DESK STUDY & BASEMENT IMPACT ASSESSMENT REPORT

41 Frognal
London
NW3 6YD

Client: BTP Group

Engineer: Elliott Wood

J15019

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Geotechnical & Environmental Associates

Document Control

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EXECUTIVE SUMMARY

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

BRIEF

This report describes the findings of a site investigation by Geotechnical and Environmental Associates Limited (GEA) on the instructions of Elliot Wood, on behalf of BTP Group, with respect to the proposed extension of the existing building, including a new single basement beneath part of the footprint of the existing house. The purpose of the investigation has been to research the history of the site with respect to possible contaminative uses, to determine the ground conditions and hydrogeology, to assess the extent of any contamination and to provide information to assist with the design of the basement structure and suitable foundations for the proposed development. The report also includes information required to comply with London Borough of Camden (LBC) Planning Guidance CPG4, relating to the requirement for a Basement Impact Assessment (BIA).

DESK STUDY FINDINGS

The earliest map studied, dated 1871, shows the site to be located in an area of fields that appear to be associated with a property to the northwest, which is annotated as The Priory. A stream is shown approximately 50 m to the east of the site, which is thought to be a tributary of the River Westbourne, one of London's 'Lost Rivers'. Between 1871 and 1896, the area became more developed, with the construction of residential streets, whilst the site was developed with an irregular shaped property positioned in the middle of the site and set back from Frognal, which was also constructed during this time. By 1915, University College School had been constructed on the opposite side of Frognal to the northeast and from that time to the present day, the surrounding area remained essentially unchanged. The building occupying the site however was demolished and replaced with the existing building some time between 1955 and 1970, and the site has since remained essentially unaltered.

GROUND CONDITIONS

Beneath a variable thickness of made ground, London Clay was encountered and proved to the maximum depth investigated of 20.00 m (64.40 m OD). The made ground extended to depths of between 0.70 m and 2.30 m and generally comprised dark greyish brown sandy clay with gravel, concrete and brick fragments. Below the made ground, the London Clay initially comprised an upper weathered horizon of firm becoming stiff fissured high strength brown clay with occasional partings of grey silt to a depth of between 8.70 m (79.50 m OD) and 10.80 m (76.94 m OD). Below these depths, stiff, becoming very stiff, fissured very high strength silty clay with occasional partings of grey fine sand and silt, was proved to the maximum depth investigated of 20.00 m (64.40 m OD). Borehole No 02 was advanced in close proximity to mature deciduous trees within the front garden and the initial horizon was noted as containing roots to a depth of 3.60 m (80.80 m OD) and was assessed as being desiccated. Subsequent laboratory inspection of this soil and the results of laboratory plasticity index tests have confirmed that the soil is desiccated to a depth of approximately 3.00 m (79.80 m OD).

Groundwater was not encountered during the drilling of the boreholes, although was subsequently measured at depths of 1.23 m (83.17 m OD) and 2.18 m (85.56 m OD) in two of the standpipes on a single occasion. The contamination test results have revealed an elevated US^{95} value for lead.

RECOMMENDATIONS

It is anticipated that the proposed basement will extend to approximately 4.50 m below existing ground floor level and will result in a formation level in the firm London Clay. Based on groundwater monitoring to date, groundwater inflows are expected to be encountered in the basement excavation, although the rate of inflow may not be significant. The most appropriate method of constructing the basement retaining walls is likely to be through the combination of traditional mass concrete underpinning below the existing house and a bored pile wall where the basement extends out below the front garden.

New spread foundations excavated from below basement level may be designed to apply a net allowable bearing pressure of 120 kN/m^2 below the level of the proposed basement floor. Alternatively, consideration may be given to piled foundations.

The proposed development is unlikely to result in any specific groundwater or land stability issues and a requirement for a flood risk assessment has not been identified.

Part 1: INVESTIGATION REPORT

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

1.0 INTRODUCTION

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by Elliott Wood, on behalf of BTP Group, to carry out a desk study and ground investigation at 41 Frognal, Hampstead, London NW3 6YD. 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.

1.1 Proposed Development

It is understood that it is proposed to refurbish the existing property, which will include the construction of an additional storey and an extension to the front of the property. It is proposed to construct a basement level below the new extension, which will also extend beneath the southern end of the existing house. Due to the sloping nature of the front of the site, the basement level will exit at approximately the same level as existing ground level.

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

1.2 Purpose of Work

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

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

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

- two cable percussion boreholes advanced to a depth of 20.00 m, by means of a standard drilling rig;
- an additional borehole advanced to a depth of 10.45 m using an opendrive percussive sampler;
- 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 a depth of 6.00 m and two subsequent monitoring visits;
- manual excavation of four trial pits around the perimeter of the existing building to determine the configuration and bearing stratum of 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 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

The work carried out also 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 Arup Report'). The aim of the work is to provide information on surface water, groundwater and land stability and in particular to assess whether the development will affect 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

1.3.2 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 surface water and flooding assessment has been carried out by Rupert Evans, a hydrologist with more than ten years consultancy experience in flood risk assessment, surface water drainage schemes and hydrology / hydraulic modelling. Rupert Evans is a Chartered Environmentalist, Chartered Water and Environmental Manager and a Member of CIWEM.

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 over 25 years' experience in geotechnical engineering and engineering geology.

All assessors meet the qualification requirements of the Council guidance.

1.4 Limitations

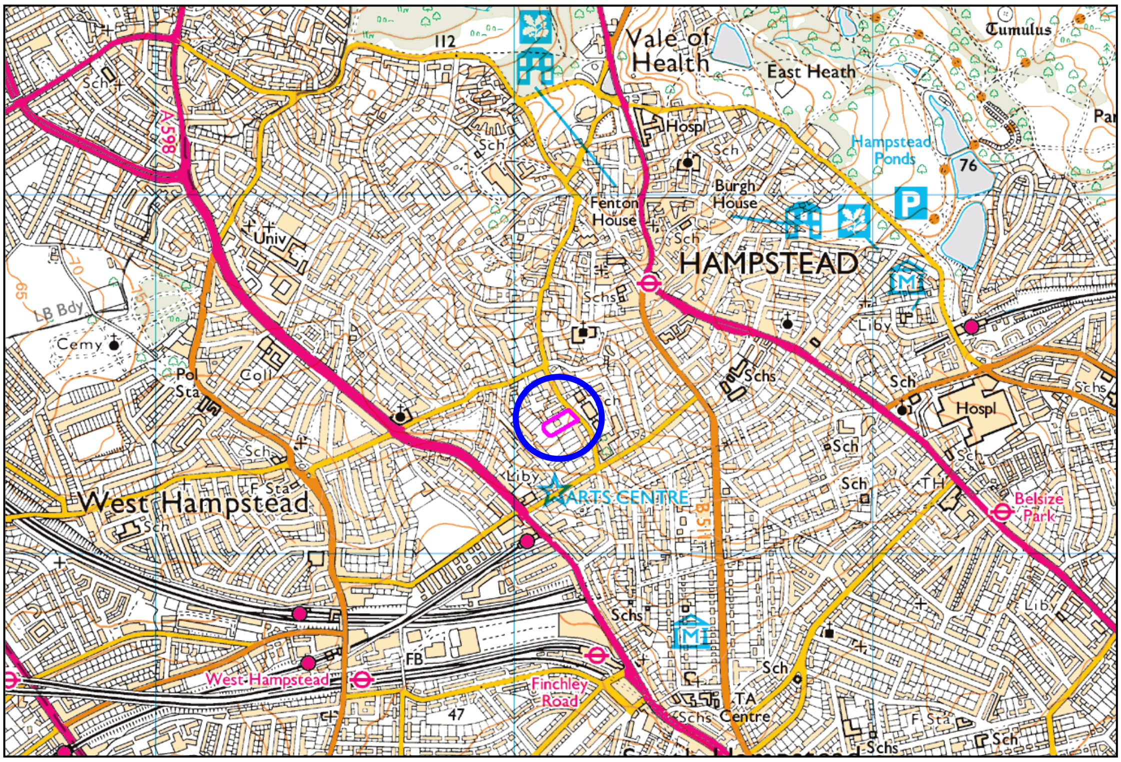
The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, 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 the London Borough of Camden, in a mainly residential area, located approximately 300 m to the northeast of Finchley Road and Frognal railway station and approximately 430 m southwest of Hampstead London Underground station. It is roughly rectangular in shape, measuring approximately 90 m northeast-southwest by 40 m northwest-southeast, fronting onto Frognal to the northeast and is bordered on all other sides by residential properties and associated gardens. The site may additionally be located by National Grid Reference 526151,185370 and is shown on the map extract overleaf.

The site is occupied by a two-storey detached house positioned in the centre of the site, with the remainder of the site occupied by a front and rear garden. The front garden is essentially soft landscaped with a number of deciduous trees of up to 20 m in height, although a tarmac driveway leads from Frognal up to a tarmac parking area in front of the house. The rear garden is also mainly soft landscaped with central lawn surrounded by planted borders and a densely vegetated area along the southwestern boundary of the site that includes a number of deciduous trees of up to 22 m in height. Tree species have been tentatively identified as including maple, beech, willow, lime and London plane, although a number of trees had been felled at the time of the investigation. The rear garden also includes a swimming pool with paved surroundings.



The site generally slopes up to the southwest, with the house at a level of approximately 4.0 m above road level, while the southwestern boundary is approximately 2.5 m above the level of the house, which has been constructed on a level plateau. The maximum slope angle is at the front of the site from the house down to the road, with a gradient of approximately 6º. The surrounding area also slopes up to the north. The site is not shown on Figure 16 of the Arup Report to be within an area of critical slope angles of greater than 7º or within an area of landslide potential, as shown by Figure 17 of the same report.

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, shows the site to be located in an area of fields that appear to have been associated with a property to the northwest, which is annotated as The Priory. A stream is shown approximately 50 m to the east of the site, which is thought to be a tributary of the River Westbourne, one of London's 'Lost Rivers'. Between 1871 and 1896, the area became more developed with the construction of residential streets, whilst the site was developed with an irregular shaped property positioned in the middle of the site and set back from Frognal, which was also constructed during this time. By 1915, University College School had been constructed on the opposite side of Frognal to the northeast and from that time to the present day, the surrounding area remained essentially unchanged. The building occupying the site however was demolished and replaced with the existing building at some time between 1955 and 1970, and the site has since remained essentially unaltered.

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 been no pollution incidents to controlled waters within 1 km of the site.

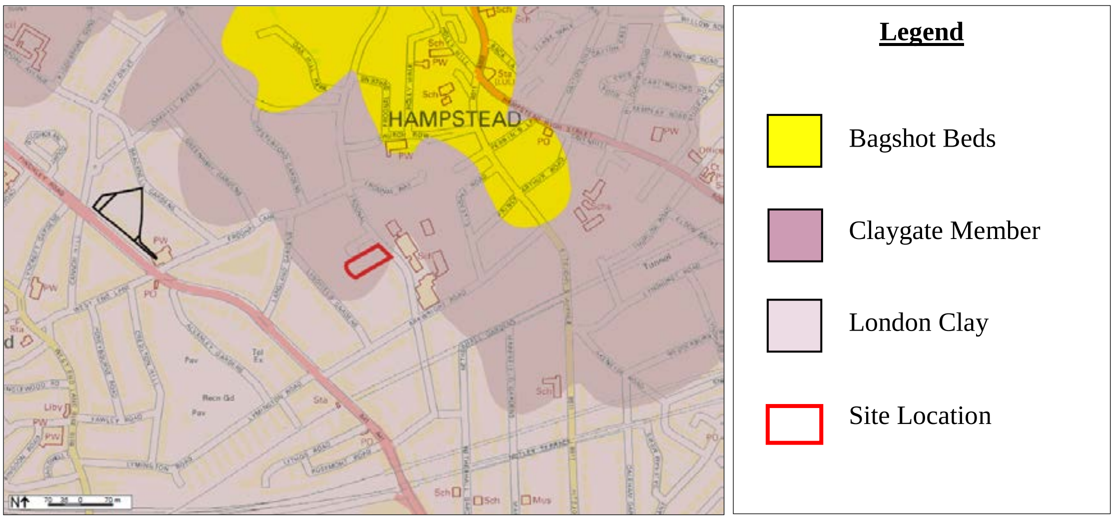
The search has indicated that the site is located in an area where less than 1% of homes are affected by radon emissions; which is the lowest classification given by the Health Protection Agency (HPA) and therefore no radon protective measures will be necessary.

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

There are no listed fuel stations within 250 m of the site.

2.4 Geology

The British Geological Survey (BGS) map of the area (Sheet 256) indicates the site to be underlain by the Claygate Member of the London Clay Formation, as shown by the digital geological map extract below.



The map extract also indicates that the site is located close to the boundary with the underlying London Clay, which is present directly beyond the southeastern boundary 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. With reference to the geological map and topographical map of the area, the boundary between the Claygate Member and the upper unit of the London Clay is shown at a level of between approximately 80 m OD and 85 m OD, and therefore may actually cross the lower parts of the site. The boundary between the Claygate Member and overlying Bagshot Beds is located approximately 250 m to the northeast of the site, at a level of approximately 105 m OD.

The aforementioned anticipated ground conditions have been confirmed by a number of previous GEA investigations carried out about 50 m and 200 m of the site, with the Claygate Member extending to either the maximum level investigated, of 90.52 m OD, or to levels of between 79.7 m OD and 84.40 m OD. One of the nearby investigations was carried out within the grounds of University College School, on the opposite side of Frognal, and encountered a thickness of Alluvium, associated with the former course of the Westbourne, to depths of between 3.10 m (77.33 m OD) and 6.45 m (73.89 m OD), whereupon the London Clay was encountered and extended to the maximum depth investigated, of 20.00 m (62.00 m OD).

The Claygate Member is described in the geological memoir as typically comprising interbedded fine grained sand, silt and clay, whilst the underlying 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.

According to the BGS Sheet 256, dated 2006, the site is within an area also shown as having a “Head Propensity”. Head propensity is shown on the BGS map as areas denoted as most likely to be covered by Quaternary Head Deposits as interpreted from digital slope analysis and confirmed by borehole data. These deposits are not mapped and have not been verified by fieldwork. These deposits are noted as having properties similar to that of the London Clay and are shown to occur close to the boundary with the overlying Claygate Member.

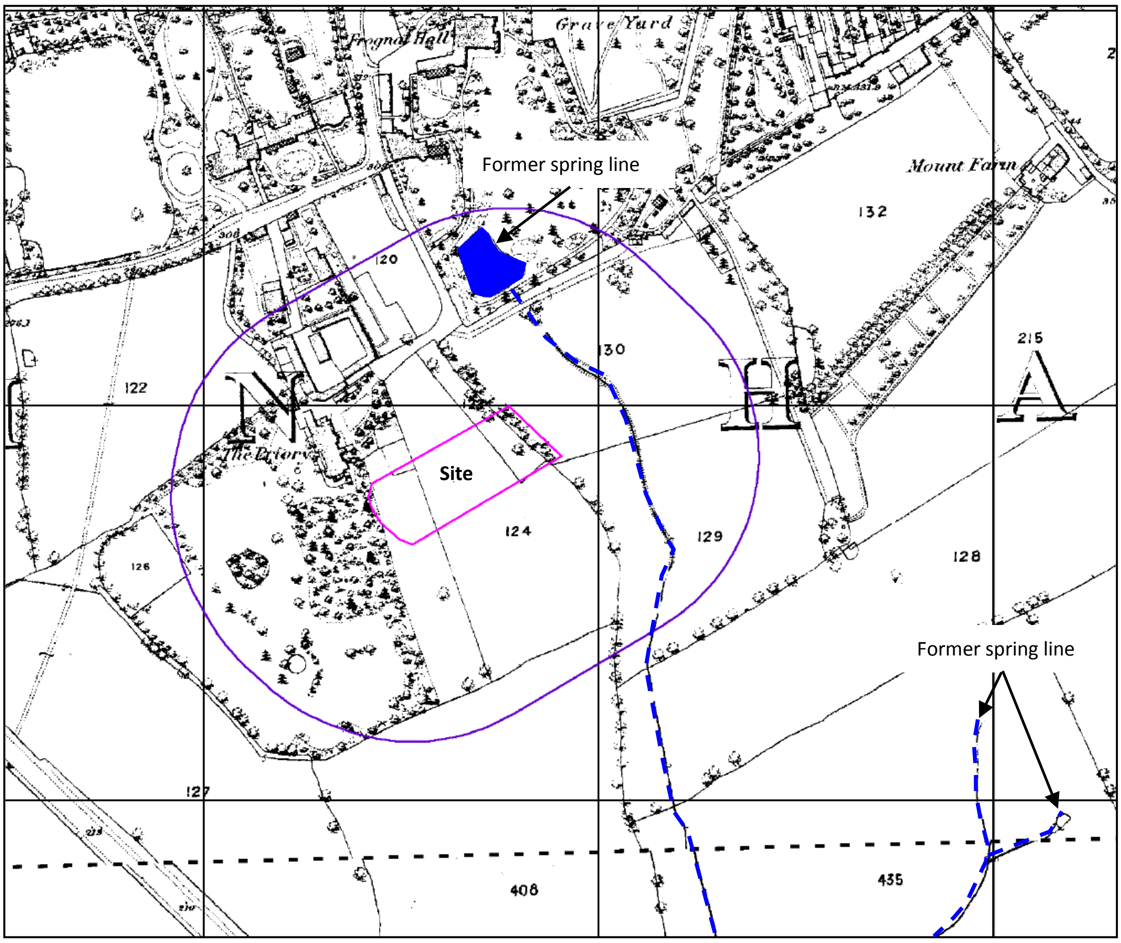
2.5 Hydrology and Hydrogeology

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 underlying London Clay is classified as a Non-Aquifer and Unproductive Stratum, which refers to a soil or rock with low permeability that has a negligible effect on local water supply or river base flow.

There are no EA designated Source Protection Zones (SPZs) on the site and there are no listed water abstraction points within 1 km of the site. The Envirocheck report indicates that there is no surface water feature located within 1 km of the site, which therefore lies outside the catchment of the Hampstead Heath chain of ponds. The site is not located in an area at risk of flooding from rivers or sea, as defined by the EA and although Frognal is listed as having suffered from surface water flooding in 2002 within a London Borough of Camden report[4], the site is not shown on Figure 5 of the Arup Report as being in an area with the potential to be at risk from surface water flooding.

Existing and historical spring lines are present at the interface of these strata, as well as 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. Historically a tributary of the Westbourne River[5] issued from a pond approximately 100 m to the north of the site and flowed in a roughly southerly direction, approximately 50 m to the east of the site, on the opposite side of Frognal. The river crossed Finchley Road heading south towards Kilburn and Paddington and then into the Serpentine in Hyde Park. Today the Westbourne is entirely covered and culverted and forms part of the surface water sewerage system, running beneath South Hampstead and discharges into the Thames to the west of Chelsea Bridge. The location of the river is shown on an extract of the historical map dated 1879 below, which also shows the location of an additional spring line to a former tributary of the Westbourne approximately 300 m to the southeast of the site.

4 London Borough of Camden (2003) *Floods in Camden, Report of the Floods Scrutiny Panel*
5 Nicholas Barton (2000) *London’s Lost Rivers.* Historical Publications Ltd



Given the location of the headwater of the Westbourne, it is likely that it was formed by springs issuing from within the interface of the Claygate Member and the underlying less permeable London Clay.

The Claygate Member is predominantly cohesive in nature and therefore groundwater flow is likely to be relatively slow, although horizons of more sandier 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.

Groundwater was recorded in the aforementioned GEA investigations at depths of between approximately 3.00 m and 5.00 m.

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 desk study research has indicated that the site has only been occupied by residential properties, with the existing residential property occupying the site since 1966. The site is therefore not considered to have had a contaminative history and no specific possible sources of contamination have been identified on the site, or within the immediate surrounding area, which comprises of residential streets.

2.6.2 Receptor

The continued use of the site as a residential dwelling represents a relatively high sensitivity end-use and end users are considered to be sensitive receptors. As the site is underlain by a Secondary 'A' Aquifer, groundwater is considered to be a moderate sensitive receptor. Site workers will come into contact with underlying soils during the construction phase, as will new buried services and both are therefore considered to be sensitive receptors. Neighbouring sites would also be considered to be moderately sensitive receptors.

2.6.3 Pathway

Below the existing house, surrounding areas of hardstanding and the proposed basement structure and new extension, end users will effectively be isolated from the underlying soils. The front and rear soft landscaped gardens are however to remain and therefore in these areas a pathway by which end users can come into direct contact with the underlying soils will exist. Groundwater within the Secondary 'A' Aquifer is considered to be a potential pathway by which any soluble contaminants may migrate off and onto to the site, although this pathway is already in existence. 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 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 Subterranean (groundwater) Screening Assessment

Question	Response for 41 Frognal
1a. Is the site located directly above an aquifer?	Yes, a Secondary 'A' Aquifer.
1b. Will the proposed basement extend beneath the water table surface?	Possible.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	The site is approximately 100 m to the southwest of a likely spring to the Former River Westbourne.
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. it is proposed to keep the proportion of hardstanding roughly the same
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. Run-off from hardstanding will drain to the sewer system, as it does currently.
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 the Claygate Member, which is a Secondary 'A' Aquifer.

Q1b There is a possibility that the proposed basement may extend beneath the water table.

Q2 The site is approximately 100 m southwest of what is thought to be a spring line to the former River Westbourne.

3.1.2 Stability Screening Assessment

Question	Response for 41 Frognal
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. A number of trees have been recently felled.*
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.*

Question	Response for 41 Frognal
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. Frognal and the associated footway is parallel to the northeastern boundary.
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, e.g. railway lines?	No.

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

Q6 It is understood the proposal will fell some of the existing trees, with a number of trees recently felled.
Q10 The site is located within the Secondary 'A' Aquifer of the Claygate Member.
Q12 Frognal runs parallel to the northeastern boundary of the site.

3.1.3 Surface Flow and Flooding Screening Assessment

Question	Response for 41 Frognal
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. There will not be an increase in impermeable area across the ground surface above the basement. There will be no surface expression of the basement development, so the surface water flow regime will be unchanged. The basement will be located under the existing buildings and hardstanding areas and therefore the ground surface above the basement will not change and will remain as hardstanding. This will ensure no increase in runoff rate or volume as a result of the proposed basement construction. The basement will be entirely beneath the footprint of the existing buildings and surrounding hard standing areas and therefore the 1m distance between the roof of the basement and ground surface as recommended by the Arup report.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	No. There will not be an increase in impermeable area across the ground surface above the basement.
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. There will not be an increase in impermeable area across the ground surface above the basement. The basement will be entirely beneath the footprint of the existing buildings and existing hardstanding areas therefore the 1m distance between the roof of the basement and ground surface as recommended by the Arup report does not generally apply.
5. Will the proposed basement result in changes to the quantity of surface water being received by adjacent properties or downstream watercourses?	
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 Camden Flood Risk Management Strategy dated 2013, North London Strategic Flood Risk Assessment dated 2008, and Environment Agency online flood maps show that the site has a low flooding risk from surface water, sewers, reservoirs (and other artificial sources), groundwater and fluvial/tidal watercourses. The site is located within the Critical Drainage Area number GROUP3-010 3015 as identified in the Camden SWMP.

The above assessment has not identified any potential issues that need further assessment, although the hydrological setting is discussed further within this report.

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 by the screening process

Potential Impact	Consequence
The site is located directly above an aquifer	The site is underlain by the Claygate Member, 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.
The proposed basement extends beneath the water table surface	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.
Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	The site is approximately 100 m southwest of a spring line to the former River Westbourne, with the former course of river located approximately 50 m to the east of the site. Whilst these features may indicate a shallow groundwater table and may also pose a risk to the site from flooding, the site is located topographically below the level of the spring line, but topographically above the river course. Furthermore, the site is not shown to be an area at risk of flooding and therefore this is not considered to be an issue to the site or the proposed development.
Is the site located within 5 m of a public highway or pedestrian right of way?	The public walkway of Frognal borders the site to the northeast and the excavation of a basement can cause instability of such structures. However the proposed basement excavation is actually over 5 m away from the footway.
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?	Trees and other vegetation can be detrimental to the stability of existing and proposed slopes, in that large scale de-vegetation of slopes can cause slope failure and thus cause damage to the existing / proposed and surrounding structures. The removal of established trees may also cause heave of underlying clay soils, which could result in damage to the proposed development and neighbouring structures with foundations within the zone of influence of the trees being removed.

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

4.2 Exploratory Work

Access to the rear of the property was limited by the presence of the existing house. Therefore, in order to meet the objectives described in Section 1.2, as far as possible within the access restrictions, two cable percussion boreholes were drilled within the front garden to a depth of 20.00 m using a standard drilling rig, which was supplemented by a 10.45 m deep borehole advanced in the rear garden using an opendrive percussive sampler (Terrier rig). Standard Penetration Tests (SPTs) were carried out at regular intervals in the boreholes to provide quantitative data on the strength of soils encountered and disturbed and undisturbed samples were recovered from the boreholes for subsequent laboratory examination and testing.

Four trial pits were excavated around the perimeter of the existing buildings as shown on the site plan included in the appendix.

A standpipe was installed in each of the three boreholes to a depth of 6.00 m and these have been monitored on two occasions to date, approximately four weeks and six weeks after installation.

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

The borehole records and results of the laboratory testing are enclosed, together with a site plan indicating the exploratory positions. The Ordnance Datum (OD) level shown on the borehole and trial pit records have been interpolated from spot heights shown on a site survey drawing (ref 12/1674 01, dated July 2012), which was provided by KSR Architects.

4.3 Sampling Strategy

The scope of the works was specified by the consulting engineers, with input from GEA. The borehole positions were specified by the consulting engineers and positioned on site by GEA with due regard to the proposed development, whilst avoiding areas of known services.

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

A single sample of the made ground was 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 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.

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.

A number of samples recovered from the boreholes were submitted to a geotechnical laboratory for a programme of testing that included moisture content and Atterberg limit tests, undrained triaxial compression tests and soluble sulphate and pH level analysis.

5.0 GROUND CONDITIONS

Contrary to what is shown on the geological map, beneath a generally moderate thickness of made ground, London Clay was encountered and proved to the maximum depth investigated of 20.00 m (64.40 m OD). The precise location of the boundary between the Claygate Member and London Clay is often difficult to define due to its gradational contact, and the close similarities in composition and geotechnical properties of each stratum. It is therefore conceivable, but considered unlikely, that part of the material interpreted as London Clay comprises the Claygate Member.

5.1 Made Ground

Beneath a layer of topsoil or tarmac, the made ground generally comprised dark greyish brown and dark brown silty sandy clay or clayey silt with gravel, concrete and brick fragments and roots up to 25 mm diameter, and extended to depths of between 0.33 m and 2.30 m, corresponding to levels of between 87.87 m OD and 85.44 m OD.

No visual or olfactory evidence of contamination was noted in the made ground, however four samples of the made ground have been subject to contamination testing as a precautionary measure and the results are presented in Section 4.4.

5.2` London Clay

The London Clay initially comprised an upper weathered horizon of firm becoming stiff fissured high strength brown clay with occasional partings of grey silt to a depth of between 8.70 m (79.50 m OD) and 10.80 m (76.94 m OD). Below these depths, stiff, becoming very stiff, fissured very high strength silty clay with occasional partings of grey fine sand and silt, was proved to the maximum depth investigated of 20.00 m. (64.40 m OD).

Borehole No 02 was advanced in close proximity of the mature deciduous trees within the front garden and the initial horizon was noted during drilling as containing roots to a depth of 3.60 m (80.80 m OD). Laboratory testing has indicated that the soil is desiccated to a depth of approximately 3.00 m (79.80.00 m OD) and has also indicated the clay to be of high shrinkability with plasticity indices of between 35% and 78 %.

The results of undrained triaxial compression tests indicate the clay to increase in strength with depth from high strength to very high strength and undrained shear strength of 82 kN/m^2 to 148 kN/m^2.

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

5.3 Groundwater

Groundwater was not encountered during drilling of the boreholes, although it was encountered in Trial Pit Nos 2 and 3 around the existing foundations within the made ground on the interface of the underlying London Clay. Monitoring of the standpipes installed in each of the boreholes has been carried out on two occasions over a one month period and the results are shown in the table below.

Borehole No	Standpipe depth(m) [Level (m OD)]	Depth to groundwater [(m) m OD]	
		18/03/2015	3/03/2015
01	6.00 [81.74]	DRY	2.18 [85.56]
02	6.00 [78.40]	DRY	1.23 [83.17]
03	6.00 [82.20]	DRY	DRY

5.4 Soil Contamination

The table below sets out the values measured within four samples of made ground analysed; 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 US95
pH	6.4	4.3	-	-
Arsenic	30	7.8	None	30.6
Cadmium	0.25	<0.10	2	0.2
Chromium	78	49	None	73.6
Copper	52	12	None	50.5
Mercury	1.2	<0.10	2	1.0
Nickel	39	18	None	39.5
Lead	**390**	17	None	**343.2**
Selenium	0.68	<0.2	2	0.6
Zinc	140	43	None	136.9
Total Cyanide	<0.5	<0.5	All	<0.5
Total Phenols	<0.3	<0.3	All	<0.3
Sulphide	1.7	1.4	None	1.7
Total TPH	14	<2	1	<10
Naphthalene	2.4	<0.1	1	2.5
Benzo(a)pyrene	0.56	<0.1	1	0.5
Total PAH	14	<2	1	15.5
Total organic carbon %	2.6	1.7	None	2.4

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