Desk Study & Basement Impact Assessment Report

Athlone House
Hampstead Lane
Highgate
N6 4RU

Client	Athlone House Ltd
Engineer	Price and Myers

J12224

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Geotechnical & Environmental Associates

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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 Price and Myers, on behalf of Athlone House Limited, with respect to the construction of a new three-storey house with a basement, which will extend to a maximum depth of 7.00 m. The purpose of the investigation has been to research the history of the site with respect to possible contaminative uses, to determine the ground and hydrogeological conditions, to assess the extent of any contamination and to provide information to assist with the design of the basement and suitable foundations for the proposed development. The report also includes a Basement Impact Assessment carried out in accordance with guidelines from London Borough of Camden in support of a planning application.

DESK STUDY FINDINGS

At the time of the earliest map studied, dated 1870, the site was occupied by Fitzroy House and its associated grounds; online information indicates that Fitzroy House was constructed between 1838 and 1839. By 1896, Fitzroy House had been replaced with what appears to be the existing manor house, although at this time it was known as Caen Wood Towers. Further online information indicates that this was constructed in 1872 but incorporated the original Fitzroy House. The map dated 1896 also shows a large pond in the northwestern corner of the site. By 1935, the house had been extended northwards and rectangular feature constructed within the grounds to the west, which on later maps this is annotated as a tennis court. The site remained unchanged until between 1953 and 1964, when a large rectangular building was constructed adjacent to the eastern elevation of the original manor house. It is on the map dated 1964 that the site is first referred to as Athlone House and is stated as forming part of the Middlesex Hospital. The site remained unchanged until between 2006 and 2012, when the large rectangular building, to the east was demolished, along with the northern extension to the existing building. The site has remained unaltered since that time until the present day.

GROUND CONDITIONS

Below a generally moderate thickness of made ground, the Claygate Member of the London Clay Formation was encountered and proved to the maximum depth investigated. In the areas close to the house, the made ground was found to extend to depths of between 0.80 m and 1.50 m, whilst in the lawn areas surrounding the house, made ground extended to a maximum depth of 0.40 m. It generally comprised brown clayey silt with rootlets, gravel, brick, concrete, coal and timber fragments. Below the made ground, the Claygate Member comprised an initial horizon of firm becoming stiff medium to high strength brown and orange-brown mottled grey silty very sandy clay with pockets of clayey fine sand and sandy silt. The initial horizon extended to the maximum depth investigated in the trial pits of 3.10 m, and to depths of 6.00 m and 7.30 m in the cable percussion boreholes, whereupon stiff brownish grey silty sandy clay with partings and pockets of pale grey silt was encountered to depths of 7.30 m and 9.00 m. Below these depths stiff high strength dark grey silty clay to clayey silt was encountered to depths of 12.00 m and 15.00 m and was underlain by very stiff high strength to very high strength dark grey silty, locally sandy, clay with traces of selenite, which was proved to the maximum depth investigated, of 20.00 m. Groundwater monitoring has indicated groundwater to be at depths of between 9.61 m and 9.89 m and the contamination testing has not indicated any elevated concentrations of any of the contaminants tested.

RECOMMENDATIONS

Excavations for the proposed basement structure will require temporary support to maintain stability and to prevent any excessive ground movements. Based on the groundwater observations to date, groundwater is not likely to be encountered within the deep basement excavation. Therefore, a contiguous bored pile wall is likely to be the best option of forming the basement structure, with localised grouting between piles as necessary to deal with any perched water inflows. As the basement structure will not intercept the groundwater table, it is unlikely to have an effect on the local hydrogeology. In addition, the proportion of hardstanding will not be significantly increased and therefore the proposals will not have an effect on the local hydrology. This is especially the case as it is proposed to incorporate a subsoil drain around the perimeter of the basement, which will prevent the build up of surface water behind the retaining walls. On the basis of the chemical testing, there is thought to be a low risk to end users from contamination and therefore a requirement for remedial measures is not envisaged.

Part 1: INVESTIGATION REPORT

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

1.0 INTRODUCTION

Geotechnical and Environmental Associates (GEA) has been commissioned by Price and Myers, on behalf of Athlone House Limited, to carry out a site investigation at the site of Athlone House, Hampstead Lane, Highgate, London N6 4RU. This report also forms part of a Basement Impact Assessment (BIA), which has been carried out in accordance with guidelines from the London Borough of Camden in support of a planning application.

A report has been prepared previously by LBH Wembley (report ref LBH2921(a), dated September 2003), which reviews their previous ground investigation carried out in June 2002. A copy has been provided by the consulting engineers and has been reviewed by GEA within this report; it is referred to where appropriate.

A letter report has also been prepared by RPS Health, Safety and Environment (report ref: FLC1578.002L, dated May 2004) providing an assessment of groundwater and the potential for future developments to impact the local trees. This report includes a review of the LBH Wembley Report among other planning documents, architect drawings and engineer designs. A copy of this report was also provided by the consulting engineers and has been reviewed by GEA.

1.1 Proposed Development

Following the demolition of the existing house, it is proposed to construct a new three-storey detached house with a basement, which will extend to a maximum depth of 7.00 m below ground level.

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

1.2 Purpose of Work

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

- to check the history of the site with respect to previous contaminative uses;
- to determine the ground conditions and their engineering properties;
- to 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;
- a walkover survey of the site carried out in conjunction with the fieldwork.

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

- Three cable percussion boreholes, advanced to depths of 20.00 m and 15.00 m, by means of a cable percussion drilling rig;
- standard penetration tests (SPTs), carried out at regular intervals in the borehole, to provide additional quantitative data on the strength of the soils;
- a series of five trial pits, mechanically excavated using a JCB 3CX to depths of 2.90 m and 3.10 m;
- the installation of three groundwater monitoring standpipes to depths of between 7.00 m and 13.00 m and three subsequent monitoring visits over a one month period;
- laboratory testing of selected soil samples for geotechnical purposes and for the presence of contamination; and
- provision of a report presenting and interpreting the above data, together with our advice and recommendations with respect to the proposed development.

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

The work carried out also includes a Hydrogeological Assessment and Land Stability Assessment (also referred to as Slope Stability Assessment), both 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 the groundwater conditions and land stability, in particular to assess whether the development will affect the stability of neighbouring properties 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

1.3.1 Qualifications

The BIA elements of the work have been carried out by Martin Cooper, a BEng in Civil Engineering, a chartered engineer (CEng) and member of the Institution of Civil Engineers (MICE), who has over 20 years specialist experience in ground engineering. The subterranean (groundwater) flow assessment has been carried out by John Evans, a qualified Hydrogeologist, Chartered Geologist (CGeol) and Fellow of the Geological Society of London (FGS). The assessment has also 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, engineering geology and hydrogeology. All of the assessors meet the Geotechnical Specialist criteria of the Site Investigation Steering Group and satisfy the qualification requirements of the Council guidance.

A screening assessment for surface water flow has also been included for completeness, although this will need to be reviewed by a suitably qualified Hydrologist.

1.4 Limitations

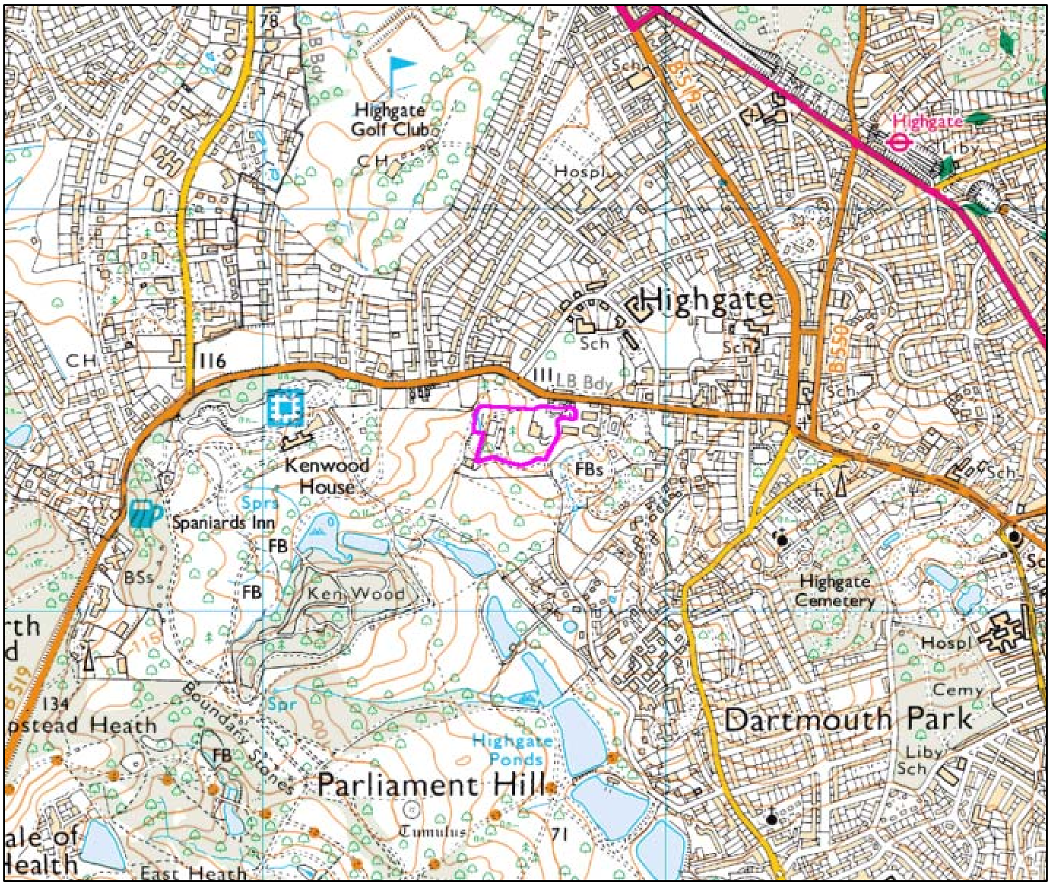
The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil,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

2.0 THE SITE

2.1 Site Description

The site is located in Highgate, north London, approximately 1 km to the southwest of Highgate London Underground station, along the northern boundary of Hampstead Heath. The site may be additionally located by National Grid Reference 527754,187097 and is shown on the map below.

The site covers a roughly rectangular area with maximum dimensions of 190 m north-south by 230 m east-west and occupies an area of approximately 2.66 hectares. It fronts onto Hampstead Lane to the north and is bordered to the east by a relatively recent residential development comprising of three blocks of four-storey apartments and to the south and west by Hampstead Heath, which to the west comprises the grounds of Kenwood House. The site is currently occupied by Athlone House, a three-storey and four-storey former manor house, which is located in the eastern half of the site. The area to the northeast of the house is covered in hardstanding and was an area formerly occupied by another building that adjoined the house. With the exception of this area, and a paved terrace adjacent to the western elevation of the house, the remainder of the site is occupied by soft landscaped gardens. These comprise a large lawn around the western and southern elevations of the house and dense vegetation along the southern and western boundaries of the site.



A large number of species of deciduous and evergreen trees are present and stand at heights of up to 25 m. In the northwestern corner of the site, a small pond is present, which is surrounded by reed bushes. This is thought to represent a spring line and the remnants of a much larger pond shown on historical maps. The house and the area of hardstanding in the northeast are situated on relatively level plateaux, although the site level slopes relatively steeply down to the south and southwest beyond the house, in keeping with the topography of the surrounding area. The slopes are at an angle of between 7° and 9°.

2.2 Site History

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

At the time of the earliest map studied, dated 1870, the site was occupied by a Manor House known as Fitzroy House and its associated grounds; online information indicates that Fitzroy House was constructed between 1838 and 1839. By 1896, Fitzroy House had been replaced with what appears to be the existing manor house, although at this time it was known as Caen Wood Towers. Further online information indicates that this was constructed in 1872 but incorporated the original Fitzroy House. A portrait of Caen Wood Towers, dated 1880, can be seen below.

The map dated 1896 also shows a large pond in the northwestern corner of the site. The pond is still there today, although is a lot smaller than shown on the historical map, which also indicates that there was a boat house along the ponds banks, which would give an indication of its size at this time. By 1935, the house had been extended northwards and a rectangular feature constructed within the grounds to the west, which on later maps this is annotated as a tennis court. The site remained unchanged until between 1953 and 1964, when a large rectangular building was constructed adjacent to the eastern elevation of the original manor house. It is on the map dated 1964 that the site is first referred to as Athlone House, which was occupied by Middlesex Hospital. Online information[4] indicates that the Ministry of Health acquired the site in 1951 and the buildings were turned into a geriatric hospital. The rectangular building constructed to the east was used for nurses' accommodation. This information also indicates that Athlone House was used in World War I as a military convalescent hospital, known as the American Hospital for English soldiers. During World War II it was used as a convalescent hospital for RAF officers, although in 1942 it became an RAF Intelligence Training School

Middlesex Hospital occupied the site until 2003 when it was sold to developers. The site configuration however remained unchanged until between 2006 and 2012, when a number of low-rise buildings to the north and east of the manor house, including the large rectangular building to the east, were demolished to make way for the construction of the existing apartment blocks to the east. The site has remained unaltered since that time until the present day and the building is currently vacant.

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.

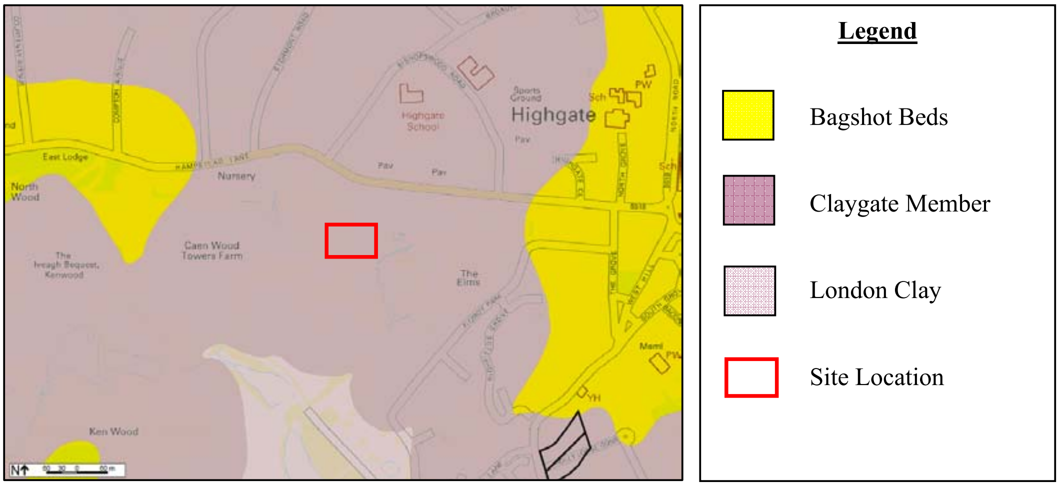
The search has revealed that there are no landfills, waste management, transfer, treatment or disposal sites within 500 m of the site. There have also not been any recorded pollution incidents to controlled waters within 250 m of the site.

4 Lost London Hospitals Website, *http://ezitis.myzen.co.uk/athlone.html*

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.

2.4 Geology

The Geological Survey map of the area (sheet 256) indicates that the site is underlain by the Claygate Member of the London Clay Formation, as shown by the geological map extract below. The geology in this area is generally horizontally bedded such that the boundary between the geological formations roughly follows the ground surface contour lines. The boundary between the Claygate Member and overlying Bagshot Beds is present approximately 350 m to the west and east of the site, at a level of approximately 115 m OD. The boundary between the Claygate Member and the upper unit of the London Clay is located approximately 300 m south of the site, at a level of 85 m OD, approximately 25 m below the site. The Claygate Member is described as typically comprising interbedded fine-grained sand, silt and clay.

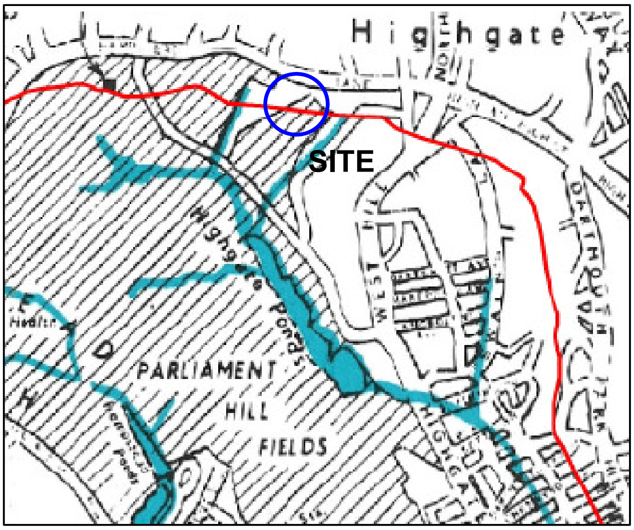


The previous LBH Wembley Investigation comprised three boreholes, advanced to a maximum depth of 30.00 m (approximately 82.00 m OD) by means of cable percussion methods and a series of five mechanically excavated trial pits to depths of 3.50 m and 4.00 m. The investigation encountered a generally moderate thickness of made ground overlying the Claygate Member of the London Clay Formation, which was proved to the maximum depth investigated. This stratum was described as comprising an upper horizon of firm yellowish brown mottled grey silty sandy clay to depths of 5.80 m (106.20 m OD) and 5.90 m (105.40 m OD), whereupon stiff grey fissured silty, locally sandy, clay with pockets and partings of silt and fine sand was encountered to depths of between 16.50 m (94.8 m OD) and 18.00 m (94.20 m OD). Below these depths, this stratum was found to comprise very stiff grey fissured silty clay with occasional pockets and partings of silt and was proved to the maximum depth investigated.

2.5 Hydrology and Hydrogeology

The Claygate Member is classified as a Secondary A Aquifer, which refers to strata that contain permeable layers capable of supporting water supply at a local level and in some cases may form an important source of base flow for local rivers, as defined by the Environment Agency (EA).

The topographical maps show that the nearest surface water features are the small pond in the northwestern corner of the site, suspected of being a former spring line, and a spring line that forms the source of a small stream that flows in a southerly direction towards a series of small ponds, which is situated approximately 150 m to the southeast of the site. Both these features are at a level of between 100 m OD and 105 m OD and provide a good indication of the depth to the groundwater table below the site. The LBH Wembley investigation encountered groundwater at depths of 5.00 m (106.3 m OD) and 7.60 m (104.60 m OD), which would correspond with the spring lines. Subsequent monitoring of standpipes installed in two of the boreholes recorded groundwater at depths of 2.78 m (109.42 m OD) and 3.82 m (109.08 m OD). However the standpipes were noted to be block by sediments at depths of 2.90 m and 4.40 m respectively and therefore the monitoring results are not considered to be indicative or true groundwater level, but rather surface water that was trapped in the standpipes.



Approximately 300 m to the south of the site, in Hampstead Heath and Parliament Hill, is a further series of spring lines and ponds, which drain in a southerly direction, down the valley, towards both the Highgate and Hampstead Ponds, located approximately 400 m and 1.2 km south of the site respectively. The positions of these springs are likely to mark the boundary between the Claygate Member and underlying essentially impermeable London Clay. Within the area of Hampstead and Highgate, existing and historical springs are also present at the interface between the Claygate Member and the overlying more sandy Bagshot Beds. These springs have been the source of a number of London's "lost" rivers, notably the Fleet, Westbourne and Tyburn. The above extract of the Lost Rivers of London Map, indicates that the pond in the northwestern corner of the site and the spring to the southeast of the site, both historically formed sources of the River Fleet. This river flowed south from the springs through the Highgate Ponds and on through Kentish Town and Camden Town before flowing through Clerkenwell and issuing into the Thames below Blackfriars Bridge. Although the river is no longer open water courses, surface and near surface waters will still flow towards the former river course and in particular the former spring lines.

On the basis of the all of the above, groundwater below the site is expected to be flowing in a generally southerly direction.

The Claygate Member is predominantly cohesive in nature and therefore groundwater flow is likely to be relatively slow, although horizons of more sandy soils are present, resulting in the permeability ranging from "very low" to "high". Published data for the permeability of the London Clay indicates the horizontal permeability to generally range between 1×10^{-10} m/s and 1×10^{-8} m/s, with an even lower vertical permeability.

With the Highgate and Hampstead Ponds hydraulically and topographically down gradient from the site, the site is not considered to be within their catchment. It is not within an area at risk from flooding, as defined by the EA and in addition, the site is not listed as being at risk from surface water flooding, nor is there a record of it having suffered from such an event in the past.

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.

2.6.1 Source

The historical usage of the site that has been established by the desk study and the site walkover indicates that the site does not have a potentially contaminative history, by virtue of it having been occupied by a manor house throughout its developed history. There are thus no obvious likely sources of contamination on the site, although it is possible that localised filling of the site was carried out in order to form a level plateau at the time the site was used as a hospital. Such thicknesses of made ground may form localised hotspots of contamination.

The desk study has also not indicated the presence of off-site sources of contamination, including historical and / or existing landfill sites.

2.6.2 Receptor

The proposed residential end use may result in exposure to the soil and thus represents a relatively high sensitivity end-use. The underlying Claygate Member is classified as a Secondary A Aquifer and therefore groundwater would be considered a sensitive receptor. Site workers will come in to contact with underlying soils during the construction phase, as will new buried services. Neighbouring sites would also be considered to be moderately sensitive receptors.

2.6.3 Pathway

End users could conceivably come into contact with soils within private garden areas through direct soil and indoor dust ingestion, consumption of homegrown produce, consumption of soil adhering to homegrown produce, skin contact with soils and dust, and inhalation of dust and vapours. The underlying Claygate Member can comprise of sandy soils that form a potential pathway for leachable contaminants to reach groundwater, with the groundwater itself representing a potential pathway for mobile contaminants to migrate off and onto site and the construction phase is considered to be a pathway by which site workers and new buried services may come in contact with any contamination.

2.6.4 Preliminary Risk Appraisal

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

3.0 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 Appendices E1, E2 and E3 which include a series of questions within screening flowcharts for surface flow and flooding, subterranean (groundwater) flow and land stability. The flowchart questions and responses to these questions are tabulated below.

3.1.1 Surface Flow and Flooding

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 Athlone House
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, although the possible effects of the basement construction on the local hydrology and hydrogeology are discussed further in Part 2 of this report.

3.1.2 Subterranean (groundwater) Flow

Question	Response for Athlone House
1a. Is the site located directly above an aquifer?	Yes, Claygate Member is classified as a Secondary ‘A’ Aquifer
1b. Will the proposed basement extend beneath the water table surface?	Possibly; groundwater is likely to be present within the Claygate Member.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	No. The nearest spring line is over 150 m to the southeast of the site.

3. Is the site within the catchment of the pond chains on Hampstead Heath?	No
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No
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
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

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

Q1a The site is located directly above an aquifer?
Q1b The proposed basement may possibly extend beneath the water table surface?

3.1.3 Slope Stability

Question	Response for Athlone House
1. Does the existing site include slopes, natural or manmade, greater than 7°?	Yes. The site includes natural slopes greater than 7°
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°?	Yes, although the slopes with angles in excess of 7° are all downslope of the location of the proposed basement.
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?	No
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	No
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 a Secondary ‘A’ aquifer
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?	No
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No
14. Is the site over (or within the exclusion zone of) any tunnels, eg railway lines?	No

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

Q1. The site includes natural slopes greater than 7°
Q4. The site is within a wider hillside setting that has slopes of greater than 7°.
Q10 The site is underlain by an aquifer.

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 impacts are assessed for each of the identified potential impact factors.

4.1 Potential Impacts

The following potential impacts have been identified.

Screening Flowchart Question	Potential Impact
Is the site located directly above an aquifer?	The site is underlain by the Claygate Member of the London Clay, which is classified as a Secondary A Aquifer. This has the potential of being able to support local water supplies as well as forming an important source of base flow for local rivers. There is the potential for the hydrogeological setting to be affected by a basement development.
Will the proposed basement extend beneath the water table?	As stated above, groundwater would be expected to be encountered within the Claygate Member and therefore it is possible that the basement excavation will extend below the water table. Should this happen, the basement structure is capable of diverting groundwater flow such that groundwater level is affected on both the up slope and down slope side of the basement structure. This in turn has the potential to affect the local hydrogeology and any adjacent structures.
Does the existing site include slopes, natural or manmade, greater than 7°?	The site includes natural slopes greater than 7°. Such natural and manmade slopes are more prone to slope failure, however it should be noted that this is is based on case studies of slopes within the London Clay.
Is the site within a wider hillside setting in which the general slope is greater than 7°?	The hillside setting, of which the site forms part of, includes slopes of 7° and greater, although it should be noted that this is an extensive hillside setting and the slopes of such angles are located downslope of the proposed basement.

These potential impacts have been investigated through the site investigation, as detailed below.

4.2 Exploratory Work

In order to meet the objectives described in Section 1.2, three cable percussion boreholes were drilled, to depths of 15.00 m and 20.00 m using a standard cable percussion drilling rig. Standard penetration tests (SPTs) were carried out at regular intervals in the boreholes and disturbed and undisturbed samples were recovered for subsequent laboratory examination, geotechnical testing and contamination analysis. The deeper borehole was supplemented by a series of five trial pits, mechanically excavated using a JCB 3CX excavator to depths of 2.80 m and 3.10 m. The field work was carried out under the supervision of a geotechnical engineer from GEA.

Groundwater monitoring standpipes were installed in the three boreholes, to depths of between 7.00 m and 13.00 m, and have subsequently been monitored on three occasions over a one-month period.

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 site plan included within the previous LBH Wembley Report. These have been compared to the contours shown on the OS map of the area and are considered to be generally accurate.

4.3 Sampling Strategy

The borehole and trial pit locations were positioned on site by GEA in order to provide optimum coverage of the site with due regard to the proposed development, whilst avoiding the areas of known services.

Five samples of 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 sample was 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.

A number of natural soil samples were tested for moisture content and Atterberg limits, in addition to particle size distributions, in order to provide engineering classification of the natural geology. Undisturbed samples were also subject to undrained uniaxial compressive tests in order to provide values of undrained shear strength for design of retaining walls and suitable foundations for the proposed development.

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

Below a generally moderate thickness of made ground, the Claygate Member of the London Clay Formation was encountered and proved to the maximum depth investigated.

5.1 Made Ground

In the areas close to the house, the made ground was found to extend to depths of between 0.80 m (111.65 m OD) and 1.80 m (110.56 m OD), whilst in the lawn areas surrounding the house, made ground extended to a maximum depth of 0.40 m (110.25 m OD). It generally comprised brown clayey silt with rootlets, gravel, brick, concrete, coal and timber fragments.

With exception of fragments of extraneous material in the made ground in close proximity of the existing house, which is likely to have originated from demolition rubble, no visual or olfactory evidence of significant contamination was observed within these soils, although four samples have been analysed for a range of contaminants and the results are summarised in Section 5.4.

5.2 Claygate Member

This stratum generally comprised an initial horizon of firm becoming stiff medium to high strength brown and orange-brown mottled grey silty very sandy clay with pockets of clayey fine sand and sandy silt. The initial horizon extended to the maximum depth investigated in the trial pits, of 3.10 m (108.94 m OD) and to depths of 6.00 m (106.36 m OD) and 7.30 m (104.74 m OD) in the cable percussion boreholes, whereupon stiff brownish grey silty sandy clay with partings and pockets of pale grey silt was encountered to depths of 7.30 m (105.06 m OD) and 9.00 m (103.40 m OD). Below these depths stiff high strength dark grey silty clay to clayey silt was encountered to depths of 12.00 m (100.95 m OD) and 15.00 m (97.04 m OD) and was underlain by very stiff high strength to very high strength dark grey silty, locally sandy, clay with traces of selenite, which was proved to the maximum depth investigated, of 20.00 m (92.04 m OD).

Desiccation of the clay soils was not encountered during the investigation, and the absence of desiccation is confirmed by the results of moisture content and plasticity index tests, which also indicate the clay to be of moderate shrinkability. These soils were observed to be free of any evidence of soil contamination.

5.3 Groundwater

During the drilling of the boreholes, groundwater was encountered at depths of 12.10 m (99.94 m OD) and 12.50 m (99.86 m OD). The results of monitoring of the standpipes installed in the boreholes are shown in the table below.

Borehole No	Standpipe Depth m (Level m OD)	Depth to groundwater in m (Level (m OD))		
		01/10/2012	10/10/2012	16/10/2012
101	13.00 (99.95)	9.63 (103.32)	9.62 (103.31)	9.63 (103.32)
102	7.00 (105.36)	DRY	DRY	DRY
103	12.50 (99.54)	9.89 (102.15)	9.87 (102.17)	9.82 (102.22)

5.4 Soil Contamination

The table below sets out the values measured within five samples of made ground; all concentrations are in mg/kg unless otherwise stated.

Determinant	Maximum concentration recorded (mg/kg)	Minimum concentration recorded (mg/kg)	Number of samples below detection limit	Normalised upper bound US_{95}
pH	7.8	4.6	-	-
Arsenic	7.1	3.6	None	7.0
Cadmium	<0.1	<0.1	All	<0.1
Chromium	27	12	None	26.6
Copper	14	7.7	None	14.6
Mercury	0.18	<0.10	4	<0.1
Nickel	14	5.5	None	13.4
Lead	120	17	None	101.3
Selenium	0.43	<0.20	1	0.4
Zinc	60	33	None	53.7

Determinant	Maximum concentration recorded (mg/kg)	Minimum concentration recorded (mg/kg)	Number of samples below detection limit	Normalised upper bound US_{95}
Total Cyanide	<0.5	<0.5	All	<0.5
Total Phenols	<0.3	<0.3	All	<0.3
Sulphide	5.1	1.8	None	4.2
Total TPH	<10	<10	All	<10
Naphthalene	1.2	<0.1	1	1.1
Benzo(a)pyrene	0.42	<0.1	1	0.4
Total PAH	8.7	<2	1	7.9
Total organic carbon %	3.2	0.6	None	2.5

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

5.4.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. To this end, the 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 is not a critical risk receptor;
- that the critical receptor for human health will be young female child (aged zero to six years old);
- that the exposure duration will be six years;
- that the critical exposure pathways will be direct soil and indoor dust ingestion, consumption of homegrown produce, consumption of soil adhering to homegrown produce, skin contact with soils and dust, and inhalation of dust and vapours; and
- that the building type equates to a two-storey terraced house.

It is considered that these assumptions are considered 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

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.

concentrations are measured in excess of these generic screening values there is considered to be a potential that they could pose an unacceptable risk and thus further action will be required which could include;

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

The results of the contamination testing have revealed any elevated concentrations of the contaminants tested. 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 significance of the contamination results is considered further in Part 2 of the report.

Part 2: DESIGN BASIS REPORT

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

6.0 INTRODUCTION

Consideration is being given to the demolition of the existing house and the subsequent construction of a new three-storey detached house that will include a basement, excavated to a maximum level of approximately 105 m OD. Loads are not known at this stage but are anticipated to moderate.

7.0 GROUND MODEL

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

- Below a generally moderate thickness of made ground, the Claygate Member of the London Clay Formation is present and was proved to the maximum depth investigated;
- made ground extends to depths of between 0.40 m (110.65 m OD) and 1.80 m (110.56 m OD) and generally comprises brown clayey silt with rootlets, gravel, brick, concrete, coal and timber fragments;
- the underlying Claygate Member initially comprises firm becoming stiff medium to high strength brown and orange-brown mottled grey silty very sandy clay with pockets of clayey fine sand and sandy silt, which extends to depths of 6.00 m (106.36 m OD) and 7.30 m (104.74 m OD);
- the initial horizon is underlain by stiff brownish grey silty sandy clay with partings and pockets of pale grey silt to depths of 7.30 m (105.06 m OD) and 9.00 m (103.04 m OD), whereupon stiff high strength dark grey silty clay to clayey silt is present to depths of 12.00 m (100.95 m OD) and 15.00 m (97.04 m OD);
- below these depths the Claygate Member very stiff high strength to very high strength dark grey silty, locally sandy, clay with traces of selenite, which was proved to the maximum depth investigated, of 20.00 m (92.04 m OD);
- groundwater monitoring visits have measured groundwater at depths of between 9.62 m (103.31 m OD) and 9.89 m (102.35 m OD) and
- the contamination analyses have not indicated any elevated concentrations of the contaminants tested.

8.0 ADVICE AND RECOMMENDATIONS

Excavations for the proposed basement structure will require temporary support to maintain stability of the surrounding structures and to prevent any excessive ground movements. Based on the information obtained to date, groundwater is not expected to be encountered within the basement excavation.

Formation level for the proposed development will be within the Claygate Member, which should provide an eminently suitable bearing stratum for spread foundations excavated from basement level. Alternatively, piled foundations would also provide a suitable solution.

8.1 Basement Excavation

It is understood that it is proposed to excavate the proposed basement to a maximum depth of 7.00 m, a level of approximately105 m OD. Groundwater has been recorded at levels of 103.31 m OD and 102.35 m OD, which is approximately 3.00 m below the depth of the proposed basement structure. Therefore groundwater is not expected to be encountered within the basement excavation and neither would the extent of any seasonal variations be of such a magnitude that the groundwater table would rise to the level of the proposed basement structure. This is particularly so as this investigation and subsequent monitoring has been carried out over a summer of record rainfall and therefore groundwater levels are likely to be at a relatively high level. As with any basement development, it is recommended that monitoring of the standpipes is continued in order to ascertain any fluctuations and that deeper trial excavations to as close the basement depth are carried out in order determine the extent of any inflows and the stability of the underlying soils.

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 will affect the excavation. The design of basement support in the temporary and permanent conditions also needs to take account of the need to maintain the stability of the excavation and surrounding structures.

Given the anticipated absence of significant groundwater inflows and the available open space, consideration could be given to the construction of insitu retaining walls within an open cut excavation, with the sides battered to a safe angle. Slopes within the made ground and underlying Claygate Member should be excavated at 1 (vertical) to 2 (horizontal), although care should be taken to protect the sides of any unsupported cut slopes during periods of rainfall and any run-off from construction operations until the retaining walls have been installed. Movement of plant at the top of any open cut should be prevented and daily inspections of the cut faces should be carried out to check stability.

Whilst the use of sheet piles are unlikely to be suitable due to the noise and vibrations associated with installation, consideration could be given to the use of some form of bored piled wall, which has the added benefit of being incorporated in the final structure and providing support for structural loads. Based on the groundwater observations to date and the trial pit findings, a contiguous bored pile wall would be considered a suitable option, with the use of localised grouting if necessary in order to deal with any perched water inflows. The use of a contiguous bored pile wall is also considered to be suitable for the ground conditions at this site.

The Claygate Member has been found to comprise predominantly silty sandy clay soils, although horizons of more sandy material have been noted. Laboratory testing has indicated these horizons to be 'clayey' in nature and they would in any case behave as a cohesive soil.

There is therefore not considered to be a risk of a loss of soil between the spacing of the piles. Instability of the sides of the trial pits, excavated to depths of 3.0 m, was not noted during the investigation.

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.

8.1.1 Basement Retaining Walls

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

Stratum	Bulk Density (kg/m^3)	Effective Cohesion (c' – kN/m^2)	Effective Friction Angle (Φ' – degrees)
Made ground	1700	Zero	27
Claygate Member	2000	Zero	25

Groundwater is unlikely to be encountered within the excavation, although monitoring of the standpipe should be continued in order to establish equilibrium levels. At this stage, it is recommended that consideration should be given to the risk of groundwater and surface water collecting behind the retaining walls. It would therefore be prudent to assume a groundwater level at a depth of three-quarters of the retained height, unless a fully effective drainage system can be ensured. The advice in BS8102:2009[6] should be followed in the design of the basement retaining walls and with regard to waterproofing requirements.

8.1.2 Basement Heave

The excavation of a 7.00 m thickness of soil in the west of the site will result in a net unloading of approximately 135 kN/m^2. This unloading will result in heave of the underlying Claygate Member, although the movements will be mitigated by some extent by the pressure applied by the new buildings. However, it is recommended that further analysis is carried out once the levels and loadings have been finalised,

8.2 Spread Foundations

The excavation of the basement extension will result in a formation level in the Claygate Member. It should be possible to adopt moderate width pad or strip foundations in the firm clay, and in the west of the site, at a depth of 7.00 m, the foundations may be designed to apply a net allowable bearing pressure of 150 kN/m^2 below the level of the proposed basement floor.

8.3 Piled Foundations

For the ground conditions at this site some form of bored pile is likely to be the most appropriate type. A conventional rotary augered pile may be appropriate, with temporary casing installed to maintain stability and prevent groundwater inflows, although it is likely that groundwater will be encountered at depth within the Claygate Member. Therefore the use of bored piles installed using continuous flight auger (cfa) techniques, which would not require the provision of casing, are likely to be the most appropriate choice of pile.

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

The following table of ultimate coefficients may be used for the preliminary design of bored piles, which have been based on the SPT & Cohesion / level graph in the appendix.

Ultimate Skin Friction		kN/m^2
Made Ground and Claygate Member	All soil above 105.0 m OD	Ignore (basement)
Claygate Member ($\alpha = 0.6$)	105.0 m OD to 92.0 m OD	Increasing linearly from 55 to 115

Ultimate End Bearing		kN/m^2
Claygate Member	97.0 m OD to 92.0 m OD	Increasing linearly from 1800 to 2070

In the design of piled foundations the effect of potential future shrinkage and swelling of the clay should be taken into account. In designing for compressive loads it should be assumed that further desiccation, and hence shrinkage of the clay, could continue where trees are to remain. Pile shaft adhesion within the theoretical maximum future desiccated thickness should therefore be ignored, and this thickness should be determined by reference to the NHBC guidelines in line with the advice given above for spread foundations. Heave of the clay soils could also occur due to future swelling as a result of trees being removed. This would exert a tensile uplift force on the piles, unless piles are effectively isolated from the surrounding soil by means of a slip layer or sleeve around the pile shaft.

On completion of construction the uplift forces would, to some extent, be counteracted by the applied loads. However, since the full structural loads may well be less than the potential uplift forces the piles would, in the absence of sleeving, need to be sufficiently "anchored" below the desiccated zone to withstand the uplift forces. Adequate reinforcement would need to be provided to accommodate the resulting tension.

On the basis of the above coefficients and a factor of safety of 3, it has been estimated that a 450 mm diameter pile founding at a depth of 15 m below ground level, with a toe level of approximately 97 m OD, should provide a safe working load of about 390 kN. Alternatively, a 450 mm diameter pile founding at a depth of 20 m below ground level (92.0 m OD) should provide an increased safe working load of 630 kN.

The above examples are not intended to constitute any form of recommendation with regard to pile size or type, but merely serve to illustrate the use of the above coefficients. Specialist piling contractors should be consulted with regard to the design of a suitable piling scheme for this site.

8.4 Shallow Excavations

On the basis of the trial pit findings, it is considered likely that it will be feasible to form relatively shallow excavations that extend through the made ground and terminate within the underlying sand without the requirement for lateral support, although localised instabilities may occur from within the made ground. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides will be required in order to comply with normal safety requirements.

Inflows of groundwater into shallow excavations are not generally anticipated, although seepages may be encountered from perched water tables within the made ground, particularly within the vicinity of existing foundations, although such inflows should be suitably controlled by sump pumping.

8.5 Basement Floor Slab

Following the excavation of the proposed basement, it is likely that the basement floor slab will need to be suspended over a void in order to accommodate the likely heave movements, unless the slab can be design such pressures. It is recommended that further analysis is carried out in this respect.

8.6 Effect of Sulphates

Generally low concentrations of total sulphate have been measured in selected soil samples and therefore indicate that buried concrete could be designed in accordance with Class DS-1 conditions of Table C2 of BRE Special Digest 1: SD1 Third Edition (2005). The measured pH conditions are near neutral and therefore on the basis of static groundwater conditions being assumed for buried concrete an ACEC classification of AC-1s may be adopted.

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

8.7 Site Specific Risk Assessment

The chemical analyses have not encountered any elevated concentrations of the contaminants tested and on the basis that the site has not had a contaminative history, remediation, in order to protect future end users, will not be required.

8.8 Waste Disposal

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE guidance[7], 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[8], would qualify for the 'lower rate' of landfill tax.

Based upon on the technical guidance provided by the Environment Agency[9] it is considered likely that the made ground from this site, as represented by the four chemical analyses carried out, would be classified as NON-HAZARDOUS waste under the waste code 17 05 04 (soils and stones not containing dangerous substances) and would be taxable at the standard rate. It is likely that the natural soils, if separated out, could be classified as an INERT waste also under the waste code 17 05 04. This material would be taxable at the lower rate, if accurately described as naturally occurring clay in terms of the 2011 Order on the waste

7 CL:AIRE (2011) *The Definition of Waste: Development Industry Code of Practice* Version 2, March 2011
8 *Landfill Tax (Qualifying Material) Order 2011*
9 Environment Agency (2008) *Hazardous Waste: Interpretation of the definition and classification of hazardous waste. Technical Guidance* WM2 Second Edition Version 2.2, May 2008

transfer note. As the site has never been developed or 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[10] 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" on site by sufficiently characterising the soils insitu prior to excavation.

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

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

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

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
The site is underlain by an aquifer	The investigation has confirmed that the site is underlain by the Secondary 'A' Aquifer of the Claygate Member.
The basement extending below the water table	On the basis of the findings of the investigation the proposed basement will not be located below the measured groundwater level and will not have an effect on the local hydrogeology.

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

Does the existing site include slopes, natural or manmade, greater than 7°?	The site includes natural slopes greater than 7°. Such natural and manmade slopes are more prone to slope failure, however it should be noted that this is based on case studies of slopes within the London Clay, which is not the shallowest geology at this site. It should also be noted that the slopes of such angles are present downslope from the proposed development, which is being constructed on a level plateaux, in an area that has been previously developed. The basement excavation is not expected to have an effect on the stability of existing slopes or introduce new slopes of 7° or greater.
Is the site within a wilder hillside setting in which the general slope is greater than 7°?	The hillside setting of which the site forms part of, includes slopes of 7° and greater, although this is an extensive hillside setting and slopes of such angles are only present downslope from the proposed basement excavation, which will therefore not have an effect on the stability of the wider hillside setting.

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.

Site is underlain by an aquifer and the basement extending below groundwater

The current development proposal includes the excavation of a basement to a level of 105.00 m OD. The formation level of the final basement will therefore be in the Claygate Member, approximately 7.00 m below ground level.

Where the construction of a basement intercepts the groundwater table, groundwater will be diverted around the basement structure. The effect that this will have on groundwater flow will be largely governed by several factors, including the gradient of the local topography and thus the groundwater level contours, the permeability of the underlying geology and the shape and orientation of the basement structure compared to the local topography and groundwater flow direction. These factors may lead to a rise in the upstream groundwater level and reduction in downstream groundwater level, which has the potential to affect the local hydrogeology and sensitive features, such as springs and wells. The increase in hydraulic gradient as result of these groundwater level fluctuations, may also give rise to higher flow velocities at the sides of the basement structure, which could result in the subsurface erosion or piping of loose sandy material. This could cause a loss of material from around and below foundations of adjacent properties and therefore cause instability. All of these factors should be considered in assessing the likely effect of the proposed basement structure on the hydrogeological setting.

Groundwater has been recorded at levels of between 103.31 m OD and 102.35 m OD, approximately 3.00 m below proposed formation level. On this basis the basement excavation will not encounter the groundwater table. However, seasonal variations in groundwater level do occur and therefore it is recommended that further monitoring is carried out in order to establish equilibrium levels, although it should be noted that this investigation and subsequent groundwater monitoring has been carried out during one of the wettest summers on record. Groundwater level would therefore not be expected to rise significantly. In the aforementioned Guidance for Subterranean Development prepared by Arup on behalf of the London Borough of Camden, it is noted that groundwater table variations in the area are generally only in the order of a few tens of centimetres throughout the year. This has been confirmed by GEA investigations in the Hampstead area, in which groundwater monitoring has been carried out during 2011 and 2012. Although 2011 was a notably very dry year, whilst, as stated above, the summer of this year has been one of the wettest summers on record, the monitoring showed a maximum variation in groundwater level of 19 cm over the two years. On the basis of the all the above, groundwater would be expected to remain well below the level of the basement.

In addition to the above, consideration should be given to the position of the site in relation to the surrounding hillside setting. The site is located at the crest of the hill and as indicated by the desk study research into the hydrogeological setting, groundwater flow is in a southerly direction towards the areas of greater catchment, which are marked by the Highgate and Hampstead Ponds. In addition, springs lines close to the site provide further evidence of the depth to the groundwater table, which is well below the depth of the proposed basement. On this basis and on the basis that the nearest developments to the proposed buildings are over 100 m, the proposed structure will not affect the local hydrogeological setting, such that it will not cause an increase in groundwater levels on the upstream side and should have no effect on neighbouring properties.

It is however recommended that suitable measures are incorporated to deal with any surface run-off. Such measures would in any case form part of the design of the basement in order to maintain required conditions, as detailed in BS 8102:2009.

The current proposals will not significantly increase the proportion of hard surfaced areas on the site and therefore the volume of surface water inflow from surface run-off is unlikely to change due to the proposed development. The desk study research has indicated that the site is not within close proximity of the Hampstead Ponds and nor is it located in close proximity to an existing or historical water course. Therefore the site is not at risk from flooding and in particular the site is not located within an area at risk from surface water flooding. On this basis a flood risk assessment should not be required.

The site includes slopes of greater than 7° is in a wider hillside setting with slopes of greater than 7°

The site and the wider hillside setting of Hampstead Heath and Highgate Hill included natural slopes of greater than 7°. Slopes of such gradients may be susceptible to natural slope failure or induced slope failure, due to increased loading, modification or de-vegetating of the slope. The area of the proposed development is however on a level plateau, above the sloping parts of the site. The excavation will therefore not have a detrimental effect on the stability of the slopes. In addition, the slopes are well vegetated, show no signs of instability and have not been reported as suffering slope failure in the past. Furthermore, the proposed development is not within 100 m of neighbouring structures and therefore the basement excavation will not be below existing foundations of other structures and as such the proposed development will not have an effect on slope stability or the stability of neighbouring buildings. A slope stability analysis is not considered to be required.

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 may 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.

Continued monitoring of the standpipes installed in the boreholes is essential to allow equilibrium groundwater levels to be established and the magnitude of any seasonal variations in level to be determined. In view of the depth of the proposed basement excavation, it is recommended that further analysis is carried out on likely heave movements, associated with the basement excavation.

These limited areas of risk should be drawn to the attention of prospective contractors and sufficient contingency should be provided to cover the outstanding risk.

APPENDIX

Borehole Records

SPT Summary Sheet

Trial Pit Records

Geotechnical Test Results

SPT & Cohesion/ Level Graph

Chemical Analyses (Soil)

Generic Risk Based Screening Values

Envirocheck Extracts

Historical Maps

Site Plan

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