Site Investigation and Basement Impact Assessment Report

Flat 1
15 Wedderburn Road
London NW3

Client Mr Dan Wagner

Engineer Fluid Structures

J13235

October 2013




GEA Geotechnical & Environmental Associates

Document Control

Project title	Flat 1, 15 Wedderburn Road, London, NW3 5QS	**Project ref**	J13235
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Issue No	**Status**	**Date**	**Approved for Issue**
1	Final	3 October 2013	
2	Final (revised)	5 November 2013	

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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 Fluid Structures, on behalf of Mr Dan Wagner, with respect to deepening and extending the existing lower ground floor level beneath the footprint of the entire building and slightly into the front and rear gardens. The proposed basement will extend to a depth of roughly 6.2 m (73 m OD), with a deepened section for a swimming pool in the southern section, extending to a depth of about 8.5 m (approximately 71 m OD). 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 investigate the existing foundations, to assess the extent of any contamination and to provide information to assist with the design of suitable foundations and retaining walls. The report also includes information required to comply with the London Borough of Camden (LBC) Planning Guidance CPG4, relating to the requirement for a Basement Impact Assessment (BIA).

DESK STUDY FINDINGS

The site was first developed with the existing building at some time between 1871 and 1896. A feature inferred as a pond is shown immediately to the southeast of the site, which appears to have been infilled by 1896. The desk study research has not indicated any potentially contaminative uses of the site or surrounding area and no risk of soil gases have been identified.

GROUND CONDITIONS

The investigation has confirmed the expected ground conditions in that, below a moderate to significant thickness of made ground, the Claygate Member was encountered overlying the London Clay, which was proved to the full depth investigated. The made ground typically comprised a brown sandy clay with occasional fragments of brick and ash and generally extended to depths of between 1.00 m and 1.70 m (78.75 m OD and 75.71 m OD), although a greater thickness was encountered within the vicinity of existing foundations, which was not proved and extends to a depth of at least 2.10 m. The Claygate Member was found to extend to depths of between 8.00 m (71.50 m OD), 5.10 m (72.21 m OD) and 6.00 m (71.41 m OD) and initially comprises firm locally soft brown mottled orange-brown and greenish grey silty sandy clay with rare flint gravel, which extended to depths of between 4.30 m and 5.80 m (74.20 m OD and 72.91 m OD), overlying firm becoming stiff grey silty sandy clay. The underlying London Clay comprises firm becoming stiff grey silty fissured clay, with rare partings of grey silt and fine sand and rare fragments of shells, which was proved to the maximum depth investigated of 15.00 m (65.00 m OD). Desiccation of the clay was encountered at a single locality in close proximity to an existing tree and extended to a depth of about 2.0 m.

Monitoring of the standpipes has measured groundwater at levels of between 76.33 m OD and 75.84 m OD.

The existing garage is founded at a depth of 0.60 m below existing ground floor level. The extent of the footings for the existing house are not known and were found to extends to depths of least 1.80 m and 2.10 m, below existing lower ground floor level.

A strong hydrocarbon odour and grey discolouration was noted within the made ground in Trial Pit No 2 from a depth of 1.60 m to the base of the pit at 2.10 m.

Contamination testing has revealed elevated concentrations of total PAH including benzo(a)pyrene and TPH in some samples of made ground tested.

RECOMMENDATIONS

Formation level of the 6.2 m deep basement is likely to be within the Claygate Member, although the deepened section for the swimming pool is likely to be close to or within the London Clay. On the basis of the investigation, some form of groundwater control will be required for basement excavation. A bored pile wall is likely to be the most effective solution, and a secant wall is likely to be required to prevent inflows of groundwater into the basement. 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.

The made ground will be removed by the basement construction and there will therefore be no risk from PAH contamination to end users. However, it is recommended that additional investigation is carried out to determine the extent and source of the TPH contamination and it would be prudent to remove contaminated TPH soils from the site.

The BIA has not indicated any concerns with regard to the effects of the proposed basement on the site and surrounding area.

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 Fluid Structures, on behalf of Mr Dan Wagner, to carry out a desk study and ground investigation at Flat No 1 of 15 Wedderburn Road, London, NW3 5QS. This report also includes a Basement Impact Assessment (BIA), which has been carried out in support of a planning application.

1.1 Proposed Development

It is proposed to deepen and extend the existing lower ground floor level beneath the footprint of the entire building and slightly into the front and rear gardens. The proposed basement will extend to a depth of roughly 6.2 m (73 m OD), with a deepened section for a swimming pool in the southern section, extending to a depth of about 8.5 m (approximately 71 m OD).

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:

- a single cable percussion borehole, advanced to depth of 15.0 m beneath the front driveway, by means of a dismantlable cable percussion drilling rig;

- two boreholes advanced by an open-drive lined percussive sampler (Terrier rig) to depths of 10.45 m and 11.00 m;

- standard penetration tests (SPTs), carried out at regular intervals in the boreholes, to provide quantitative data on the strength of the soils;

- the installation of three groundwater monitoring standpipes, to depths of between 6.0 m and 15.0 m and three monitoring visits to date;

- three trial pits excavated by hand to depths of between 0.70 m and 2.10 m to investigate the existing foundations;

- 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 scope of the investigation was limited to that required to support a planning application and additional investigation will be required at a later date to provide further information to assist in finalising the foundation design.

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 includes a Hydrological and Hydrogeological Assessment and Land Stability Assessment (also referred to as Slope Stability Assessment), all of which form part of the BIA 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 provide information on land stability and groundwater and in particular to assess whether the development will affect the stability of neighbouring properties or groundwater movements and whether any identified impacts can be appropriately mitigated by the design of the development.

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

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

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

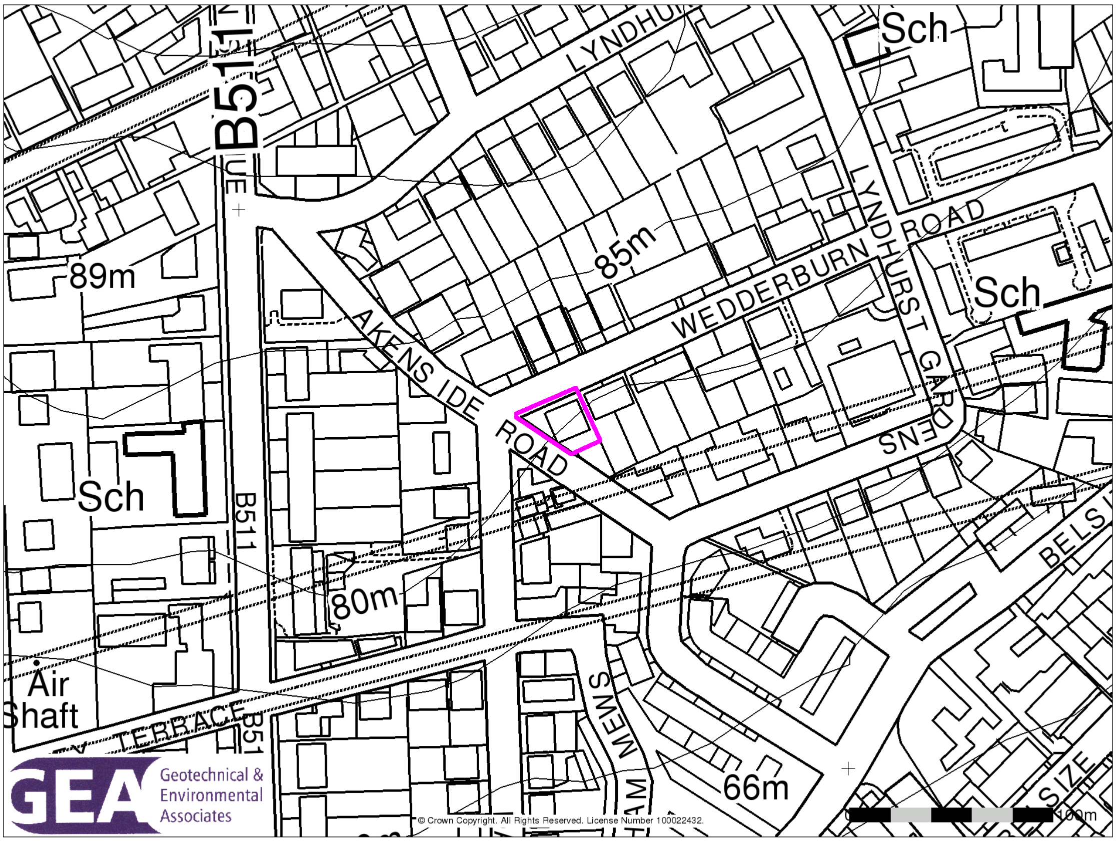
The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, 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 residential area in the London Borough of Camden, to the south of Hampstead Village, approximately 650 m to the northwest of Belsize Park London Underground Station. It is irregular in shape, measuring approximately 25 m north-south by 30 m east-west in maximum dimensions and occupies a corner plot bounded by Wedderburn Road to the north and Akenside Road to the west. The site is bounded to the east by No 13 Wedderburn Road, a three-storey semi-detached property, with a single level basement, which is divided into apartments. It is bounded to the south by what appears to be a single storey building, fronting onto Akenside Road to the west, which is accessed down the eastern boundary of No 15 Wedderburn Road.

The site may be located by National Grid Reference 526720, 185120 and is shown on the map below.



The local topography slopes down towards the south and the site is on a number of different levels to accommodate the change in slope. The lowest level is at existing lower ground floor level at 77.28 m OD and the highest level is 4.58 m above this level at 81.86 m OD on the front driveway.

The site is currently occupied by a building that is cut into the slope of the ground, such that it comprises three-storeys plus a single level basement at the front and four storeys at the rear, plus a single storey rear extension. The property is divided into three apartments each with it own entrance, comprising Nos 1 to 3 of 15 Wedderburn Road.

Flat Nos 1 and 2 share a driveway in the northwestern part of the site and access to No 1 is through a gate in the eastern part of the driveway. Access to Flat No 2 is up external steps along the western elevation of the single storey garage that lead up to a front door at first floor level. Flat No 2 comprises the first and second floor of the building in the western part of the site and Flat No 3 occupies the first and second floor of the building in the eastern part of the site. Flat No 3 has its own separate entrance in the northeastern half of the site. There is a driveway at the front of Flat No 3, which fronts onto Wedderburn Road to the north, but is owned by the property at the rear. Along the eastern elevation of the building are steps leading down to a side passage which provides access to the property at the rear of No 15, which fronts onto Akenside Road to the west.

The client's property is Flat No 1, which occupies the entire ground floor and lower ground floor of the building, together with the garden areas and an adjoining single storey garage in the northwest of the site. A single storey extension is present along the southern elevation of the building, which includes a swimming pool. A patio terrace is present at ground floor level on the roof of the single storey extension, with steps leading down to the rear garden at lower ground floor level. Along the southern elevation, the rear garden is essentially paved and on two levels, with a man-made pond on the higher level, located roughly 0.45 m higher than lower ground floor level. Along the western elevation is a paved area at ground floor level, together with steps leading down to a patio area at lower ground floor level, along the southern elevation of the building. A paved area is present along the eastern elevation at ground floor level, and can be accessed through a gate from the rear garden.

At the front of Flat No 1, along the northern elevation of the building, a paved area is present, with steps leading up to ground floor level, which can be accessed through a gate in the eastern part of the driveway. The rear garden can be accessed externally through a gate located along the eastern elevation of garage. An enclosed basement lightwell is present at the front of Flat No 3, with patio doors leading onto a paved area.

An apple tree is present in the rear garden and there are a number of mature and semi-mature trees along the northern and western perimeters of the site.

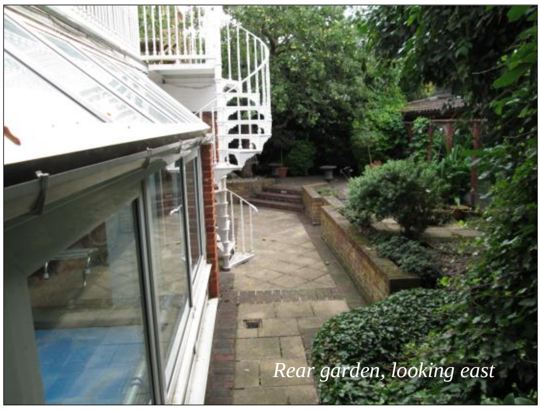

Northern elevation of existing building


Southern elevation of existing building


Front garden

Driveway of Flat Nos 1 and 2


Steps to rear garden


Rear garden, looking east

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 the site to be undeveloped, comprising open fields with a few trees. On this map, a feature inferred as a pond is shown immediately to the southeast of the site, with a similar feature shown roughly 120 m to the northwest of the site, which forms a headwater for a stream.

At some time between 1871 and 1896, Wedderburn Road and Akenside Road were constructed along with the existing property and the neighbouring properties immediately to the east and the properties to the south, which front onto Lyndhurst Gardens. During this period, the pond to the southeast of the site appears to have been infilled as it is no longer shown on the map and forms the rear garden of the neighbouring property; No 13 Wedderburn Road. On the 1896 map, an air shaft is shown roughly 20 m to the southwest of the site, associated with New Belsize Tunnel, with Belsize Tunnel, shown roughly 80 m to the south of the site, although the tunnels themselves are not marked on maps until 1955.

Between 1896 and 1915, development had taken place along on the northern side of Wedderburn Road and by 1935, the property appears to have been divided into two, with what appears to be the construction of a wall at the front of the building.

A building was constructed on the property immediately to the south of the site between 1955 and1966, and appears to have been extended to the north between 1979 and 1986. During this period a number of extensions appear to have been constructed to the building on the site.

The site and immediately surrounding area appear to have subsequently remained essentially unchanged to the present day.

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 500 m of the site and there have been no pollution incidents to controlled waters within 1 km of the site.

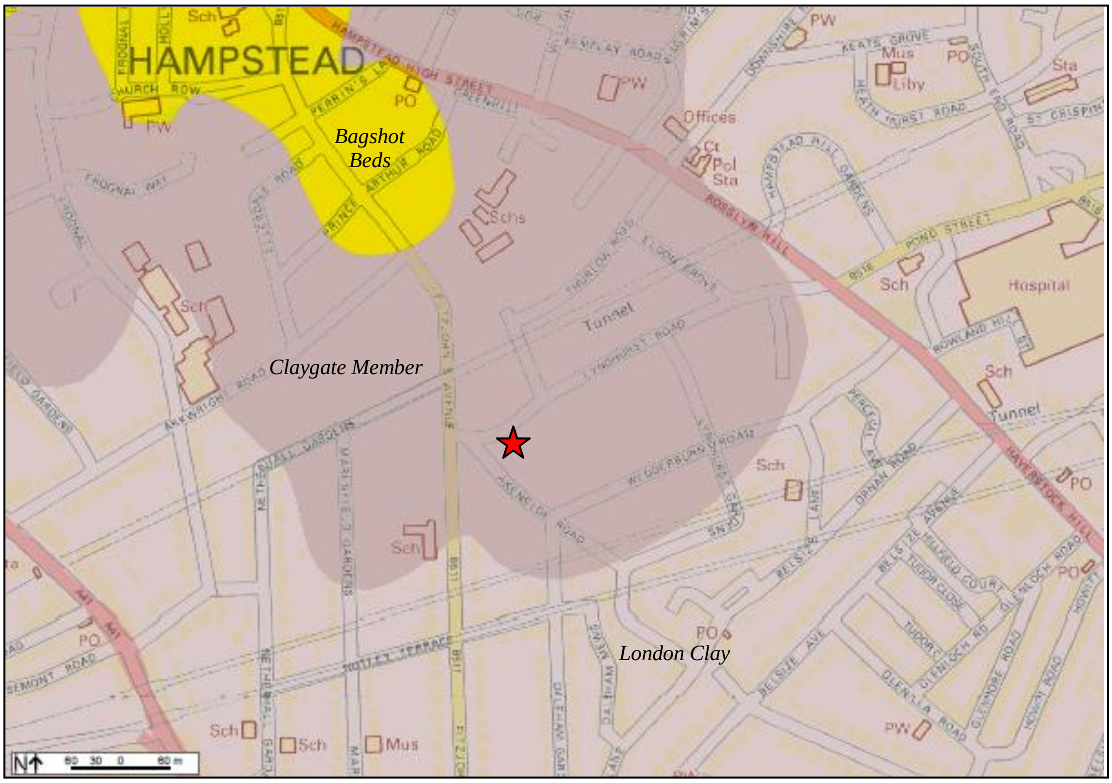
The search has indicated that the site is located in an area where less than 1% of homes are affected by radon emissions; which is the lowest classification given by the Health Protection Agency (HPA) and therefore no radon protective measures will be necessary.

The site is not located within a nitrate vulnerable zone or any other sensitive land use.

As noted above, a railway tunnel is located approximately 20 m to the south of the southern boundary of the site.

2.4 Geology

The British Geological Survey (BGS) map of the area (Sheet 256) indicates that the site should be directly underlain by the Claygate Member overlying the London Clay.



According to the British Geological Society memoir, the Claygate Member comprises alternating beds of clay, silt and fine grained sand. 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.

The boundary between the Claygate Member and London Clay is shown approximately 150 m to the south of the site and the Bagshot Formation is shown to outcrop approximately 260 m to the north of the site. The geology in this area is generally horizontally bedded such that the boundary between the geological formations roughly follows the ground surface contour lines.

A nearby investigation, carried out by GEA roughly 80 m to the north of the site on Lyndhurst Road, indicated the Claygate Member to extend to a depth of 8.60 m (83.10 m OD). However, the contours and spot heights shown on the OS and geological maps would suggest that the Claygate Member extends to a depth of approximately 77.00 m OD, where it is in turn underlain by London Clay. Groundwater was measured at a depth of 5.00 m (86.70 m OD) at this nearby site, although this may not have represented an equilibrium level.

2.5 Hydrology and Hydrogeology

The Claygate Member is classified by the Environment Agency as a Secondary ‘A’ Aquifer, defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers, however, this classification is based on the presence of saturated sand bed horizons within the Claygate

Member. 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.

There are no Environment Agency designated Source Protection Zones (SPZs) on the site. The nearest surface water feature is located 790 m northeast of the site. The site lies outside the catchment of the Hampstead Heath chain of ponds.

Groundwater is likely to be present within the Claygate Member, and other investigations carried out around the area of Hampstead Heath indicate that spring lines, reflecting the presence of perched groundwater, are present at the interface of the Bagshot Beds and the Claygate Member, and at a lower level at the boundary between the Claygate Member and the underlying essentially impermeable London Clay. These springs have been the source of a number of London's "lost" rivers, notably the Fleet, Westbourne and Tyburn, which all rose on Hampstead Heath, to the south and southwest of the current site, at the base of the Bagshot Beds.

Historically the Tyburn River[4] flowed approximately 100 m west of the site. The stream flowed in a southerly direction, towards Regent's Park where it flowed into a large lake that is still present today.

Given the location of the headwaters of the Tyburn, it is likely that it was formed by springs issuing from within the interface of the Bagshot Formation and Claygate Member.

Groundwater within the silty sandy clays of the Claygate Member is considered to be dominated by fissure flow. The absence of any significant sand bed horizons reduces the water bearing potential of the Claygate Member to that similar to the underlying London Clay. Due to the very low permeability of the London Clay, any groundwater flow will be at very low rates. Published data for the permeability of the London Clay indicates the horizontal permeability to generally range between 1 x 10-10 m/s and 1 x 10-8 m/s, with an even lower vertical permeability. However, the Claygate Member is sandier in composition and permeability could be expected to be higher.

The direction of groundwater flow within the Claygate Member beneath the site is likely to be controlled by the local topography and therefore in a south and southwesterly direction.

The site is not at risk of flooding from rivers or sea, as defined by the Environment Agency; Wedderburn Road 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.

2.6 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.

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

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 inferred pond feature to the southeast of the site may have possibly been infilled by 1896 and given the age of the infill it is not considered to represent a risk of soil gas to the site. In addition there are no historical or existing landfill sites within 500 m

2.6.2 Receptor

The site will continue to have a residential end use following the excavation of the basement 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 a Secondary 'A' Aquifer, groundwater may be considered to be a moderately sensitive target.

2.6.3 Pathway

The majority of the shallow soils will be removed by the excavation of a basement and no new pathways will be introduced for end users to come into contact with the soil. End users could conceivably come into contact with soils within private garden areas although this pathway is already in existence. 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 Claygate Member, 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 construction work and services will come into contact with any contamination within the soils in which they are laid.

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 no evidence of potential soil gas has been identified 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 15 Wedderburn Road
1a. Is the site located directly above an aquifer?	*Yes. The Site is underlain by the Claygate Member of the London Clay Formation, which is designated as Secondary 'A' Aquifer by the Environment Agency, capable of supplying local water supplies and supporting small watercourses.*
1b. Will the proposed basement extend beneath the water table surface?	*Yes. Groundwater has been monitored at levels of between 76.33 m OD to 75.84 m OD.. The proposed basement will extend to a depth of roughly 6.2 m (73 m OD), with a deepened section for a swimming pool in the southern section, extending to a depth of about 8.5 m (approximately 71 m OD).*
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	*Unlikely. A pond like feature was shown on the historical maps to the east of the site,prior to 1896... The historic maps indicate that the River Tyburn flowed c. 100 m to the west of the site. This river is no present at surface and is likely to have 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 is 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 existing site is covered entirely by the existing building and hard-standing areas so will not increase the amount of hard covered surfaces. Site drainage will be directed to public sewer as ground conditions would not be suitable for a soakaway or similar SUDS based system.*
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 very lowly permeable nature of the Claygate Member 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 screening exercise has identified the following potential issues which should be assessed:

Q1a The Site is located on a Secondary 'A' Aquifer.
Q1b The basement is likely to extend below the groundwater level.

3.1.2 Stability Screening Assessment

Question	Response for 15 Wedderburn Road
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?	*No*
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?	*Yes. 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?	*Not known. The Claygate Member has some potential for shrink-swell.*

Question	Response for 15 Wedderburn Road
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?	*Yes. The Site is underlain by the Claygate Member of the London Clay Formation which is designated a Secondary 'A' Aquifer by the Environment Agency, capable of supporting baseflow to watercourses.*
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 Wedderburn Road to the north and Akenside Road to the west.*
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	*Yes. The property is detached but the new proposed development will increase foundation depths to a maximum depth of 8.5 m (71 m OD).*
14. Is the site over (or within the exclusion zone of) any tunnels, eg railway lines?	*Possibly. The New Belsize Tunnel is located roughly 20 m to the south of the site.*

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

Q6 Trees may be felled as part of the development.

Q7 The site is possibly in an area of seasonal shrink-swell.

Q10 The site is underlain by a Secondary 'A' Aquifer.

Q12 The site is within 5 m of a public highway along its northern and western boundaries.

Q13 The development will increase the foundation depths relative to the neighbouring properties to a relatively significant extent.

Q14 The southern part of the site may be located within the exclusion zone of the New Belsize Tunnel, which should be checked with Network Rail.

3.1.3 Surface Flow and Flooding Screening Assessment

This 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.

Question	Response for 15 Wedderburn Road
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*
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 Claygate Member 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 basement could lead to damage
The site is located above a Secondary 'A' Aquifer	The basement may extend into the underlying aquifer and affect the groundwater flow regime
The basement is likely to extend below the groundwater table	This may affect the groundwater flow regime
Trees will be felled as part of the refurbishment.	Heave of the clay soils resulting in structural damage to the buildings.
It is understood that works are proposed within tree root zones.	Damage to roots resulting in death of trees.
The site may be located within the exclusion zone for the New Belsize Tunnel.	Damage to the tunnel. Contact should be made with Network Rail to confirm that the proposed development will not have an influence on the existing tunnel.
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

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

4.2 Exploratory Work

in view of the limited access and 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, in total three boreholes were drilled, which included a single cable percussion borehole on the front driveway, advanced to a depth of 15.00 m, using a dismantlable cable percussion drilling rig. A further two boreholes were drilled to depths of 10.45 m and 11.00 m in the rear garden at lower ground floor level, using an open-drive percussive sampler.

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

Groundwater monitoring standpipes were installed in three of the boreholes to depths of 6.00 m, 10.45 m and 15.00 m, and have been monitored on three occasions to date.

In addition to the boreholes, three trial pits were manually excavated to investigate the foundations of the existing building.

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 were 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 laboratory analyses are appended together with a site plan indicating the exploratory positions. The Ordnance Datum (OD) levels shown on the borehole and trial pit records have been interpolated from spot heights shown on a drawing by EDI Surveys Limited, which was provided by the consulting engineers.

4.3 Sampling Strategy

The boreholes were positioned on site by GEA to suit site limitations, whilst providing optimum coverage of the site with due regard to the proposed development. The trial pit locations were specified by the consulting engineers and positioned on site by GEA, whilst avoiding the areas of known services, notably drain runs.

Originally it was proposed to excavate six trial pits. However it was not possible to carry out three of the pits, due to the presence of services, trees and steps.

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

Three 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.

5.0 GROUND CONDITIONS

The investigation has confirmed the expected ground conditions in that, below a moderate thickness of made ground, the Claygate Member was encountered overlying the London Clay, which was proved to the full depth investigated. The precise location of the boundary between the Claygate Member and London Clay can be difficult to determine as it is a gradational contact.

5.1 Made Ground

The made ground generally extended to depths of 1.25 m (78.75 m OD) 1.00 m (76.31 m OD) and 1.70 m (75.71 m OD) in the boreholes and generally comprised brown sand clay with rare flint gravel and occasional fragments of brick, chalk and pottery.

The greatest thickness of made ground was encountered within the vicinity of the existing foundations and the extent of the made ground was not proved in the trial pits and was found to extend to depths of 1.80 m (75.46 m OD), 2.10 m (75.52 m OD) and 0.70 m (79.24 m OD), in the vicinity of existing foundations and in Trial Pit Nos 1 and 2, the made ground typically comprised orange-brown mottled grey silty sandy clay with occasional fragments of brick.

A strong hydrocarbon odour and grey discolouration was noted within the made ground in Trial Pit No 2 from a depth of 1.60 m (75.52 m OD) to the base of the pit at 2.10 m (75.52 m OD).

No evidence of hydrocarbon contamination was noted at any other exploratory positions during the fieldwork and the hydrocarbon contamination seems to be along the central eastern part of the existing building.

Presence of extraneous material such as ash fragments were noted within the made ground, which can commonly contain elevated concentrations of PAH, including benzo(a)pyrene. Three samples of the made ground have been sent for contamination testing and the results are presented in Section 6.5.

5.2 Claygate Member

The Claygate Member typically comprised an initial layer of firm locally soft brown mottled orange-brown and greenish grey silty sandy clay, extended to depths of 5.80 m (74.20 m OD), 4.40 m (72.91 m OD) and 4.30 m (73.11 m OD). In Borehole Nos 2 and 3, rare flint gravel was scattered within this initial layer, extending to depths of between 1.30 m (76.01 m OD) and 4.30 m (73.11 m OD) respectively. The presence of gravel within the stratum suggests that the upper levels of the Claygate Member may have been naturally reworked.

Below this depth, firm becoming stiff grey silty sandy clay with occasional shell fragments was encountered, which became less sandy with depth, and extended to depths between 8.00 m (72.00 m OD), 5.10 m (72.21 m OD) and 6.00 m (71.41 m OD).

Rootlets were noted to extend to a maximum depth of 2.00 m in Borehole No 1 and the clay of the Claygate Member was noted to be stiff to a depth of about 2.0 m (78.00 m OD), in close proximity to an existing tree, indicating signs of desiccation. The results of the natural moisture content tests on samples from Borehole No 1 confirm that the ground is deficient in mositure to a depth of roughly 2.0 m below ground level.

Atterberg limit tests indicate the clay to be of moderate volume change potential.

The results of the laboratory undrained triaxial compression tests indicate the Claygate Member to generally be of high strength with undrained shear strengths of 89 kN/m² at a depth of 4.00 m and 88 kN/m² at a depth of 6.50 m.

At a depth of 2.0 m, the Claygate Member was found to be of very high strength, thought to be the result of desiccation of this sample.

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

5.3 London Clay

The London Clay comprised stiff dark grey fissured silty clay, with rare partings of grey silt and fine sand and rare fragments of shells, which was proved to the maximum depth investigated of 15.00 m (65.00 m OD).

The laboratory strength tests have indicated the London Clay to be of high strength with undrained shear strength generally increasing with depth from 107 kN/m² at a depth of 9.50 m to 111 kN/m² at a depth of 12.50 m.

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

5.4 Groundwater

Groundwater was not encountered during drilling of Borehole Nos 1 or 2. A standing water level of 7.30 m (72.70 m OD) was however measured within Borehole No 1, upon completion of the drilling.

Groundwater was encountered during drilling of Borehole No 3, from a depth of 1.32 m from within the made ground. Significant groundwater inflows were noted from a depth of about 3.00 m to 10.00 m and resulted in poor recovery of the soils between these depths. Borehole No 3 was located roughly 1.0 m to the east of an existing drain.

Perched water was also noted in Trial Pit Nos 1 and 2 at depths of 1.40 m (75.86 m OD) and 1.50 m (76.12 m OD) respectively, in the vicinity of the existing footings.

Malodorous groundwater was encountered within Trial Pit No 2 at a depth of 1.60 m during excavation works.

The table below shows the depths at which groundwater was measured within the installed standpipes.

Borehole No	Standpipe depth in m (m OD)	Depth to groundwater in m (m OD)		
		18/09/2013	27/09/2013	09/10/2013
1	15.00 (65.00)	-	3.96 (76.04)	4.14 (75.86)
2	10.45 (66.86)	1.27 (76.04)	1.44 (75.87)	1.47 (75.84)
3	6.00 (71.41)	1.09 (76.32)	1.08 (76.33)	1.15 (76.26)

It was not possible to monitor Borehole No 1 at the time of the first groundwater monitoring visit due to a car parked over the standpipe.

5.5 Soil Contamination

The table below sets out the values measured within three samples of made ground analysed. All concentrations are in mg/kg unless otherwise stated.

Determinant	TP2: 0.50 m	TP2: 1.60 m	TP1: 0.30 m
Arsenic	9.3	5.5	14
Cadmium	0.12	<0.10	<0.10
Chromium	39	28	37
Copper	22	12	38
Mercury	<0.10	<0.10	0.17
Nickel	33	26	40
Lead	36	8.9	52
Selenium	<0.20	0.34	<0.20
Zinc	85	39	65
Total Cyanide	<0.5	<0.5	<0.5
Total Phenols	<0.3	<0.3	<0.3
Sulphide	6.9	44-	6.3
Total PAH	3.9	<2	**15**
Benzo(a)pyrene	0.69	<0.1	**1.1**
Naphthalene	<0.1	<0.1	<0.1
TPH	<10	**1300**	<10
Total Organic Carbon %	0.54	0.27	0.34
Notes: Figure in **bold** indicates concentration in excess of risk-based soil guideline values, as discussed in Part 2 of this report			

5.5.1 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 guideline 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:

- 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;

5 *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.

- 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.

This assessment is based upon the potential for risk to human health, which at this site is considered to be the critical risk receptor.

The chemical analyses have revealed elevated concentrations of total PAH, including benzo(a)pyrene, in a single sample of made ground tested from Trial Pit No 1 at a depth of 0.30 m and total petroleum hydrocarbons (TPH) were also noted to be slightly elevated in Trial Pit No 2 at a depth of 1.60 m. In Trial Pit No 2 at a depth of 1.60 m, TPH exceeded the 1000 mg/kg criteria and automatically triggered speciated testing for the TPH aromatic / aliphatic split. The results have measured elevated concentrations of chains lengths16-21 and represent diesel contamination and may be attributable to gas oil or light heating oil.

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

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

5.6 Existing Foundations

The footings of the garage are founded at a depth of 0.60 m (79.34 m OD) below existing ground level on orange-brown fine sand with rootlets, which may possibly be made ground.

The footings of the existing house extend to depths of at least 1.80 m (75.46 m OD) and 2.10 m (75.52 m OD). However, due to the presence of perched water in the pits and to safely continue the pits shoring would have need to been installed, along with a sump pump, and the pits could therefore not be completed in the time available.

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.

6.0 INTRODUCTION

Consideration is being given to the deepening and extension of the existing lower ground floor level beneath the footprint of the entire house and slightly into the front and rear gardens and existing garage. The proposed basement will extend to a depth of roughly 6.2 m (73 m OD), with a deepened section for a swimming pool in the southern section, extending to a depth of about 8.5 m (approximately 71 m OD).

7.0 GROUND MODEL

The desk study has revealed that the site and surrounding area have not had a potentially contaminative history, and on the basis of the fieldwork, the ground conditions at this site can be characterised as follows.

- Below a moderate to significant thickness of made ground, the Claygate Member is present overlying the London Clay, which was proved to the full depth investigated;
- the made ground typically comprises a sandy clay with occasional fragments of ash and brick and generally extends to depths of 1.25 m (78.75 m OD) 1.00 m (76.31 m OD) and 1.70 m (75.71 m OD), although a significant thickness of made ground will be encountered within the vicinity of existing foundations, which was noted proved and extends to depths of at least 2.10 m;
- the Claygate Member extends to depths of 8.00 m (71.50 m OD), 5.10 m (72.21 m OD) and 6.00 m (71.41 m OD) and initially comprises firm locally soft brown mottled orange-brown and greenish grey silty sandy clay with rare flint gravel, overlying firm becoming stiff grey silty sandy clay;
- the London Clay comprises firm becoming stiff grey silty fissured clay, with rare partings of grey silt and fine sand and rare fragments of shells, which was proved to the maximum depth investigated of 15.00 m (65.00 m OD);
- desiccation of the clay soils is expected close to trees to depths of about 2 m;
- monitoring of the standpipes has measured groundwater at levels of between 76.33 m OD and 75.84 m OD;
- a strong hydrocarbon odour and grey discolouration of the made ground was noted in Trial Pit No 2 from a depth of 1.60 m (75.52 m OD) to the base of the pit at 2.10 m (75.52 m OD); and
- the chemical analyses have revealed elevated Total PAH including benzo(a)pyrene and TPH, within some samples of the made ground, with contamination with heating

oil indicated within the sample recovered from Trial Pit No 2.

8.0 ADVICE AND RECOMMENDATIONS

It is proposed to deepen and extend the existing lower ground floor level beneath the footprint of the entire building and slightly into the front and rear gardens. The proposed basement will extend to a depth of roughly 6.2 m (73 m OD), with a deepened section for a swimming pool in the southern section, extending to a depth of about 8.5 m (approximately 71 m OD). Formation level of the 6.2 m deep basement is likely to be within the Claygate Member, although the deepened section for the swimming pool is likely to be close to or within the London Clay. It has been assumed that all of the desiccated soils will be removed from the basement excavation. The results of the groundwater monitoring to date indicate that it will not be possible to construct the basement without some form of groundwater control.

Excavations for the proposed basement structure will require temporary support to maintain stability of the excavation and surrounding structures at all times. It will be necessary to underpin the existing foundations of the existing house and neighbouring structures or to design the new retaining walls to accommodate the load from the existing structures.

8.1 Basement Construction

8.1.1 Basement Excavation

The investigation has indicated that formation level for the approximately 6.2 m deep basement, below existing ground floor level, will be within the Claygate Member at a level of 73 m OD. The deepened section for the swimming pool is likely to have a formation level close to the base of the Claygate Member or top of the London Clay at a level of about 71 m OD.
Monitoring of the standpipes has measured groundwater at levels of between 76.33 m OD and 75.84 m OD and is expected to be encountered within the excavation of the basement. Further monitoring should be carried out to establish equilibrium levels and the extent of any seasonal fluctuations. Perched water was also noted in Trial Pit Nos 1 and 2 at depths of 1.40 m (75.86 m OD) and 1.50 m (76.12 m OD) respectively, in the vicinity of the existing footings.

The permeability of the Claygate Member is likely to vary across the site but on the basis of results from previous investigations it is likely to be between 1.1 x 10^{-8} m/s and 2.3 x 10^{-8} m/s. On this basis inflow rates into the excavation are expected to be slow, although as the basement extends below the water table they are likely to be prolonged. Inflow rates will also be higher where more permeable layers within the Claygate Member are encountered and, as the basement excavation will cover a much larger area than that covered by the investigation; it is possible that larger pockets or inter-connected layers of groundwater could be encountered. In addition to continued monitoring of the standpipes, it would be prudent to pump out the standpipes and monitor the rate at which groundwater levels in the standpipes recover. For example, the groundwater encountered in Borehole No 3 may have been associated with the occurrence of more gravelly soils, and a simple pumping test will provide a better understanding of the extent to which the excavation will be affected by groundwater inflows from this material.

Shallow inflows of perched water may also be encountered from within the made ground, particularly within the vicinity of existing foundations, although such inflows are unlikely to be significant and should be adequately dealt with through sump pumping.

There are a number of methods by which the sides of the basement excavations 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, and the extent to which groundwater inflows need to be prevented.

The proposed basement is below the measured groundwater level and careful consideration will therefore need to be given to method of basement construction and support. Ideally it would be prudent to carry out trial excavations to the proposed full depth of the basement. However, given the limited space at the site and the proposed maximum excavation depth of 8.50 m this is unlikely to be possible.

The noise and vibrations associated with sheet piling is likely to make it unacceptable. A bored pile wall is likely to be the most effective solution, and a secant wall is likely to be required to prevent inflows of groundwater into the basement.

Alternatively, it may be possible to adopt a contiguous bored pile wall, if trial excavations confirm that inflows are unlikely to be significant. It is important to bear in mind that higher inflows may result from the presence of larger and / or interconnected pockets of water, which may be present within the basement excavation; however, once the piled wall is in place, it may be possible to deal with any areas of higher inflow through localised grouting or pumping.

Careful control of pumping will be required to ensure that it does not lead to settlement of the adjacent buildings and it is difficult to estimate the rate at which groundwater will enter the excavation on the basis of the investigation carried out. However, there is insufficient space to carry out trial excavations and pumping trials and recourse to a secant bored pile wall may therefore be the most sensible solution. A secant wall may also have the benefit of removing 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 and structures.

8.1.2 Basement Retaining Walls

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 (□' – degrees)
Made Ground	1700	Zero	20
Claygate Member	1850	Zero	25
London Clay	1950	Zero	25

Groundwater has been measured at levels of between 76.83 m OD and 75.84 m OD to date and is likely to be encountered within the 6.2 m and 8.5 m deep basement excavations, with formation levels at roughly 73 m OD and 71 m OD. Monitoring should be continued to determine an appropriate design groundwater level.

Reference should be made to BS8102:2009[6] with regard to requirements for waterproofing and design with respect to groundwater pressures.

8.1.3 Basement Heave

The proposed construction of the 6.2 m and 8.5 m deep excavations will result in a variable unloading of the Claygate Member and London Clay at formation level. The excavations will result in an approximate unloading of between 115N/m^2 and around 155 kN/m^2, which will result in an elastic heave and long term swelling of the Claygate Member and London Clay. The effects of the longer term swelling movement will be mitigated to some extent by the load applied by the new foundations and the continued presence of the existing house, but these movements may be relatively significant and should be the subject of additional analysis.

It is recommended that the basement slab is suitably reinforced to withstand heave and groundwater pressures or that a void is incorporated below the slab to allow the movement to take place. Tension piles may be required to accommodate these movements. Consideration should also be given to the effects of differential movement between the 6.2 m and 8.5 m deep basements.

8.2 Spread Foundations

Groundwater is likely to be encountered within the basement excavation and it may not be possible to form spread foundations, although this will depend on the basement support system and the extent to which a water-tight excavation is maintained at formation level, although some form of pumping will be required in any case to deal with water within the excavation.

The volume of groundwater anticipated in the basement excavation should be further investigated, as discussed in Section 8.1.1. Provided that a dry excavation can be maintained, spread foundations excavated from basement level to bear within the firm or stiff silty sandy clay of the Claygate Member at a depth of 6.2 m (about 73 m OD) may be designed to apply a net allowable bearing pressure of 120 kN/m^2,

Where the excavation is deepened to accommodate the swimming pool, formation level is likely to be within the base of the Claygate Member or very close to the top of the London Clay. It should be possible to adopt a net allowable bearing pressure of 150 kN/m^2 at a depth of 8.5 m within the stiff clay of the Claygate Member or London Clay (roughly 71 m OD).

The above values incorporate an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits.

The depth of the proposed 6.2 m and 8.5 m deep basement excavations should be such that foundations will be placed below the depth of actual or potential desiccation.

If 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*

8.3 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 is known.

8.4 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 is unlikely to be suitable, as temporary casing would need to be installed into the Claygate Beds to protect against ground water inflows. Therefore, to avoid the requirement for casing, bored piles installed using continuous flight auger (cfa) techniques are likely to be the most appropriate technique.

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. At this stage some assumptions have been made to obtain pile parameters from a depth of 15.00 m to 25.00 m, as the deepest borehole carried out on-site during the investigation, only extended to a depth of 15.00 m (65.00 m OD). It may be necessary, depending on the foundation loads, to carry out a deeper borehole, to provide additional foundation design data.

Ultimate Skin Friction		**kN/m^2**
Made Ground and Claygate Member	GL to 8.5 m (about 71 m OD)	Ignore (basement excavation)
London Clay ($\alpha = 0.5$)	8.50 m to 25.0 m (71 m OD to 55 m OD)	Increasing linearly from 45 to 105*

Ultimate End Bearing		**kN/m^2**
London Clay	20.0 m to 25.0 m (60 m OD to 55 m OD)	Increasing linearly from 1600* to 1900*

*(*denotes assumed value based on extrapolation from the results of this investigation, which should be confirmed by additional investigation)*

In the absence of pile tests, guidance from the London District Surveyors Association[7] (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 the basis of the above coefficients and a factor of safety of 2.6, it has been estimated that a 450 mm diameter pile extending to a depth of 10 m below basement level (approximately

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

61 m OD) should provide a safe working load of about 465 kN.

The above example is not intended to constitute any form of recommendation with regard to pile size or type, but merely serves to illustrate the use of the above coefficients. Specialist piling contractors should be consulted with regard to the design of a suitable piling scheme for this site. Their attention should be drawn to the presence of sand partings and associated groundwater seepage within the Claygate Member and London Clay.

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

8.5 Basement Floor Slab

Following the excavation of the basement, it is likely that the floor slab for the proposed basement will need to be suspended over a void 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.

8.6 Shallow Excavations

On the basis of the borehole findings and trial pits, it is considered that shallow excavations for foundations and services that extend through the made ground or Claygate Member should remain generally stable in the short term, although some instability may occur. 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.

The investigation has indicated that groundwater inflows might be encountered within made ground, particularly within the vicinity of existing foundations and from silt and sand partings from within the Claygate Member. Some form of groundwater control is likely to be required and should be suitably controlled by sump pumping, although this should be confirmed by additional investigations, ideally in the form of trial excavations to the full depth of the proposed basement.

8.7 Effect of Sulphates

Chemical analyses carried out on two samples; a single sample of made ground and a single sample of London Clay and the results have revealed low concentrations of soluble sulphate and near-neutral pH in accordance with Class DS-1 conditions of Table C2 of BRE Special Digest 1 Part C (2005). The measured pH value of the samples show that a ACEC class of AC-1s 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.

8.8 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.

However, the chemical analysis has revealed elevated concentrations of total PAH including benzo(a)pyrene within one of the three samples of made ground tested, obtained from Trial Pit No 1, at a depth of 0.30 m, located within the existing rear garden. Other constituent PAHs were not elevated.

The likely source of the PAH is fragments of ash noted within the made ground at this location. The PAH compounds within the made ground are considered likely to be of low solubility and a risk to groundwater has not been identified.

The chemical analyses has revealed elevated concentrations of total petroleum hydrocarbons (TPH) within the made ground in Trial Pit No 2 encountered at a depth of 1.60 m, extending to the base of the pit at 2.0 m. The results of the speciated testing have measured elevated concentrations of chains lengths 16-21 and may be attributable to gas oil or light heating oil. The extent of the TPH contamination was noted to be localised as it was not encountered in Borehole No 3, carried out approximately 2.0 m to the north of this trial pit or Trial Pit No 1, carried out roughly 5.5 m to the south.

It would be prudent to carry out additional investigations in this area to determine the extent and possible source of the TPH contamination. It is recommended that this contaminated soil is excavated off-site and kept separate from other excavated soils for waste disposal purposes.

The area of the elevated concentration TPH and PAH is currently below hardstanding, and will remain as such following the redevelopment. There is therefore no pathway for contamination to reach end users and there is a low potential for migration to adjacent sites or groundwater.

The made ground will be removed by the basement construction and there will therefore be no risk to end users.

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.

8.8.1 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[8] and CIRIA[9] and the requirements of the Local Authority Environmental Health Officer.

8.8.2 Plastic Services

Elevated concentrations of PAH and TPH have been measured in the made ground and consideration will, therefore, need to be given to the protection of buried plastic services laid within the made ground. Details of the proposed protection measures for buried plastic services will in any case need to be approved by the EHO and the relevant service authority prior to the adoption of any scheme. It is possible that barrier pipe will be required or additional testing will need to be carried out.

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

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

8.9 Waste Disposal

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE guidance[10], 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[11], would qualify for the 'lower rate' of landfill tax.

Based upon on the technical guidance provided by the Environment Agency[12] it is considered likely that the made ground from this site, as represented by the three 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. The soils contaminated with TPH may be classified as HAZARDOUS. It is recommended that the depth and lateral extent of the TPH contamination is investigated and the contaminated soils removed off-site and disposed of appropriately.

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[13] 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 in-situ 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.

10 CL:AIRE (2011) *The Definition of Waste: Development Industry Code of Practice* Version 2, March 2011
11 *Landfill Tax (Qualifying Material) Order 2011*
12 Environment Agency (2008) *Hazardous Waste: Interpretation of the definition and classification of hazardous waste. Technical Guidance* WM2 Second Edition Version 2.2, May 2008
13 Regulatory Position Statement (2007) *Treating non-hazardous waste for landfill - Enforcing the new requirement* Environment Agency 23 Oct 2007

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.

9.0 BASEMENT IMPACT ASSESSMENT

It is understood that it is proposed to deepen and extend the existing lower ground floor level beneath the footprint of the entire building and slightly into the front and rear gardens. The proposed basement will extend to a depth of roughly 6.2 m (73 m OD), with a deepened section for a swimming pool in the southern section, extending to a depth of about 8.5 m (approximately 71 m OD). Formation level of the 6.2 m deep basement is likely to be within the Claygate Member, although the deepened section for the swimming pool is likely to be close to or within the London Clay.

The Claygate Member was found to extend to depths of between 8.00 m (71.50 m OD), 5.10 m (72.21 m OD) and 6.00 m (71.41 m OD). Monitoring of the standpipes has measured groundwater at levels of between 76.33 m OD and 75.84 m OD.

The proposed 8.5 m deep basement excavation for the swimming pool is likely to extend through the Claygate Member and toe into the London Clay. The Claygate Member is not capable of storing and transmitting water in usable amounts and receives very low levels of annual recharge due to its lowly permeable nature. The Claygate Member strata does not support flow to any ponds or watercourses within 100 m of the site. The proposed basement will not increase the existing area of hard-standing.

On the basis of the results of the ground investigation, it is not considered that the proposed basement would result in a significant change to the groundwater flow regime in the vicinity of the proposal or on the amount of annual recharge into the Claygate Member.

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 can result in foundation movements	*Plasticity index tests indicate the Claygate Member to be of moderate volume change potential at the site. Shrinkable clay is present within a depth that can be affected by tree roots. The basement depth will however extend well below the potential depth of root action.*
Location of public highway – excavation of basement could lead to damage	*Akenside Road and Wedderburn Road are located within 5 m of the basement excavation. A normal retention system will maintain the stability of the highway.*
The basement will extend below the groundwater table – this may affect the groundwater flow regime	*The basement is likely to encounter water during excavation, however, the Claygate Member and London Clay beneath the site is characterised by a very low*

Potential Impact	Site Investigation Conclusions
	permeability and cannot store or transmit significant quantities of groundwater. It is not considered that the proposed basement would result in a significant change to the groundwater flow regime in the vicinity of the proposal.
Site is underlain by Secondary Aquifer – the basement may extend into the underlying aquifer and affect the groundwater flow regime	*Groundwater was encountered at levels of between 76.33 m OD and 75.84 m OD and the excavation of the 6.2 m (73 m OD) and 8.5 m (71 m OD) basement excavations will therefore extend into the groundwater.*
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.*
Damage to tree roots	*An arboriculturist should be consulted and their advice should be sought for guidance.*
The New Belsize Tunnel is located roughly 20 m to the south of the southern boundary of the site.	*The site is not located over the tunnel. However piled foundations and the proposed excavation may have implications for the exiting tunnel. Contact should be made with London Underground Limited to confirm details of proposals once finalised for the appropriate analyses to be undertaken. It is however not considered that the development is sufficiently close to the tunnel to be of significant concern.*
Founding depths relative to neighbours – excavation may lead to structural damage to neighbouring properties if there is a significant differential depth between adjacent 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 Claygate Member

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.

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.

Location of public highways

The proposed basement excavation will be located within 5 m of Wedderburn Road and Akenside Road. A retention system will need to be adopted that maintains the stability of the excavation at all times to protect the highways. This is however standard construction practice.

Proposed basement structure is located over Secondary 'A' Aquifer and will extend below groundwater table

The ground investigation has confirmed the presence of Claygate Member strata beneath the site extending to depths of between 8.00 m (72.00 m OD), 5.10 m (72.21 m OD) and 6.00 m (71.41 m OD), which is in turn underlain by the London Clay. Groundwater has been measured at levels of between 76.33 m OD and 75.84 m OD.

Formation level of the 6.2 m deep basement is likely to be within the Claygate Member, although the deepened section for the swimming pool, extending to a depth of about 8.5 m, is likely to be close to or within the London Clay.

Previous investigations have indicated that the Claygate Member has very low bulk hydraulic permeability. Flow within the silty sandy clay of the Claygate Member is very slow and is not capable of storing and transmitting water in usable amounts, and receives very low levels of annual recharge due to its lowly permeable nature and this stratum does not support flow to any ponds or watercourses within 100 m of the site. On the basis of the above, the proposed basement will not affect the amount of annual recharge into the Claygate Member. On this basis, it is not considered that the proposed basement would result in a significant change to the groundwater flow regime in the vicinity of the proposal.

Increase in the differential depth of neighbouring foundations

The stability of neighbouring properties and structures will be ensured at all times, through a suitable retention system. There is nothing unusual or exceptional in the proposed development or the findings of the investigation that give rise to any concerns with regard to stability over and above any development of this nature.

New Belsize Tunnel

The site is not located over the tunnel. However piled foundations and the proposed excavation may have implications for the exiting tunnel. Contact should be made with Network Rail to confirm that the proposed development will not impact their infrastructure. It is not considered that there will be any significant concerns but some supporting analysis may need to be provided in this respect.

10.0 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.

Further groundwater monitoring should be carried out to establish equilibrium levels and the extent of any seasonal fluctuations. It would be prudent to carry out a number of trial excavations, to depths as close to the full basement depth to provide an indication of the likely groundwater conditions.

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.

Additional investigations in the form of a deeper borehole may be required to confirm parameters for the pile design.

It would be prudent to consider additional investigation in the area of Trial Pit No 2 where possible leakage from a heating oil tank has been indicated.

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.

APPENDIX

Borehole Records

SPT Summary Sheet

Trial Pit Records

Geotechnical Laboratory Test Results

SPT & Cohesion / Depth Graph

Chemical Analyses (Soil)

Generic Risk Based Screening Values

Envirocheck Report and Extracts

Historical Maps

Site Plan

Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Site	Borehole Number
15 Wedderburn Road, London, NW3 5QS	BH1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 2.00m	80.00	Mr Dan Wagner	J13235
	Location	**Dates**	**Engineer**	**Sheet**
		13/08/2013-14/08/2013	Fluid Structures	1/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description
						(0.25)	Brick paving over concrete
0.30-0.80	B1				79.75	0.25	MADE GROUND (brown sandy clay with rare flint gravel and occasional fragments of brick, chalk, pottery and roots
						(1.00)	
1.00-1.45	SPT N=19	1.00	DRY	2,2/3,4,6,6			
1.00-1.45	B2				78.75	1.25	'Stiff' high strength brown mottled orange-brown and greenish grey silty sandy CLAY with occasional gravel and roots - suspected desiccated soil to a depth of about 2.00 m
						(0.75)	
1.70	D3						
2.00-2.45	U4	2.00	DRY	40 blows	78.00	2.00	Firm locally soft high strength brown mottled orange-brown and greenish grey silty sandy CLAY with roots noted to a depth of 3.0 m
2.45	D5						
2.70	D6						
3.00-3.45	SPT N=9	2.00	DRY	1,2/2,2,3,2			
3.00-3.45	D7						
3.70	D8						
						(3.80)	
4.00-4.45	U9	2.00	DRY	18 blows			
4.45	D10						
4.70	D11						
5.00-5.45	SPT N=10	2.00	DRY	1,2/2,3,2,3			
5.00-5.45	D12						
5.80	D13				74.20	5.80	Stiff high strength grey silty sandy CLAY with occasional shell fragments
6.50-6.95	U14	2.00	DRY	30 blows			
						(2.20)	
6.95	D15						
7.50	D16						
8.00-8.45	D17			13/08/2013:DRY	72.00	8.00	Stiff fissured high strength grey silty CLAY with rare partings of grey fine sand and silt and occasional shell fragments
8.00-8.45	SPT N=17	2.00	DRY	14/08/2013:7.30m 1,2/3,3,5,6			
9.00	D18						
9.50-9.95	U19	2.00	DRY	30 blows			

Remarks
Hand-dug service pit to a depth of 1.20 m
Installed standpipe to a depth of 15.00 m
Groundwater measured at a depth of 3.96 m (76.04 m OD) on 27/09/2013

Scale (approx)	Logged By
1:50	HD

Figure No. J13235.BH1

Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Site 15 Wedderburn Road, London, NW3 5QS				**Borehole Number** BH1
Boring Method Cable Percussion	**Casing Diameter** 150mm cased to 2.00m	**Ground Level (mOD)** 80.00	**Client** Mr Dan Wagner	**Job Number** J13235
	Location	**Dates** 13/08/2013-14/08/2013	**Engineer** Fluid Structures	**Sheet** 2/2

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
9.95	D20								
10.50	D21								
11.00-11.45 11.00-11.45	SPT N=19 D22	2.00	DRY	2,3/3,4,6,6					
12.00	D23								
12.50-12.95	D24	2.00	DRY	40 blows		(7.00)			
12.95	D25								
13.50	D26								
14.00-14.45 14.00-14.45	SPT N=28 D27	2.00	DRY	3,4/6,7,7,8					
15.00	D28			14/08/2013:DRY	65.00	15.00	Complete at 15.00m		

Remarks	**Scale (approx)** 1:50	**Logged By** HD
	Figure No. J13235.BH1	

Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Site	15 Wedderburn Road, London, NW3 5QS
Number	BH2
Excavation Method	Open-drive sampler
Dimensions	
Ground Level (mOD)	77.31
Client	Mr Dan Wagner
Job Number	J13235
Location	
Dates	16/09/2013-16/09/2014
Engineer	Fluid Structures
Sheet	1/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records
0.25	D1		
0.80	D2		
1.00-1.45	SPT N=9		2,1/2,2,2,3
1.00-1.45	D3		
1.50	D4		
2.00-2.45	SPT N=9		0,1/2,2,2,3
2.00	D5		
2.00-2.45	D6		
2.50	D7		
3.00	D8		
3.50	D9		
4.00-4.45	SPT N=14		2,2/3,3,4,4
4.00	D10		
4.00-4.45	D11		
4.50	D12		
5.00	D13		
5.50	D14		
6.00-6.45	SPT N=15		2,3/3,3,4,5
6.00	D15		
6.00-6.45	D16		
6.50	D17		
7.00-7.45	SPT N=19		2,2/4,4,5,6
7.00	D18		
7.00-7.45	D19		
8.00	D20		
8.50	D21		
9.00-9.45	SPT N=18		3,2/3,3,5,7
9.00	D22		
9.00-9.45	D23		
9.50	D24		
10.00-10.45	SPT N=27		5,4/6,6,8,7

Level (mOD)	Depth (m) (Thickness)	Description
77.26	(0.05) 0.05	Paving slab (30 mm thick), over concrete
77.18	(0.08) 0.13	Made Ground (brown silty sand)
77.09	(0.09) 0.22	Lean mix concrete
77.01	(0.08) 0.30	Made Ground (orange-brown mottled grey clayey sand with occasional fine gravel, fine rootlets and rare fragments of ash)
76.31	(0.70) 1.00	Made Ground (greyish brown silty sandy clay with rare flint gravel and occasional fragments of brick, ash and pottery)
74.81	(1.50) 2.50	Firm orange-brown mottled greenish grey silty sandy CLAY with rare carbonaceous material. Rare scattered flint gravel noted to a depth of 1.3 m
73.61	(1.20) 3.70	Firm locally soft orange-brown mottled greenish grey silty sandy CLAY - soil noted to be damp
72.91	(0.70) 4.40	Firm brown mottled grey silty sandy CLAY with abundant orange-brown partings of fine sand and silt and selenite crystals
72.21	(0.70) 5.10	Firm greyish brown mottled grey silty sandy CLAY with selenite crystals and decayed rootlets
71.31	(0.90) 6.00	Firm grey silty fissured CLAY with rare partings of grey fine sand and silt and selenite crystals
	(4.45)	Stiff grey silty fissured CLAY with rare partings of grey fine sand and silt and selenite crystals

Remarks
Hand-dug service pit to a depth of 1.20 m
Groundwater not encountered during drilling
Standpipe installed to a depth of 10.45 m - response zone from 1.00 m to 10.45 m
Groundwater measured at a depth of 1.27 m (76.04 m OD) on 18/09/2013 and 1.44 m (75.87 m OD) on 27/09/2013

Scale (approx)	Logged By
1:50	HD

Figure No. J13235.BH2

GEA Geotechnical & Environmental Associates Tyttenhanger House Coursers Road St Albans AL4 0PG	Site 15 Wedderburn Road, London, NW3 5QS	Number **BH2**

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Open-drive sampler		77.31	Mr Dan Wagner	J13235
	Location	**Dates** 16/09/2013- 16/09/2014	**Engineer** Fluid Structures	**Sheet** 2/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.00 10.00-10.45	D25 D26				(4.45)			
				66.86	10.45			
						Complete at 10.45m		

Remarks	Scale (approx)	Logged By
	1:50	HD
	Figure No. J13235.BH2	

GEA Geotechnical & Environmental Associates Tyttenhanger House Coursers Road St Albans AL4 0PG	**Site** 15 Wedderburn Road, London, NW3 5QS		**Number** **BH3**
Excavation Method Drive-in Window Sampler	**Dimensions**	**Ground Level (mOD)** 77.41	**Client** Mr Dan Wagner	**Job Number** J13235
	Location	**Dates** 16/09/2013- 16/09/2014	**Engineer** Fluid Structures	**Sheet** 1/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records
0.50	D1		
0.90	D2		
1.00-1.45	SPT N=0		0,0/0,0,0,0
1.00-1.45	D3		
1.20	D4		
			Water strike(1) at 1.32m.
1.50	D5		
1.90	D6		
2.40	D7		
2.90	D8		
3.00-3.45	D9		Water strike(2) at 3.00m.
3.00-3.45	SPT N=9		1,2/1,2,3,3
3.30	D10		
3.70	D11		
4.40	D12		
4.60	D13		
5.00-5.45	SPT N=11		2,2/2,2,3,4
5.00-5.45	D14		
5.20	D15		
5.70	D16		
6.70	D17		
7.00-7.45	SPT N=15		2,2/3,3,4,5
7.00-7.45	D18		
7.90	D19		
8.70	D20		
9.00-9.45	SPT N=16		2,2/3,3,5,5
9.00-9.45	D21		
9.80	D22		
10.00-10.45	SPT N=18		2,2/3,4,5,6

Level (mOD)	Depth (m) (Thickness)	Description	Water
77.20	(0.21) 0.21	Paving slab (50 mm thick), over sand sub-base (110 mm thick), over lean mix concrete (50 mm thick)	
76.21	(0.99) 1.20	Made Ground (brown silty sandy clay with occasional flint gravel, fine rootlets and fragments of brick and ash)	
75.71	(0.50) 1.70	Made Ground (orange-brown mottled greenish grey silty sandy clay with occasional flint gravel, fine rootlets and abundant fragments of ash and burnt coal)	∇1
74.51	(1.20) 2.90	Soft grey mottled brown silty sandy CLAY. A layer of fine to medium subangular to subgrounded gravel noted between 2.60 m and 2.70 m	
73.11	(1.40) 4.30	Soft becoming firm orange-brown mottled greenish grey silty sandy CLAY with rare fine subangular to subrounded flint gravel and decaying rootlets	∇2
70.91	(2.20) 6.50	Firm locally soft grey silty sandy CLAY with abundant partings of orange-brown fine sand and silt and shell fragments	
67.71	(3.20) 9.70	Firm grey silty fissured CLAY with occasional shell fragments and rare partings of grey fine sand and silt	
		Stiff grey silty fissured CLAY with occasional shell fragments and rare partings of grey fine sand and silt	

Remarks
Hand-dug service pit to a depth of 1.20 m
Poor sample recovery due to the presence of significant groundwater inflows from 3.00 m to 10.00 m
Standpipe installed to a depth of 6.00 m - response zone from 1.00 m to 6.00 m
Groundwater measured at a depth of 1.09 m (76.32 m OD) on 18/09/2013
Groundwater measured at a depth of 1.08 m (76.33 m OD) on 27/09/2013

Scale (approx)	Logged By
1:50	HD

Figure No. J13235.BH3

GEA Geotechnical & Environmental Associates	Tyttenhanger House Coursers Road St Albans AL4 0PG	Site 15 Wedderburn Road, London, NW3 5QS	Number **BH3**

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Drive-in Window Sampler		77.41	Mr Dan Wagner	J13235
	Location	**Dates**	**Engineer**	**Sheet**
		16/09/2013-16/09/2014	Fluid Structures	2/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
10.00-10.45	D23							
					(1.30)			
10.80	D24							
				66.41	11.00			
						Complete at 11.00m		

Remarks	Scale (approx)	Logged By
	1:50	HD
	Figure No. J13235.BH3	

Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

Standard Penetration Test Results

Site : 15 Wedderburn Road, London, NW3 5QS

Client : Mr Dan Wagner

Engineer : Fluid Structures

Job Number J13235

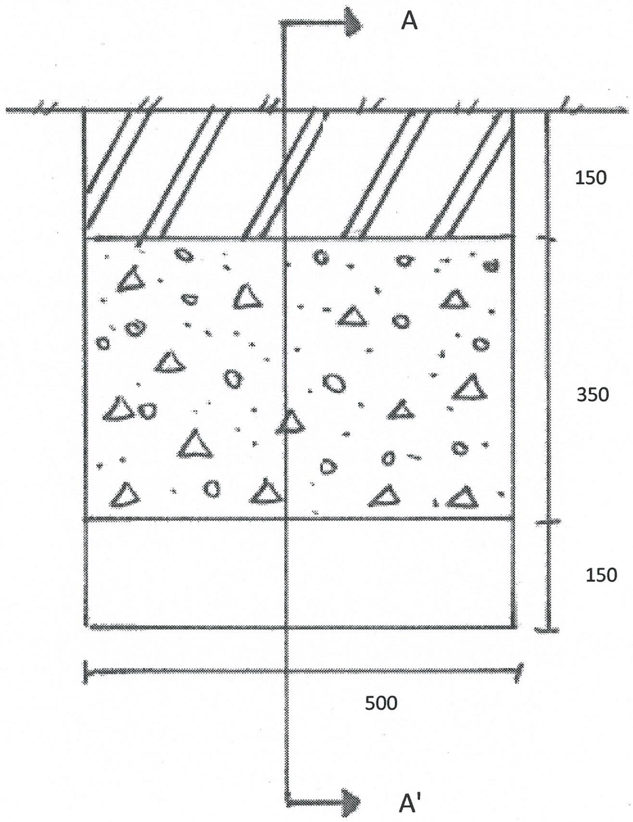
Sheet 1 / 1

Borehole Number	Base of Borehole (m)	End of Seating Drive (m)	End of Test Drive (m)	Test Type	Seating Blows per 75mm		Blows for each 75mm penetration				Result	Comments
					1	2	1	2	3	4		
BH1	1.00	1.15	1.45	SPT	2	2	3	4	6	6	N=19	
BH1	3.00	3.15	3.45	SPT	1	2	2	2	3	2	N=9	
BH1	5.00	5.15	5.45	SPT	1	2	2	3	2	3	N=10	
BH1	8.00	8.15	8.45	SPT	1	2	3	3	5	6	N=17	
BH1	11.00	11.15	11.45	SPT	2	3	3	4	6	6	N=19	
BH1	14.00	14.15	14.45	SPT	3	4	6	7	7	8	N=28	
BH2	1.00	1.15	1.45	SPT	2	1	2	2	2	3	N=9	
BH2	2.00	2.15	2.45	SPT	0	1	2	2	2	3	N=9	
BH2	4.00	4.15	4.45	SPT	2	2	3	3	4	4	N=14	
BH2	6.00	6.15	6.45	SPT	2	3	3	3	4	5	N=15	
BH2	7.00	7.15	7.45	SPT	2	2	4	4	5	6	N=19	
BH2	9.00	9.15	9.45	SPT	3	2	3	3	5	7	N=18	
BH2	10.00	10.15	10.45	SPT	5	4	6	6	8	7	N=27	
BH3	1.00	1.15	1.45	SPT	0	0	0	0	0	0	N=0	
BH3	3.00	3.15	3.45	SPT	1	2	1	2	3	3	N=9	
BH3	5.00	5.15	5.45	SPT	2	2	2	2	3	4	N=11	
BH3	7.00	7.15	7.45	SPT	2	2	3	3	4	5	N=15	
BH3	9.00	9.15	9.45	SPT	2	2	3	3	5	5	N=16	
BH3	10.00	10.15	10.45	SPT	2	2	3	4	5	6	N=18	

GEA Geotechnical & Environmental Associates	Tyttenhanger House Coursers Road St Albans Herts AL4 0PG	Site 15 Wedderburn Road, London, NW3 5QS	Trial Pit Number 1

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Manual	650 x 500 x 1800	77.26	Mr Dan Wagner	J13235
	Location	**Dates**	**Engineer**	**Sheet**
		08/08/2013	Fluid Structures	1/6

PLAN

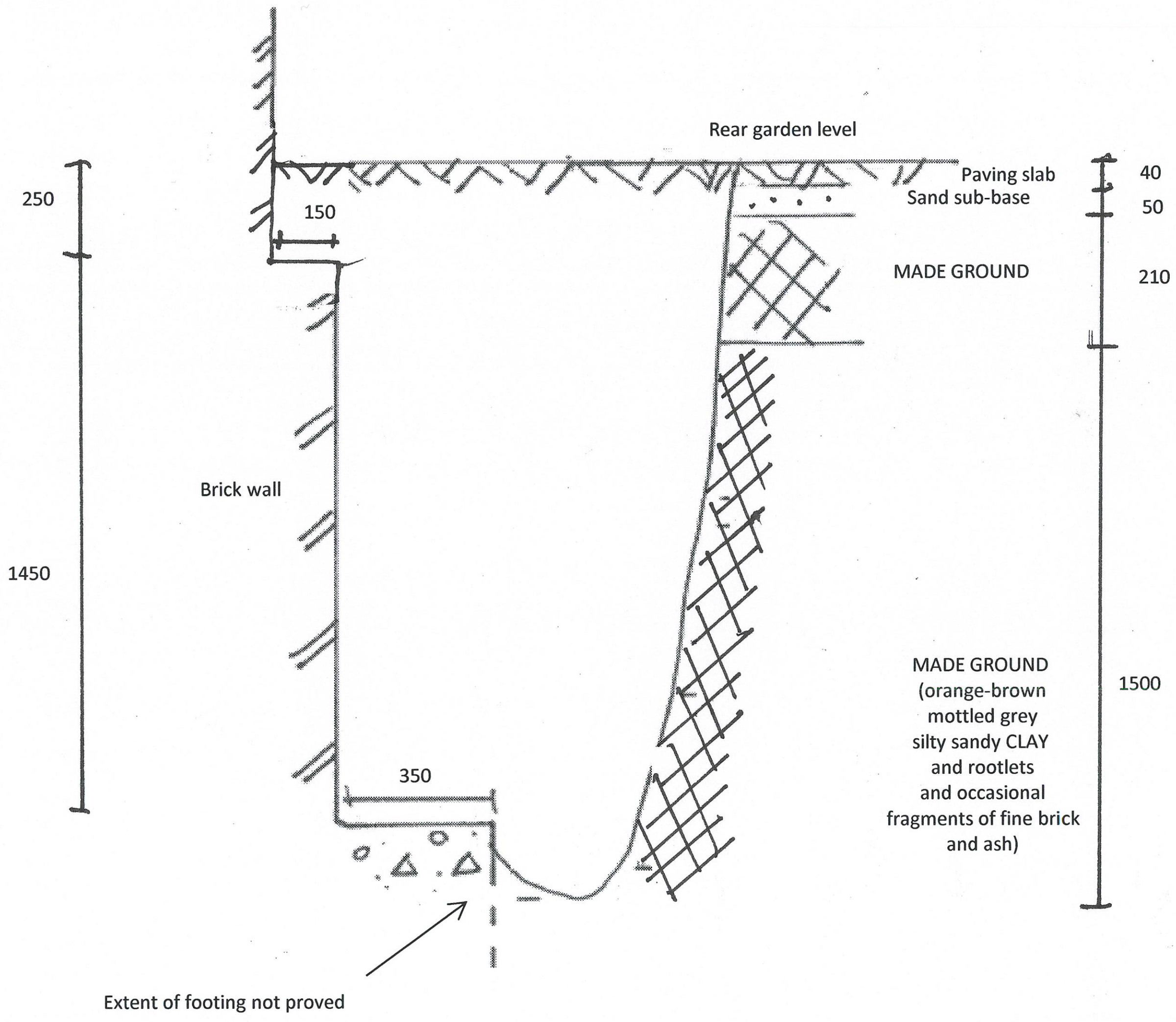


Remarks:	Scale:
All dimensions in millimetres	1:10
Sides of trial pit remained relatively stable during excavation, although minor instabilities were noted	Logged by:
Perched water noted at a depth of 1.4 m	HD

GEA Geotechnical & Environmental Associates	Tyttenhanger House Coursers Road St Albans Herts AL4 0PG	Site 15 Wedderburn Road, London, NW3 5QS	Trial Pit Number 1

Excavation Method	Dimensions	Ground Level (mOD)	Client	Job Number
Manual	650 x 500 x 1800	77.26	Mr Dan Wagner	J13235
	Location	**Dates**	**Engineer**	**Sheet**
		08/08/2013	Fluid Structures	2/6

SECTION A - A'

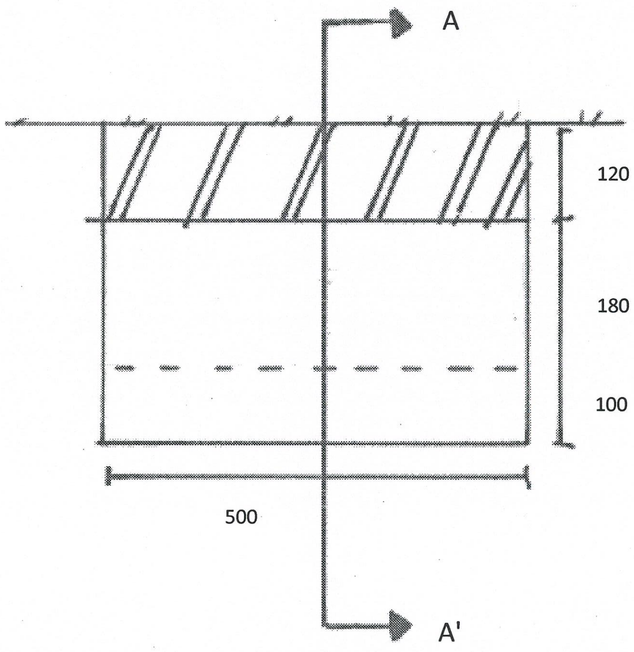


Note: Water in base of pit, obscured view of footing

Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained relatively stable during excavation, although minor instabilities were noted	Logged by:
Perched water noted at a depth of 1.4 m	HD

GEA Geotechnical & Environmental Associates		Tyttenhanger House Coursers Road St Albans Herts AL4 0PG	**Site** 15 Wedderburn Road, London, NW3 5QS	**Trial Pit Number** 2
Excavation Method Manual	**Dimensions** 400 x 500x 2100	**Ground Level (mOD)** 77.62	**Client** Mr Dan Wagner	**Job Number** J13235
	Location	**Dates** 08/08/2013	**Engineer** Fluid Structures	**Sheet** 3/6

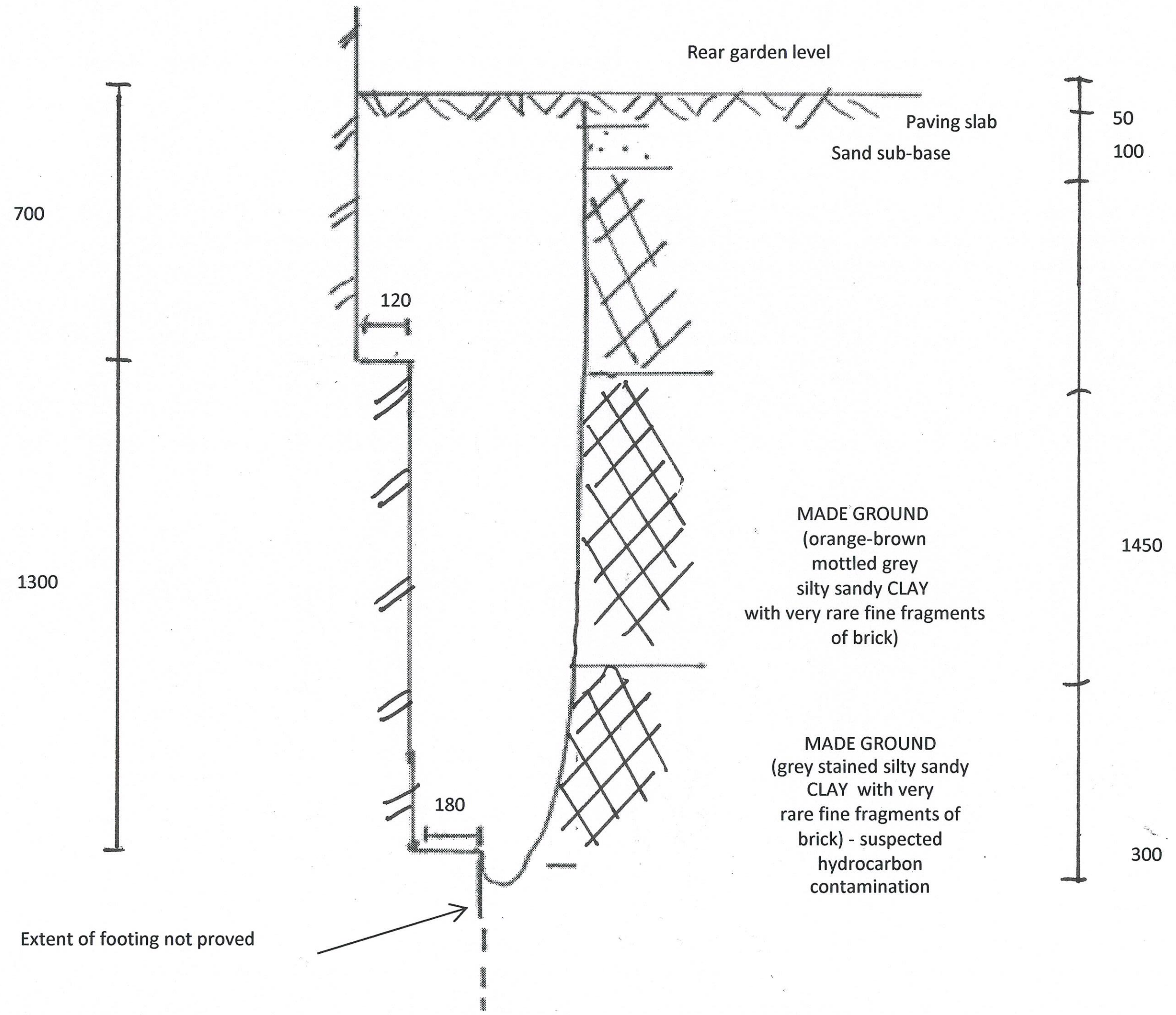
PLAN



Remarks:	Scale:
All dimensions in millimetres	1:10
Sides of trial pit remained relatively stable during excavation, although minor instabilities were noted	Logged by:
Perched water noted at a depth of 1.5 m	HD

GEA Geotechnical & Environmental Associates — Tyttenhanger House, Coursers Road, St Albans, Herts AL4 0PG		**Site** 15 Wedderburn Road, London, NW3 5QS	**Trial Pit Number** 2
Excavation Method Manual	**Dimensions** 400 x 500 x 2100	**Ground Level (mOD)** 77.62	**Client** Mr Dan Wagner	**Job Number** J13235
	Location	**Dates** 08/08/2013	**Engineer** Fluid Structures	**Sheet** 4/6

SECTION A - A'



Note: Water in base of pit, obscured view of footing

Remarks:	Scale:
All dimensions in millimetres	1:20
Sides of trial pit remained relatively stable during excavation, although minor instabilities were noted	Logged by:
Perched water noted at a depth of 1.5 m	HD