.50m		Deroda Investments Ltd	J10229
	Location	**Dates** 03/11/2010-04/11/2010	**Engineer** Price and Myers	**Sheet** 1/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
							Made Ground (brown silty gravelly clay with occasional brick and ash fragments and rootlets)		
						(0.90)			
0.50	D1								
						0.90	Firm becoming stiff brown silty sandy gravelly CLAY		
1.20-1.65	CPT N=13	1.00	DRY	2,3/3,3,3,4					
1.50	D2								
2.00-2.45	CPT N=17	1.50	DRY	2,3/4,4,4,5					
2.50	D3					(3.40)			
3.00-3.45	CPT N=17	1.50	DRY	2,4/4,4,4,5					
3.50	D4								
4.00-4.45	CPT N=19	1.50	DRY	3,4/4,5,5,5					
						4.30	Stiff brown mottled grey silty fissured CLAY with traces of selenite crystals		
4.50	D5								
5.00-5.45	U6								
5.50	D7								
6.00-6.45	SPT N=20	1.50	DRY	3,4/5,5,5,5					
						(5.10)			
7.50-7.95	U10								
7.95-8.00	D11								
9.00-9.45 9.00	SPT N=26 D12	1.50	DRY	4,5/6,6,7,7					
						9.40	Stiff becoming very stiff from about 12 m dark brown and grey silty fissured CLAY with traces of pyrites and occasional silt partings at depth		

Remarks
Service inspection pit excavated to 1.2 m - 1hr
18 mm diameter standpipe installed to a depth of 8 m
Groundwater not encountered - Standpipe dry on subsequent monitoring visit on 16/12/10

Scale (approx)	Logged By
1:50	MK

Figure No.
J10229.BH2

GEA Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Site	Borehole Number
75 Avenue Road, London, NW8 6JD	BH2

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	200mm cased to 1.50m		Deroda Investments Ltd	J10229
	Location	**Dates** 03/11/2010-04/11/2010	**Engineer** Price and Myers	**Sheet** 2/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.00	D13								
10.50-10.95	U14								
10.95-11.00	D15								
12.00-12.45 12.00	SPT N=37 D16	1.50	DRY	7,8/9,9,9,10					
12.50	D17								
13.00	D18								
13.50-13.95	U19								
13.95-14.00	D20								
15.00-15.45 15.00	SPT N=45 D21	1.50	DRY	7,9/10,11,12,12					
16.00	D22								
16.50-16.95	U23								
16.95-17.00	D24								
						(16.05)			
18.00-18.44 18.00	SPT 50/285 D25	1.50	DRY	9,11/12,14,14,10					
19.00	D26								
19.50-19.95	U27								

Remarks

Scale (approx)	Logged By
1:50	MK

Figure No.
J10229.BH2