Document Control

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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 Engenuiti, on behalf of Aliya Nedungadi, with respect to the construction of a rear extension and lowering of the existing lower ground floor level to a depth of roughly 4m. The purpose of the investigation has been to research the history of the site with respect to possible contaminative uses, to determine the ground conditions and hydrogeology, to assess the extent of any contamination and to provide information to assist with the design of the basement support and suitable foundations for the proposed development. The report also includes information for a Basement Impact Assessment (BIA) in accordance with guidelines from the London Borough of Camden in support of a planning application.

DESK STUDY FINDINGS

The earliest map studied, dated 1871, indicates that the site was undeveloped at that time, but it was developed by 1896, with what appears to be the existing building and an outbuilding along the western boundary of the site. At some time between 1935 and 1954 the outbuilding was demolished. The site appears to have remained essentially unchanged to the present day, other than the construction of a rear extension. Historically a tributary of the River Tyburn flowed close to the eastern side of Fitzjohn's Avenue.

GROUND CONDITIONS

The investigation has confirmed the expected ground conditions in that, below a moderate thickness of made ground, extending to depths of between 0.50 m and 1.75 m, the London Clay was encountered and proved to the maximum depth investigated of 15.0 m. The London Clay initially comprised naturally reworked soft becoming firm orange-brown mottled grey silty sandy clay, with varying proportions of gravel, which extended to depths of between 1.10 m and 3.40 m. This upper zone was underlain by firm becoming stiff brown mottled grey silty fissured clay with occasional partings of orange-brown fine sand and silt, carbonaceous material, claystones and selenite crystals, which extended to depths of between 9.00 m and 10.50 m. Below this depth stiff grey silty fissured clay was encountered and proved to the maximum depth investigated. Desiccation was encountered in Borehole Nos 1 and 4, located in close proximity to existing trees, to a maximum depth of roughly 2.5 m.

A seepage was encountered in Borehole No 1 at a depth of 11.0 m, associated with a claystone and perched water was encountered around the base of the existing footings in Trial Pit No 3 at a depth of 0.95 m. Subsequent monitoring has measured groundwater at depths of between 5.68 m and ground level, although this high level probably reflects surface water.

The trial pits indicate that the existing house is founded at depths of between 0.20 m and 1.10 m on made ground or naturally reworked London Clay. The store room is founded at a depth of 0.82 m on 'stiff' desiccated London Clay and the northern garden boundary wall is founded at a depth of 0.84 m on made ground. Contamination testing has revealed elevated concentrations of lead and total PAH including benzo(a)pyrene within samples of the made ground.

RECOMMENDATIONS

Excavations for the basement structure will require temporary support to maintain stability and prevent any excessive ground movement. Groundwater inflows may be encountered locally from granular pockets within the reworked London Clay and some form of groundwater control may be required. The excavation of the basement will result in a formation level in the London Clay and it should be possible to apply a net allowable bearing pressure of 150 kN/m^2 below the level of the proposed basement floor, provided that groundwater inflows can be controlled sufficiently to allow spread foundations to be constructed.

The measured concentrations of contaminants are in line with contamination levels in the area and thus no remedial measures are deemed necessary.

The BIA has not indicated any concerns with respect to land stability or groundwater and a requirement for a flood risk assessment has not been identified.

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 Engenuiti, on behalf of Aliya Nedungadi, to carry out a desk study and ground investigation at 9 Fitzjohn's Avenue, London, NW3 5JY. This report also forms part of a Basement Impact Assessment (BIA), which has been carried out in accordance with guidelines from the London Borough of Camden (LBC) in support of a planning application.

This report was originally prepared in April 2013 for a slightly different proposed scheme. Since that time additional sampling has been carried out to provide more information on the presence of contamination in the rear garden and the findings were reported separately in GEA letter report J14031A, dated 12 September 2014. The report herein refers to the current development proposal and includes details of the updated contamination recommendations.

1.1 Proposed Development

It is understood that it is proposed to construct a basement beneath part of the existing lower ground floor level. A four-storey rear extension will be constructed above the basement in the rear garden. The proposed single level basement will extend to a depth of approximately 4 m below existing lower ground floor level.

This report is specific to the proposed development and the advice herein should be reviewed if the proposals are amended.

1.2 Purpose of Work

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

- to check the history of the site and surrounding areas with respect to previous contaminative uses;
- to determine the ground conditions and their engineering properties;
- to investigate the configuration of existing foundations;
- to assess the possible impact of the proposed development on the local hydrogeology;
- 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 and hydrogeological maps;
- a review of historical Ordnance Survey (OS) maps and environmental searches sourced from the Envirocheck database; and
- a walkover survey of the site carried out in conjunction with the fieldwork.

In light of the desk study, an intrusive ground investigation was carried out which comprised, in summary, the following activities:

- two cable percussion boreholes, advanced to depths of 15.0 m, by means of a dismantlable drilling rig;
- standard penetration tests (SPTs), carried out at regular intervals in the cable percussion boreholes, to provide quantitative data on the strength of the soils;
- five drive-in window sampler boreholes advanced to depths of 6.0 m;
- the installation of three groundwater monitoring standpipes and three subsequent monitoring visits over a period of roughly four weeks;
- a simple rising head test was carried out in a single standpipe to provide preliminary information on the groundwater inflows that may be encountered during basement excavation;
- ten trial pits manually excavated to investigate the existing foundations;
- seven sample pits hand excavated to a depth of 0.2 m to obtain disturbed samples for chemical analyses in September 2014;
- 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.

1.3.1 Basement Impact Assessment (BIA)

The work carried out also includes a Hydrogeological Assessment and Land Stability Assessment (also referred to as Slope Stability Assessment), all of which form part of the BIA

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

procedure specified in the London Borough of Camden (LBC) Planning Guidance CPG4[2] and their Guidance for Subterranean Development[3] prepared by Arup. The aim of the work is to assess whether the development will affect the stability of neighbouring properties or groundwater and whether any identified impacts can be appropriately mitigated by the design of the development.

1.4 Qualifications

The land stability element of the Basement Impact Assessment (BIA) has been carried out by Martin Cooper, a BEng in Civil Engineering, a chartered engineer (CEng), member of the Institution of Civil Engineers (MICE), and Fellow of the Geological Society (FGS) who has over 20 years specialist experience in ground engineering. The subterranean (groundwater) flow assessment has been carried out by John Evans, MSc in Hydrogeology, Chartered Geologist (CGeol) and Fellow of the Geological Society of London (FGS). The assessments have been made in conjunction with Steve Branch, a BSc in Engineering Geology and Geotechnics, MSc in Geotechnical Engineering, a chartered geologist (CGeol) and Fellow of the Geological Society (FGS) with 25 years' experience in geotechnical engineering and engineering geology. All assessors meet the Geotechnical Adviser criteria of the Site Investigation Steering Group and satisfy the qualification requirements of the Council guidance.

The surface water and flooding element of the BIA is provided for guidance only and should be confirmed by a suitably qualified engineer experienced in carrying out surface water assessments.

1.5 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.

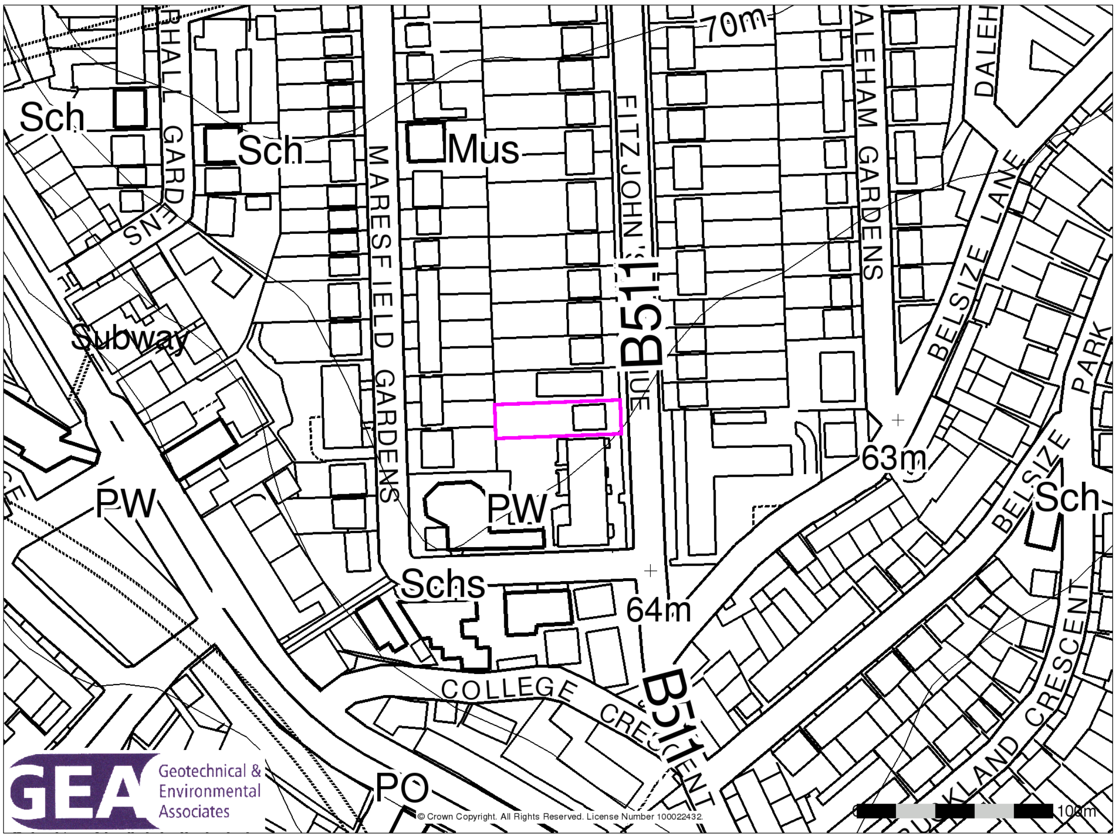
2.0 THE SITE

2.1 Site Description

The site is located in a mainly residential area, in the London Borough of Camden, about 200 m to the east of Finchley Road London Underground station. It is roughly rectangular in shape, measuring approximately 22 m north-south by 45 m east-west, and fronts onto Fitzjohn's Avenue to the east and is bordered to the north by No 11, a four-storey detached building including a semi-basement and to the south by Nos 3-7 (De Laszlo House), which appears to be a detached four-storey building including a semi-basement. It is known that the neighbouring property to the south has a basement car park beneath their rear garden. The site is bordered to the west by the rear gardens of houses fronting onto Maresfield Gardens. The

2 London Borough of Camden Planning Guidance CPG4 *Basements and lightwells*
3 Ove Arup & Partners (2010) *Camden geological, hydrogeological and hydrological study. Guidance for Subterranean Development.* For London Borough of Camden November 2010

site may be additionally located by National Grid Reference 526540, 184700 and is shown on the map extract below.



Fitzjohn's Avenue slopes down towards the south, although the site is essentially on a level plot at approximately 65 m OD. The site is currently occupied by a four-storey detached building including a semi-level basement with a number of rear extensions. At the front is a driveway with a soft landscaped area along the northern side. There are steps leading up to the front door at raised ground floor level and a basement lightwell with steps leading down to the lower ground floor level. The rear garden is on two levels, with a partial lightwell, about 0.5 m lower than the garden level with steps up to a patio area along the western elevation and a central lawn; a selection of photographs of the site is shown below.

Semi-mature to mature trees are present along the northern, southern and western perimeters of the rear garden and a tree approximately 15 m high is present along the northern boundary with the neighbouring property of No 11. Another tree, roughly 15 m high, is present on the pavement to the east of the property.

Suspected Japanese Knotweed has been identified on site in the rear garden in a flower bed located roughly in the southwestern part of the site.

2.2 Site History

The history of the site and surrounding area has been researched by reference to historical Ordnance Survey (OS) maps sourced from the Envirocheck database.

The earliest map studied, dated 1871, indicates that the site was undeveloped, and to comprise open fields. The site was first developed at some time between 1874 and 1896, with what appears to be the existing building and an outbuilding along the western boundary of the site. Fitzjohn's Avenue and the surrounding area are also developed over this period. At some time between 1935 and 1954 the outbuilding was demolished. The site appears to have remained essentially unchanged to the present day, other than the construction of a rear extension.

2.3 Other Information

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

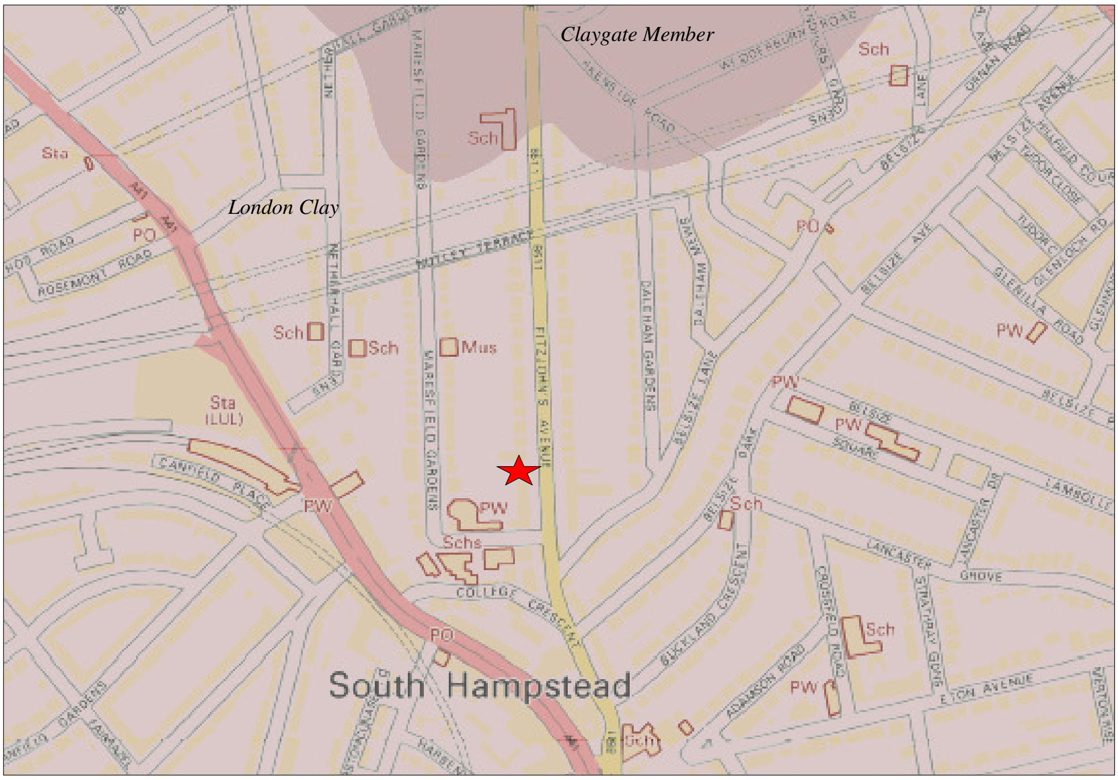
The desk study research has indicated that there are no registered landfills, historic landfills, registered waste transfer sites or waste management facilities within 250 m of the site.

There have been no pollution incidents to controlled waters within 1 km 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 not located within a nitrate vulnerable zone or any other sensitive land use.

The Envirocheck report lists that a fuel station is located 146 m southwest of the site, but given the prevailing topography this is unlikely to have affected the site.

2.4 Geology



The British Geological Survey (BGS) map of the area (Sheet 256) indicates the site to be directly underlain by London Clay. The boundary between the Claygate Member and London Clay is approximately 280 m to the north of the site, as shown on the previous map. The geology in this area is generally horizontally bedded such that the boundary between the geological formations roughly follows the ground surface contour lines.

Our archives of nearby investigations indicate that the Claygate Member extends to a level of approximately 90 m OD.

According to the British Geological Society memoir, the London Clay Formation is homogenous, slightly calcareous silty clay to very silty clay, with some beds of clayey silt grading to silty fine grained sand.

BGS borehole records available online indicate that an investigation was carried out on the neighbouring site to the south at Nos 3 to 7 Fitzjohn's Avenue by Soiltechnics in March 2007. The investigation comprised two cable percussion boreholes advanced to depths of 25.0 m and 30.0 m, supplemented by six drive-in window sample boreholes advanced to depths of 5.0 m. In addition to the boreholes, 13 trial pits were excavated to depths of between 0.32 m and 1.50 m to determine the configuration of the footings of the previous building. The previous investigation encountered made ground to depths of between 0.4 m and 3.0 m and was underlain by London Clay, proved the maximum depths investigated of 30.0 m. The London Clay initially comprised gravelly sandy clay to depths of between 0.8 m and 2.5 m, where encountered. A seepage was encountered at a single location at a depth of 12.1 m, associated with a claystone.

2.5 Hydrology and Hydrogeology

The London Clay is classified as 'Unproductive Strata', as defined by the Environment Agency as rock or drift deposits with low permeability that have negligible significance for water supply or river base flow.

Any groundwater flow within the London Clay will be at a very slow rate, due to its negligible permeability; the permeability will be predominantly secondary, through fissures in the clay. Published data for the permeability of the London Clay indicates the horizontal permeability to generally range between 1×10^{-11} m/s and 1×10^{-9} m/s, with a lower vertical permeability.

There are no Environment Agency designated Groundwater Source Protection Zones (SPZs) on the site and there are no list water abstraction points within 250 m of the site.

The nearest surface water feature is located 433 m southeast of the site.

The site lies outside the catchment of the Hampstead Heath chain of ponds.

The site is not at risk of flooding from rivers or sea, as defined by the Environment Agency. Fitzjohm's Avenue has not been identified as a street at risk of surface water flooding, specified in the London Borough of Camden (LBC) Planning Guidance CPG4 and therefore a flood risk assessment will not be required.

Historically a headwater tributary of the River Tyburn[4] flowed down or near to the eastern side of Fitzjohn's Avenue perched on the London Clay, and flowed toward the southeast, into lakes

4 Nicholas Barton (2000) *London's Lost Rivers.* Historical Publications Ltd

in Regent's Park, and then onto the River Thames. It is likely that any groundwater beneath the site within the London Clay Formation would be controlled by local contours, thus flow would be towards the southeast and the River Thames. Today the Tyburn is entirely covered and culverted and forms part of the surface water sewerage system.

2.6 Preliminary Contamination 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.

2.6.1 Source

The desk study research has indicated that the site has only been occupied by the existing residential property for its entire known developed history. The site and immediate surrounding areas are not considered to have had a contaminative history.

The fuel station located 146 m southwest of the site may represent a potential source of off-site contamination. However, the site is located upslope and the fuel station is therefore unlikely to have had any impact on the site.

There are no historical or existing landfill sites within 250 m of the site and therefore there is not a risk to the site from landfill gas.

2.6.2 Receptor

The site will continue to have a residential end use following the redevelopment and no new receptors will result. However, the residential end use is considered a high sensitivity end-use. Buried services are likely to come into contact with any contaminants present within the soils through which they pass and site workers are likely to come into direct contact with any contaminants present in the soil and through inhalation of vapours during basement excavation and construction. Being underlain by unproductive strata groundwater is not considered to be a receptor.

2.6.3 Pathway

End users would be effectively isolated from direct contact with any contaminants present within the near surface soils by the presence of the building, but a potential for direct contact would exist in any proposed garden areas. This pathway is considered to already be in existence. The presence of negligibly permeable London Clay beneath the site will limit the potential for groundwater percolation into the underlying chalk, and thus a pathway is not considered likely to exist to the principal aquifer. There will be limited potential for contaminants to move on or off the site, except horizontally within any made ground, in association with perched groundwater movements, this pathway is also already in existence. A pathway for ground workers to come into contact with any contamination will exist during demolition and construction work and services will come into contact with any contamination within the soils in which they are laid. There is thus considered to be a low potential for a contaminant pathway to be present between any potential contaminant source and a target for the particular contaminant.

2.6.4 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 of the site and no landfill sites, 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 landfill gas exclusion systems.

3.0 SCREENING

The LBC guidance suggests that any development proposal that includes a subterranean basement should be screened to determine whether or not a full BIA is required.

3.1 Screening Assessment

A number of screening tools are included in the Arup document and for the purposes of this report reference has been made to Appendix E which includes a series of questions within a screening flowchart for three categories; groundwater flow; land stability; and surface water flow. Responses to the questions are tabulated below.

3.1.1 Subterranean (groundwater) Screening Assessment

Question	Response for 9 Fitzjohn's Avenue
1a. Is the site located directly above an aquifer?	No. The Site is underlain by the London Clay which is designated as Unproductive Strata by the Environment Agency and cannot store and transmit water in sufficient quantities to support groundwater abstractions or watercourses.
1b. Will the proposed basement extend beneath the water table surface?	Possibly This will need to be confirmed through further groundwater monitoring.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	No. The nearest surface water feature is located 433 m southeast of the site. However, reference to the Lost Rivers of London indicates that the Tyburn flowed down or near to the eastern side of Fitzjohn's Avenue. This former watercourse is not present at the surface and has been culverted to form part of the local surface water sewer.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	No. The Site lies outside the catchment of Hampstead Heath ponds.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. The area of the proposed rear extension is already paved.
5. As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	No. The low permeable nature of the London Clay strata is unsuitable for receiving discharge to ground.
6. Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to or lower than, the mean water level in any local pond or spring line?	No. There are no local ponds or spring lines present within 100m of the site.

The above assessment has not identified any potential issues that need to be assessed.

3.1.2 Stability Screening Assessment

Question	Response for 9 Fitzjohn's Avenue
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No
5. Is the London Clay the shallowest strata at the site?	Yes, the site is underlain by London Clay.
6. Will any trees be felled as part of the proposed development and / or are any works proposed within any tree protection zones where trees are to be retained?	Possibly. It is understood that some trees may be removed.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	Yes. The area is prone to these effects as a result of the presence of shrinkable London Clay and abundant mature trees.
8. Is the site within 100 m of a watercourse or potential spring line?	No
9. Is the site within an area of previously worked ground?	No
10. Is the site within an aquifer?	No
11. Is the site within 50 m of Hampstead Heath ponds?	No
12. Is the site within 5 m of a highway or pedestrian right of way?	Yes, the site fronts onto Fitzjohn's Avenue.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Yes? The development will increase foundation depths to depths of roughly 4.0 m. The depths of foundations of the adjacent property to the north of the site are not known, but it is assumed that the foundations of the building to the south, are deeper than proposed as the neighbouring property has a basement.
14. Is the site over (or within the exclusion zone of) any tunnels, eg railway lines?	No

The above assessment has identified the following potential issues that need to be assessed:

Q5 The London Clay is the shallowest stratum at the site
Q6 Trees may be felled as part of the developments and a number of trees on site have tree preservation orders
Q7 The site is underlain by London Clay, which is prone to shrink / swell subsidence
Q12 The site is within 5 m of a public highway
Q13 The development will increase the foundation depths relative to the neighbouring properties to a relatively significant extent

3.1.3 Surface Flow and Flooding Screening Assessment

Although we have answered the questions below relating to the surface flow screening assessment, we are not qualified in accordance with the requirements with CPG4.

Question	Response for 9 Fitzjohn's Avenue
1. Is the site within the catchment of the pond chains on Hampstead Heath?	No
2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	No
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. The basement excavation has no surface expression and will be within the footprint of the existing house
4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	No
5. Will the proposed basement result in changes to the quantity of surface water being received by adjacent properties or downstream watercourses?	No
6. Is the site in an area known to be at risk from surface water flooding such as South Hampstead, West Hampstead, Gospel Oak and Kings Cross, or is it at risk of flooding because the proposed basement is below the static water level of a nearby surface water feature?	No

The above assessment has not identified any potential issues that need to be assessed.

4.0 SCOPING AND SITE INVESTIGATION

The purpose of scoping is to assess in more detail the factors to be investigated in the impact assessment. Potential consequences are assessed for each of the identified potential impact factors.

4.1 Potential Impacts

The following potential impacts have been identified.

Potential Impact	Possible Consequence
The London Clay is prone to seasonal shrink / swell (subsidence and heave)	Shrinkage and swelling of the underlying soil may result in structural damage of the buildings.
Site within 5 m of a highway or pedestrian right of way	Excavation of a basement may result in structural damage to the road or footway
The development will increase the foundation depths relative to the neighbouring properties to a relatively significant extent	Excavation may lead to structural damage to neighbouring properties if there is a significant differential depth between adjacent properties
Trees will be felled as part of the refurbishment	Heave of the clay soils resulting in structural damage of the buildings.
Works are proposed within tree protection zones	Damage to roots resulting in death of the trees.

These potential impacts have been further assessed through the ground investigation, as detailed below.

5.0 EXPLORATORY WORK

In order to meet the objectives described in Section 1.2 and to assess the potential impacts identified in the screening exercise of the BIA, two cable percussion boreholes were advanced, to depths of 15.0 m, using a dismantlable drilling rig.

Standard Penetration Tests (SPTs) were carried out at regular intervals in the cable percussion boreholes to provide quantitative data on the strength of soils encountered.

In addition, a further five window sampler boreholes were drilled to depths of 6.00 m to provide additional coverage of the site. A single window sampler borehole was carried out through the base of a trial pit using hand held window sampling equipment.

Groundwater monitoring standpipes were installed in three boreholes to depths of 6.0 m and 7.0 m, and have been monitored on three occasions to date, over a period of roughly four weeks.

In addition to the boreholes, ten trial pits were manually excavated to investigate the foundations of the existing building and boundary wall.

A second phase of sampling was carried out by hand to obtain additional samples for chemical analysis in September 2014 and the results have been combined with the original fieldwork.

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

A selection of the disturbed and undisturbed samples recovered from the boreholes and trial pits was submitted to a soil mechanics laboratory for a programme of geotechnical testing and an analytical laboratory for a programme of contamination testing.

The borehole and trial pit records and results of the geotechnical laboratory testing are enclosed, together with a site plan indicating the exploratory positions.

5.1 Sampling Strategy

The scope of the works was specified by the consulting engineers. The borehole and trial pit positions were agreed at an initial site meeting between GEA and the consulting engineers to provide optimum coverage of the site with due regard to the proposed development.

Laboratory geotechnical classification and strength tests were undertaken on samples of the natural soil.

Four samples of 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 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.

6.0 GROUND CONDITIONS

The investigation encountered the expected ground conditions in that, below a moderate thickness of made ground, the London Clay was encountered and proved to the full depth investigated of 15.00 m.

6.1 Made Ground

The made ground generally comprised greyish brown silty sandy clay with occasional fragments of glass, brick and charcoal and extended to depths of between 0.50 m and 1.75 m.

No visual or olfactory evidence of contamination was noted in the made ground, apart from the presence of extraneous material such as charcoal and ash fragments, which can commonly contain elevated concentrations of PAH, including benzo(a)pyrene. Four samples of the made ground have been sent for contamination testing as a precautionary measure and the results are presented in Section 6.4.

6.2 London Clay

The London Clay initially comprised naturally reworked soft becoming firm orange-brown mottled grey silty sandy clay, with varying proportions of gravel, which extended to depths of between 1.10 m and 3.40 m. Gravel was not encountered in Borehole No 3, located in the western part of the rear garden, suggesting that the occurrence of gravel may be associated with the former course of the river.

This upper zone was underlain by firm becoming stiff brown mottled grey silty fissured clay with occasional partings of orange-brown fine sand and silt, carbonaceous material, claystones and selenite crystals which extended to depths of between 9.00 m and 10.50 m. Below this depth stiff grey silty fissured clay with rare partings of grey fine sand and silt, was encountered and proved to the maximum depth investigated.

Fine rootlets were noted to depths of between 1.60 m and 4.00 m in Borehole Nos 1 to 7. In-situ pocket penetrometer readings indicates that the clay was desiccated in Borehole No 4 to a depth of between 2.50 and 3.00 m and may also have been desiccated in Borehole No 3, located 5.00 m from a tree to a depth of roughly 4.00 m.

Laboratory examination of the samples indicated that the clay was noted to be particularly stiff and dry indicating desiccation in Borehole No 1 at a depth of 2.00 m to 2.45 m.

The results of the natural moisture contents measured in Borehole No 1 and 4 have been compared to more "typical" un-desiccated moisture contents recorded in Borehole No 6. The natural moisture content plot confirms that the ground is deficient in water to a depth of roughly 2.5 m below ground level in Borehole No 4 and is desiccated in Borehole No 1 to a depth of approximately 2.0 m.

The results of laboratory testing indicate the silty clay of the London Clay to be of high volume change potential. The naturally reworked London Clay, with varying amounts of gravel is of moderate volume change potential. In any case, high shrinkability soils should be assumed.
The results from the laboratory triaxial tests, which are plotted on a graph in the appendix, indicate the London Clay to be generally of high strength. The clay was noted to be of very high strength in Borehole No 1 at a depth of 2.0 m, which is likely to be the result of desiccation.

These soils were observed to be free of any evidence of soil contamination.

6.3 Groundwater

A seepage was encountered in Borehole No 1 at a depth of 11.0 m, associated with a claystone.

Perched water was encountered around the base of the existing footings in Trial Pit No 3 at a depth of 0.95 m.

Standpipes have been installed in Borehole Nos 1 to 3 to depths of 6.0 m and 7.0 m and subsequent groundwater monitoring has been carried out on three occasions to date, over a period of roughly one month.

The table shows the depths at which water was measured on each of the monitoring visits:

Borehole No	Standpipe depth (m)	Depth to groundwater in m		
		27/02/2013	11/03/2013	19/03/2013
1	6.00	Dry	Dry	5.68
2	7.00	Dry	4.12	1.70
3	6.00	Dry	0.30-	Ground Level

Groundwater levels do not appear to have reached equilibrium levels over the three weeks of monitoring.

The groundwater level measured in Borehole No 3 possibly reflects surface water.

The rate of groundwater recovery in the monitoring standpipes reflects the very low permeability of the London Clay beneath the site. Groundwater monitoring should be continued to determine the equilibrium water table and extent of seasonal fluctuations.

A rising head test was carried out at the time of the second groundwater monitoring visit in Borehole No 2 to give a preliminary assessment of the rate of recharge of the measured high water table; a copy of the results is appended. Groundwater was measured at a depth of 1.70 m and was then bailed out of the standpipe to reduce the water to a depth of 3.53 m. Over a period of roughly three hours the groundwater level within the standpipe subsequently rose to a depth of 3.84 m.

6.4 Soil Contamination

The table below sets out the US95 values, based on ten samples in total, including the seven additional samples and the three previous samples of made ground test as part of the original ground investigation. All concentrations are in mg/kg unless otherwise stated.

Determinant	Maximum concentration recorded (mg/kg)	Minimum concentration recorded (mg/kg)	Number of samples below detection limit	Normalised upper bound US_{95}
Arsenic	64	9.9	ALL	37.2
Cadmium	1.2	<0.10	ALL	0.6
Chromium	57	28	ALL	45.1
Copper	130	25	ALL	97
Mercury	1.80	0.65	ALL	1.2
Nickel	46	21	ALL	33.3
Lead	**990**	150	NONE	**741.2**
Selenium	1.0	<0.20	ALL	0.9
Zinc	250	54	ALL	211.7
Total Cyanide	0.70	<0.50	ALL	0.6
Total Phenols	<0.3	<0.3	ALL	0.3
Total Sulphate	1700	800	ALL	1347.1
Chloride	0.016	<0.010	ALL	0.01
Sulphide	5.90	<0.50	ALL	2.4
TPH C5-C35	66	<10	ALL	48.7
Naphthalene	0.15	<0.10	ALL	0.1
Benzo(a)pyrene	3.1	<0.1	ALL	1.8
Total PAH	30	<2	ALL	18.8
Total Organic Carbon %	5.4	1.6	-	-
pH	8.3	6.0	-	-

Note: The use of the normalised upper bound for 95^{th} percentile confidence aims to remove some of the uncertainty associated with calculation of an arithmetic sample mean of a relatively small number of samples. The US95 value is the upper bound of the range within which it can be stated with 95% confidence that the true mean concentration of the data set will fall.
Figure in **bold** indicates concentration in excess of risk-based soil guideline values, as discussed in Part 2 of this report

6.4.1 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 contaminants of concern are those that have values in excess of a generic human health risk based screening values which are either that of the CLEA[5] 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:

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

- that groundwater will not be a critical risk receptor;
- that the critical receptor for human health will be young female children aged zero to six years old;
- that the exposure duration will be six years;
- that the critical exposure pathways will be direct soil and indoor dust ingestion, consumption of homegrown produce, consumption of soil adhering to homegrown produce, skin contact with soils and indoor dust, and inhalation of indoor and outdoor 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 at this site that is to be redeveloped for residential purposes is considered to be a critical risk receptor.

Contaminant of Concern	Maximum concentration recorded (mg/kg)	Locations where elevated concentrations recorded	Normalised upper bound US95	Generic Risk-Based Screening Value
Lead	990	Location 1: 0.20 m Location 2: 0.20 m Location 3: 0.20 m Location 4: 0.20 m Location 5: 0.20 m Location 6: 0.20 m Location 7: 0.20 m BH4: 0.30 m BH5: 0.50 m	741.2	200

When comparing the results from the contamination testing to those in the Soil Screening Values and Generic Guideline Values, the analyses have revealed a normalised upper bound

US_{95} concentration for lead in excess of the generic risk-based screening value for a residential end use. No US_{95} values for any other contaminants were found to be elevated above their respective guideline values. A single sample of arsenic was also noted to be slightly elevated but the US_{95} value for arsenic remained below the screening value and is not deemed to represent a risk to end users.

Although the more recent testing was carried out on sieved samples the results are similar to obtained previously on the unsieved samples.

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.

No other contaminants were in excess of the generic risk-based screening values for a residential end-use with plant uptake.

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

6.5 Existing Foundations

The trial pits indicate that, where proved, the existing house is founded on made ground or London Clay at depths of between 0.20 m and 1.10 m and the northern garden boundary wall is founded at a depth of 0.84 m on made ground.

It was not possible to expose the existing footings at the locations of Trial Pit Nos 2, 4, 5 and 6.

Perched water was encountered around the base of the existing footings in Trial Pit No 3 at a depth of 0.95 m, but not in any other trial pits. The presence of water in this pit had softened the clay.

A copy of the trial pit records are included in the Appendix.

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.

7.0 INTRODUCTION

It is understood that it is proposed to construct a basement beneath part of the existing lower ground floor level. A four-storey rear extension will be constructed above the basement in the rear garden. The proposed single level basement will extend to a depth of approximately 4 m below existing lower ground floor level.

8.0 GROUND MODEL

The desk study has revealed that the site has not had a potentially contaminative history, having apparently been occupied by a residential property for the entirety of its developed history. On the basis of the investigation carried out, the ground conditions at this site can be characterised as follows:

- Beneath a moderate thickness of made ground, London Clay is present and was proved to the full depth investigated of 15.0 m;
- the made ground extends to depths of between 0.50 m and 1.75 m and generally comprises greyish brown silty sandy clay with occasional fragments of glass, brick and charcoal;
- the London Clay initially comprises naturally reworked soft becoming firm orange-brown mottled grey silty sandy clay, with varying amounts of gravel, which extends to depths of between 1.10 m and 3.40 m;
- this upper zone is underlain by firm becoming stiff brown mottled grey silty fissured clay which extends to depths of between 9.00 m and 10.50 m;
- below this depth grey silty fissured clay was encountered and proved to the maximum depth investigated;
- the clay was found to be desiccated in close proximity to existing trees to depths of between 2.5 m and 3.0 m;
- a seepage was encountered in Borehole No 1 at a depth of 11.0 m, associated with a claystone and perched water was encountered around the base of the existing footings in Trial Pit No 3 at a depth of 0.95 m;
- subsequent monitoring has measured groundwater at depths of between 5.68 m and ground level; and
- the chemical analyses revealed slightly elevated concentrations of lead and total PAH, including benzo(a)pyrene within some samples of made ground.

9.0 ADVICE AND RECOMMENDATIONS

Formation level for the approximately 4 m deep basement should be within the firm or stiff London Clay and it can be assumed that all potentially desiccated soils will be removed as part of the basement excavation. On the basis of the groundwater observations to date, groundwater will be encountered in the basement excavation and a requirement for groundwater control should be envisaged, although monitoring of the standpipes should be continued to determine the equilibrium level and the extent of any seasonal fluctuations.

Excavations for the proposed basement structure will require temporary support to maintain stability of the excavation and surrounding structures at all times. The existing foundations will need to be underpinned prior to construction of the proposed new basement or will need to be supported by new retaining walls.

9.1 Basement Construction

9.1.1 Basement Excavation

It is proposed to construct a 4.0 m deep basement below the footprint of part of the existing house. The investigation has indicated that formation level for the basement will be within firm or stiff London Clay.

During drilling a slow seepage was noted in Borehole No 1 at a depth of 11.0 m associated with a claystone and perched water was encountered in Trial Pit No 3 at a depth of 0.95 at the base of the existing footings. Monitoring was subsequently carried out roughly one, two and three weeks after installation; all three standpipes were recorded to be dry on the first visit and on the second visit groundwater was measured at depths of 4.12 m and 0.30 m in Borehole Nos 2 and 3, whilst the standpipe in Borehole No 1 wad recorded to be dry. On the third visit groundwater was measured at depths of 5.68 m, 1.70 m and ground level in Borehole Nos 1 to 3 respectively.

The groundwater measured in the boreholes has probably not yet reached equilibrium. The results indicate that groundwater is likely to be encountered within the basement excavation, but monitoring should be continued to establish equilibrium levels and the extent of any seasonal fluctuations.

Whilst monitoring should be continued, it is not possible to draw entirely meaningful conclusions from the measurements made in the standpipes, as the level of the water is not necessarily 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.

Trial excavations to depths as close to the full basement depth as possible would also be useful to determine the likely rate of inflow from the granular soils, encountered at the top of the London Clay. Shallow inflows of perched water may also be encountered from within the made ground, particularly within the vicinity of existing foundations. Inflows may also result from more silty and sandy pockets within the London Clay.

There is evidence from the pattern of measurements encountered in the standpipes, over a period of three weeks, and the results of the rising head test, that any groundwater inflows within the basement excavation should be slow. It is therefore expected that any groundwater inflows encountered should be adequately dealt with through sump pumping; more prolonged or significant inflows could however be encountered from more granular pockets within the

London Clay and the appointed contractor should have a contingency in place to deal with such inflows.

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 the requirement to prevent ground water inflows and whether it is to be incorporated into the permanent works and have a load bearing function.

It will be necessary to underpin the existing foundations of the existing house prior to the construction of the new basement, or to design the new retaining walls to accommodate the load from the existing structures.

If trial excavations indicate that problematic groundwater inflows will not be encountered it may be possible to support the basement excavation by mass concrete underpinning of the existing foundations.

Sheet piles could be installed as a temporary measure to ensure the stability of the basement and overcome the need for groundwater control, prior to the construction of a permanent structure following the completion of the basement excavation. Consideration for the installation of sheet piles will need to be given to noise and vibrations and if these are deemed unacceptable a pressing technique may need to be adopted, 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.

A bored pile wall would have the advantage of being incorporated into the permanent works and will be able to provide support for structural loads. If trial excavations indicate that significant groundwater inflows will be encountered localised grouting and / or sump pumping will be required in association with the bored pile wall, or a secant wall will need to be considered. A contiguous bored piled wall would however have the disadvantage of reducing usable space in the basement, and in this respect a secant wall may be preferable as it would overcome the requirement for any secondary groundwater protection in the permanent works and maximise the basement area.

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. Consideration will need to be given to a retention system that maintains the stability at all times of neighbouring properties to the north and south.

9.1.2 Basement Retaining Wall

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

Stratum	Bulk Density (kg/m^3)	Effective Cohesion (c' – kN/m^2)	Effective Friction Angle (ϕ' – degrees)
Made Ground	1700	Zero	20
London Clay	1950	Zero	25

Groundwater has been measured at depths of between 5.68 m and ground level and inflows are likely be encountered within the 4 m deep basement excavation. Monitoring should be continued to determine an appropriate design groundwater level.

At this stage, it is recommended that the basement is designed with a water level at 1 m below ground level, unless a fully effective drainage system can be ensured. It may however be possible to review this requirement following additional investigation by means of trial excavations and further monitoring and the advice in BS8102:2009[6] should be followed in this respect.

9.1.3 Basement Heave

The proposed construction of the approximately 4 m deep basement will result in an unloading of the London Clay at formation level. The excavations will result in an approximate unloading of around 70 kN/m^2, which will result in an elastic heave and long term swelling of the London Clay. The effects of the longer term swelling movement within the London Clay will be mitigated to some extent by the structural loads but it would be prudent to conduct an analysis of these movements once the basement design has been finalised.

9.2 Spread Foundations

All new foundations or underpins should bypass the made ground and potentially desiccated clay soils.

The excavation of the basement will extend to a depth of approximately 4 m below existing lower ground floor level and formation level will be within the London Clay. It has been assumed that desiccated soils will be removed as part of the basement excavation. Groundwater is likely to be encountered within the basement excavation and it may not be possible to adopt spread foundations above the water table, although this will depend on the basement support system and the extent to which a water-tight excavation is maintained at formation level. The volume of groundwater anticipated in the basement excavation should be further investigated, as discussed in Section 9.1. Provided that a dry excavation can be maintained, spread foundations excavated from basement level to bear within the firm or stiff London Clay may be designed to apply a net allowable bearing pressure of 150 kN/m^2 below the level of basement floor, provided that groundwater inflows can be sufficiently controlled. This value incorporates an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits.

The depth of the basement excavation should be such that foundations will be placed below the depth of actual or potential desiccation but this should be checked once the proposals have been finalised. Notwithstanding NHBC guidelines, all foundations should extend beyond the zone of desiccation. In this respect it would be prudent to have all foundation excavations inspected by a suitably experienced engineer. Due allowance should be made for future growth of the trees. The requirement for compressible material alongside foundations should be determined by reference to the NHBC guidelines.

If the required founding depths become uneconomic or it is not possible to construct spread foundations above the water table, piled foundations would provide a suitable foundation option.

6 BS8102 (2009) *Code of practice for protection of below ground structures against water from the ground*

9.3 Basement Raft Foundation

The suitability of a raft foundation will be governed by the net load of the new development, taking into consideration the effects of the basement excavation. On this site, in view of the depth of the proposed excavation and the estimated heave it is anticipated that the gross load on the raft will not be sufficient to balance the weight of soil removed and the raft may need to be anchored into the ground by piles to resist movements. The raft could be constructed so that it forms a rigid box with the retaining walls such that differential movements are minimised. Further analyses should be carried out once the proposed uniform distributed load

9.4 Piled Foundations

For the ground conditions at this site, driven or bored piles could be adopted. Driven piles would have the advantage of minimising the spoil that is generated, but the effects of noise and vibrations on neighbouring sites are unlikely to be acceptable. Some form of bored pile may therefore be more appropriate. A conventional rotary augered pile may be appropriate but consideration will need to be given to the possible instability and water ingress within any silty or sandy zones within the London Clay. The use of bored piles installed using continuous flight auger (cfa) techniques may therefore be the most appropriate.

The following table of ultimate coefficients may be used for the preliminary design of bored piles, based on the measured SPT and cohesion / depth graph in the appendix.

Ultimate Skin Friction		***kN/m^2***
All soils	GL to 4.0 m	Ignore (basement)
London Clay (α =0.5)	4.0 m to 15.0 m	Increasing linearly from 35 to 70
Ultimate End Bearing		***kN/m^2***
London Clay	10.0 m to 15.0 m	Increasing linearly from 990 to 1260

In the absence of pile tests, guidance from the (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. On this basis it has been estimated that a 450 mm diameter pile, 10.0 m long extending to a depth of roughly 14.0 m below existing lower ground floor level should provide a safe working load of about 360 kN.

The above example is 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 and their attention should be drawn to the possible presence of groundwater inflows from within sand or silt partings within the London Clay.

Consideration may also need to be given to the effects of heave as a result of the basement excavation.

9.5 Shallow Excavations

On the basis of the borehole and trial pit findings it is considered that shallow excavations for foundations and services that extend through the made ground are likely to remain stable. 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 into shallow excavations from within the gravel layers within the London Clay may be encountered, but are not likely to be significant. Seepages may also be encountered from perched water tables within the made ground, particularly within the vicinity of existing foundations and more silty and sandy pockets within the London Clay, although such inflows should be suitably controlled by sump pumping.

However, should deeper excavations be considered or if excavations are to remain open for prolonged periods it is recommended that provision be made for battered side slopes or lateral support. 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.

9.6 Basement Floor Slab

Following the excavation of the basement, the basement floor slab may need to be suspended over a void or layer of compressible material to accommodate the anticipated heave and any potential uplift forces from groundwater pressures unless the slab can be suitably reinforced to cope with these movements. This should be reviewed once the levels and loads are known.

9.7 Effect of Sulphates

Chemical analyses of selected samples of the made ground and underlying London Clay have revealed generally low concentrations of soluble sulphate, corresponding to Class DS-1 and DS-3 of BRE Special Digest 1 Part C (2005). The measured pH value of the samples show that a ACEC class of AC-1s and ACEC AC-3 of Table C2 would be appropriate for the site. This assumes a static water condition at the site. The guidelines contained in the above digest should be followed in the design of foundation concrete.

9.8 Site Specific Risk Assessment

The desk study has not indicated the site to have had a potentially contaminative history, having been occupied by the existing house for it entire developed history. The chemical analysis has revealed elevated concentrations of lead and total PAH including benzo(a)pyrene in excess of the generic risk-based screening values for a residential end-use with plant uptake. Other constituent PAHs were not elevated.

Since completion of the original investigation, the screening values for a number of contaminants have been reviewed as part of the Category 4 Screening Level (C4SL) Project and the generic screening value for benzo(a)pyrene has since been increased, whilst lead has been decreased. Based on the new C4SL guidelines the contamination results indicate elevated concentrations of lead, whilst benzo(a)pyrene and PAH are not elevated and fall well below the newly introduced C4SL screening values.

The source of the lead contamination is likely to be extraneous paint fragments and possibly ash noted within the made ground, originating from coal fires or historical use of leaded petrol. The. Reference to the Envirocheck report indicates that published background levels of lead in this area are in excess of 900 mg/kg; this is based on research carried out by the British Geological Survey on behalf of Defra to determine normal background concentration of contaminants in English soils. The US_{95} value for lead for the site is 741.2 mg/kg and falls below the background level.

On the basis of the contamination results, despite elevated lead concentrations being measured, remediation is not considered to be warranted for the following reasons;

- measured lead concentrations are well below published background levels;
- it is assumed that the soil has been on the site for over 100 years and throughout this period has been exposed to rainfall, such that the lead contamination that has been measured is clearly not in a readily soluble form;
- if the lead is not soluble it will not be available for a number of the assumed contamination pathways, such that the generic risk assessment will have been overly conservative and a more detailed numerical assessment may be require;
- the proposed development will not alter the existing site layout and will not introduce any new pathways that are not already in existence.

Site workers will be protected from the contamination through adherence to normal high standards of site safety but there may be a requirement for protection of buried plastic services laid within the made ground.

9.8.1 Site Workers

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[7] and CIRIA[8] and the requirements of the Local Authority Environmental Health Officer.

9.9 Waste Disposal

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE guidance[9], will need to be disposed of to a licensed tip. Under the European Waste Directive, waste is classified as being either Hazardous or Non-Hazardous and landfills receiving waste are classified as accepting hazardous or non-hazardous wastes or the non-hazardous sub-category of inert waste in accordance with the Waste Directive. Waste going to landfill is subject to landfill tax at either the standard rate of £64 per tonne (about £120 per m^3) or at the lower rate of £2.50 per tonne (roughly £5 per m^3). However, the classifications for tax purposes and disposal purposes differ and currently all made ground and topsoil is taxable at the 'standard' rate and only naturally occurring rocks and soils, which are accurately described as such in terms of the 2011 Order[10], would qualify for the 'lower rate' of landfill tax.

Based upon on the technical guidance provided by the Environment Agency[11] it is considered

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

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

9 CL:AIRE (2011) *The Definition of Waste: Development Industry Code of Practice* Version 2, March 2011

10 *Landfill Tax (Qualifying Material) Order 2011*

11 Environment Agency (2008) *Hazardous Waste: Interpretation of the definition and classification of hazardous waste. Technical Guidance* WM2 Second Edition Version 2.2, May 2008

likely that the made ground from this site, as represented by the four chemical analyses carried out, would be classified as NON-HAZARDOUS waste under the waste code 17 05 04 (soils and stones not containing dangerous substances) and would be taxable at the standard rate. It is likely that the natural soils, if separated out, could be classified as an INERT waste also under the waste code 17 05 04. This material would be taxable at the lower rate, if accurately described as naturally occurring clay in terms of the 2011 Order on the waste transfer note. As the site has never been used for the storage of potentially hazardous materials, it is likely that WAC leaching tests would not be required for such inert waste going to landfill. This would however need to be confirmed by the receiving landfill site.

Under the requirements of the European Waste Directive all waste needs to be pre-treated prior to disposal. 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 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[12] 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 by sufficiently characterising the soils insitu prior to excavation.

The above opinion with regard to the classification of the excavated soils and its likely landfill taxable rate is provided for guidance only and should be confirmed by the receiving landfill once the soils to be discarded have been identified.

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 but may require further testing.

Specialist advice should be sought regarding the removal or treatments of the Japanese Knotweed on the site.

If consideration were to be given to the re-use of the soil as a structural fill on this or another site, in accordance with the Code of Practice for the definition of waste, it would be necessary to confirm its suitability for use, its certainty of use and to confirm that only as much material is to be used as is required for the specific purpose for which it was being used. A materials management plan could then be formulated and a tracking system put in place such that once placed the material would no longer be regarded as being a waste and thus waste management licensing and landfill tax would not apply.

10.0 BASEMENT IMPACT ASSESSMENT

The current development proposal is to construct a basement beneath part of the existing lower ground floor level. A four-storey rear extension will be constructed above the basement in the rear garden. The proposed single level basement will extend to a depth of approximately 4 m below existing lower ground floor level.

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

The proposed basement is unlikely to have any significant effect on groundwater levels as it is wholly within the London Clay so does not provide any form of cut-off into less permeable strata.
The screening identified a number of potential impacts. The desk study and ground investigation information has been used below to review the potential impacts, to assess the likelihood of them occurring and the scope for reasonable engineering mitigation.

The table below summarises the previously identified potential impacts and the additional information that is now available from the site investigation in consideration of each impact.

Potential Impact	Site Investigation Conclusions
Seasonal shrink / swell (subsidence and heave)	The investigation has confirmed that the site is directly underlain by London Clay and plasticity index tests indicate the London Clay to be of high volume change potential at the site. Desiccation was encountered in close proximity to existing trees. However the basement depth will extend well below the potential depth of root action.
Location of public highway	The highway is located within 5 m of the basement excavation. A retention system will maintain the stability of the highway.
Felling of trees – heave of clay soils	Removal of trees may result in long term swelling of clay. Foundations will bypass the zone affected by tree root activity.
Tree protection orders – damage to roots	An arboriculturist should be consulted and their advice should be sought for guidance.
Increase in the differential depth of foundations relative to neighbouring properties	The neighbouring properties are detached. The retention system will ensure the stability of the excavation and neighbouring properties at all times.

The results of the site investigation have therefore been used below to review the remaining potential impacts, to assess the likelihood of them occurring and the scope for reasonable engineering mitigation.

Shrink / swell potential of London Clay

Shrinkable clay is present within a depth that can be affected by tree roots. There is no evidence of structural movement within the existing building. The basement depth will extend well below the potential depth of root action.

Location of public highway

The proposed basement excavation will be located within 5 m of Fitzjohn's Avenue. A retention system will be adopted that maintains the stability of the excavation at all times to protect the highway.

Increase in the differential depth of neighbouring foundations

The stability of neighbouring structures, to the north and south will be ensured at all times.

Felling of trees – heave of clay soils

Removal of trees may result in long term swelling of clay. However the foundations of the basement will extend beyond the zone of tree root activity.

Tree protection orders – damage to roots

An arboriculturist should be consulted for advice.

11.0 OUTSTANDING RISKS AND ISSUES

This section of the report aims to highlight areas where further work is required as a result of limitations on the scope of this investigation, or where issues have been identified by this investigation that warrant further consideration. The scope of risks and issues discussed in this section is by no means exhaustive, but covers the main areas where additional work is considered to be required.

The ground is a heterogeneous natural material and variations will inevitably arise between the locations at which it is investigated. This report provides an assessment of the ground conditions based on the discrete points at which the ground was sampled, but the ground conditions should be subject to review as the work proceeds to ensure that any variations from the Ground Model are properly assessed by a suitably qualified person.

The main issue that requires careful consideration at this site is the extent to which groundwater will affect the basement excavation in the temporary condition and the level of the water table to be adopted in the permanent design. Recommendations have been made for carrying out trial excavations and continued monitoring of the standpipes to address these issues, but it is important that the contractor is able to deal with inflows of groundwater that may be locally more significant than anticipated in view of the sand and silt pockets within the London Clay.

It is recommended that heave movements are checked by further analysis once the loadings and final levels are known.

It is assumed that the basement will extend beneath the depth of any potential desiccation; however it is recommended that the basement excavation is inspected by a qualified and experienced geotechnical engineer.

If during ground works any visual or olfactory evidence of contamination is identified it is recommended that further investigation be carried out and that the risk assessment is reviewed. These areas of doubt should be drawn to the attention of prospective contractors and further investigation will be required or sufficient contingency should be provided to cover the outstanding risk.

A specialist will need to be consulted regarding the eradication of Japanese Knotweed in the rear garden of the site.

APPENDIX

Borehole Records

SPT Results

Trial Pit Records

Results of Rising Head Test

Geotechnical Laboratory Test Results

SPT & Cohesion / Depth Graph

Moisture Content Plot

PenetrometerPlot

Chemical Analyses

Generic Risk Based Screening Values

Envirocheck Report Summary

Historical Maps

Site Plan