3.0 Site Investigation

SITE INVESTIGATION & BASEMENT IMPACT ASSESSMENT REPORT

Wallace House
Fitzroy Park
London

Client: Derrick and Claire Dale

Engineer: Elliott Wood

J17111

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GEA

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This report is intended as a Ground Investigation Report (GIR) as defined in BS EN1997-2, unless specifically noted otherwise. The report is not a Geotechnical Design Report (GDR) as defined in EN1997-2 and recommendations made within this report are for guidance only.

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Part 3: GROUND MOVEMENT ASSESSMENT

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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 Elliott Wood, on behalf of Derrick and Claire Dale. It is understood that it is proposed to construct a single-storey extension to the existing pool house building and to construct a new two-storey structure, with a basement extending to a depth of 2.80 m (80.84 m OD), in place of the existing single storey garage. 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 suitable foundations and retaining walls. The report also includes information required to comply with the London Borough of Camden (LBC) Planning Guidance CPG4, relating to the requirement for a Basement Impact Assessment (BIA), including a ground movement assessment.

DESK STUDY FINDINGS

The desk study research has indicated that the site was already developed by 1870 with a square building, of unknown but presumably residential use. By 1896, the footprint of the building had changed and an outbuilding had been constructed along the northern boundary. By 1935, another outbuilding had been constructed to the east of the site. From 1952, the main building was labelled as "Lodge", and from 1975 this building was labelled as "The Bungalow". Between 1991 and 1999 the buildings were demolished and replaced with the existing house. The desk study has not indicated any potential sources of soil gas that could affect the site.

GROUND CONDITIONS

The investigation generally encountered the expected ground conditions in that, beneath a moderate thickness of made ground, London Clay was found to the full depth investigated, although suspected Head Deposits were locally encountered overlying the London Clay. The made ground extended to depths of between 0.82 m and 1.30 m (80.58 m OD and 81.90 m OD). Directly beneath the made ground in Borehole Nos 2 and 3, suspected Head Deposits were encountered and generally comprised soft orange-brown mottled grey silty clay or firm brown or brown mottled grey silty clay, with a reworked texture; this material extended to depths of between 2.00 m and 2.70 m (81.40 m OD and 78.70 m OD) where encountered. The London Clay was found to comprise firm becoming stiff medium strength becoming high strength fissured brown mottled grey silty clay with occasional fine selenite crystals, and extended to a depth of between 7.45 m and 11.00 m (75.95 m OD and 72.20 m OD). Below this, stiff fissured high strength grey silty clay was encountered and proved to a depth of 15.00 m (68.20 m OD). Silt horizons were encountered in Borehole Nos 2 and 3 at depths of 7.23 m and 6.30 m respectively (76.17 m OD and 75.10 m OD). Groundwater was encountered during drilling within silt pockets in Borehole Nos 2 and 3, at depths of 6.20 m and 7.20 m, (75.20 m OD and 76.20 m OD) respectively. Monitoring of standpipes has subsequently been undertaken on five occasions over a period of roughly seven weeks and water has been measured in the pipes at depths of between 0.84 m and 5.55 m (82.36 m OD and 77.77 m OD). Contamination testing has revealed elevated concentrations of lead and asbestos in the made ground.

RECOMMENDATIONS

The excavation of the 2.8 m (80.84 m OD) deep basement will result in a formation level in either the Head Deposits or London Clay. Significant groundwater inflows are not anticipated and it should be possible to adopt spread foundations constructed from basement level. New spread foundations may be designed to apply a net allowable bearing pressure of 120 kN/m² below the level of the proposed basement floor, provided that any potentially desiccated clay soils can be bypassed. It is understood that piles are proposed to support the new extensions, which would provide a suitable foundation solution. Care should be taken at all times to ensure the stability of neighbouring properties and the existing foundations will need to be underpinned prior to basement excavation or supported by new retaining walls. Site workers should adopt suitable precautions with regard to the lead and asbestos contamination. It may be prudent to carry out additional testing to ensure the absence of any widespread contamination.

BASEMENT IMPACT ASSESSMENT

The BIA has not indicated any concerns with regard to the effects of the proposed basement on the site and surrounding area. It has been concluded that the impacts identified can be mitigated by appropriate design and standard construction practice.

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 of this report and Part 3 comprises a Ground Movement Assessment.

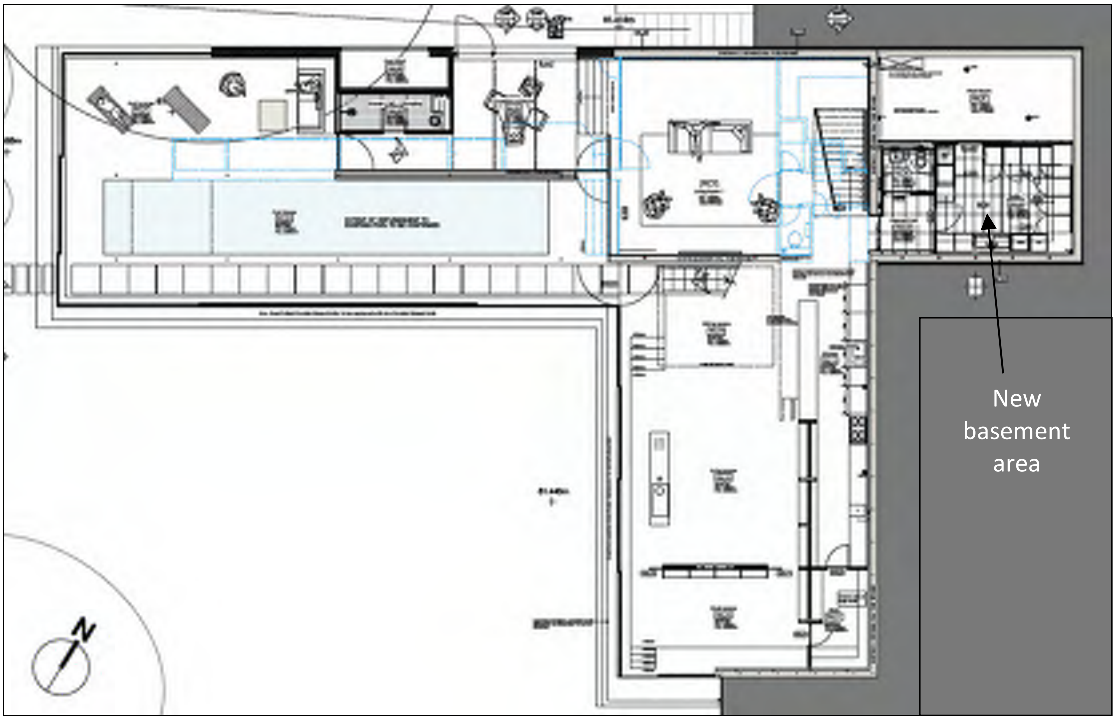
1.0 INTRODUCTION

Geotechnical and Environmental Associates Limited (GEA) has been commissioned by Elliott Wood, on behalf of Derrick and Claire Dale, to carry out a desk study and ground investigation at Wallace House, Fitzroy Park, London, N6 6HT. 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. In addition, a ground movement analysis and building damage assessment has been completed.

1.1 Proposed Development

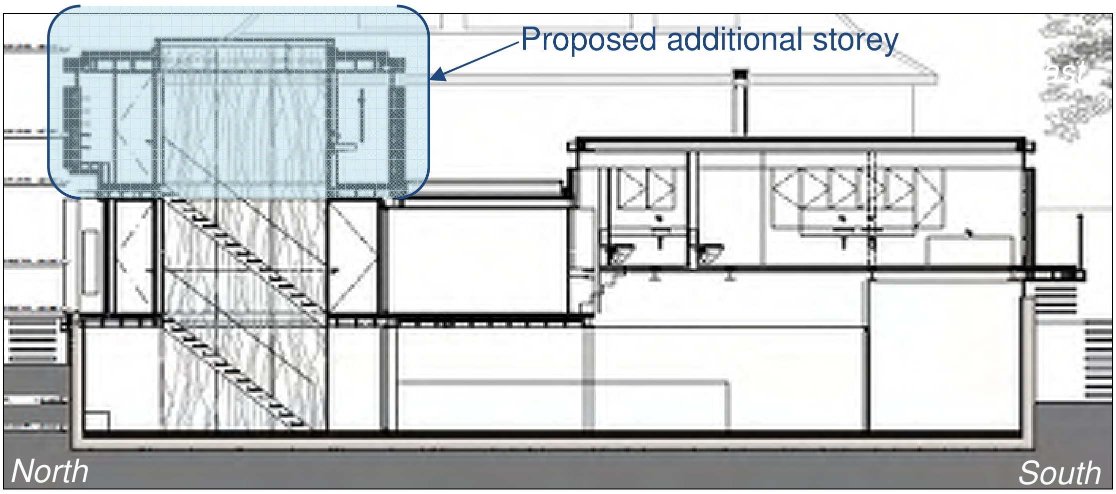
It is understood that it is proposed to construct a single storey extension along the northern elevation of the existing pool house building and to replace the existing single-storey garage with a two-storey building with a single level basement, extending to a depth of roughly 2.80 m (80.84 m OD).

A plan showing the proposed layout overlaying the existing development is shown below (drawing ref; 100, revision 00, by SOUP, dated Nov 2016), provided by the consulting engineers.



Plan showing proposed site layout with the existing site layout highlighted in blue

A section through the proposed development is shown overleaf.



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 assess the level of risk from Unexploded Ordnance (UXO);
- to determine the ground conditions and their engineering properties;
- to determine the configuration of the existing foundations;
- to assess the impact of the proposed basement on the local hydrogeology, hydrology and stability of the surrounding natural and built environment;
- 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;
- to assess the risk that any such contamination may pose to the proposed development, its users or the wider environment; and
- to assess the ground movements caused by excavation of the proposed basement and the level of damage to the surrounding structures.

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 preliminary Unexploded Ordnance (UXO) risk assessment, commissioned by GEA and carried out by 1st Line Defence (ref EP4796-00, issue 1, dated 8 May 2017); and

- a review of historical Ordnance Survey (OS) maps and environmental searches sourced from the Envirocheck database.

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

- a single cable percussion borehole advanced to a depth of 15.00 m on the driveway;
- two open-drive sampler boreholes advanced to a depth of 7.45 m;
- standard penetration tests (SPTs), carried out at regular intervals in the boreholes to provide quantitative data on the strength of the soils;
- installation of three groundwater monitoring standpipes to depths of 5.00 m and 6.00 m and five subsequent monitoring visits, over a period of roughly seven weeks;
- rising head tests carried out in the standpipes at the time of the second monitoring visit;
- seven hand-dug trial pits, excavated to a maximum depth of 1.00 m, in order to determine the configuration of the existing foundations;
- laboratory testing of selected soil samples for geotechnical purposes and for the presence of contamination;
- a ground movement analysis and building damage assessment; 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 exploratory methods adopted in this investigation have been selected on the basis of the constraints of the site including but not limited to access and space limitations, together with any budgetary or timing constraints. Where it has not been possible to reasonably use an EC7 compliant investigation technique a practical alternative has been adopted to obtain indicative soil parameters and any interpretation is based upon engineering experience, local precedent where applicable and relevant published information.

1.3.1 Basement Impact Assessment

The work carried out includes a Hydrological and Hydrogeological Assessment and Land Stability Assessment (also referred to as Slope Stability Assessment), all of which form part of the BIA procedure specified in the London Borough of Camden (LBC) Planning Guidance CPG4[2] and their Guidance for Subterranean Development[3] prepared by Arup (the "Arup report"). The aim of the work is to provide information on surface water, groundwater and

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

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.

1.3.2 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 of London (FGS) who has over 25 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 some 30 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 research carried out. The results of the research should be viewed in the context of the work that has been carried out and no liability can be accepted for matters outside the stated scope of the research. Any comments made on the basis of information obtained from third parties are given in good faith on the assumption that the information is accurate. No independent validation of third party information has been made by GEA.

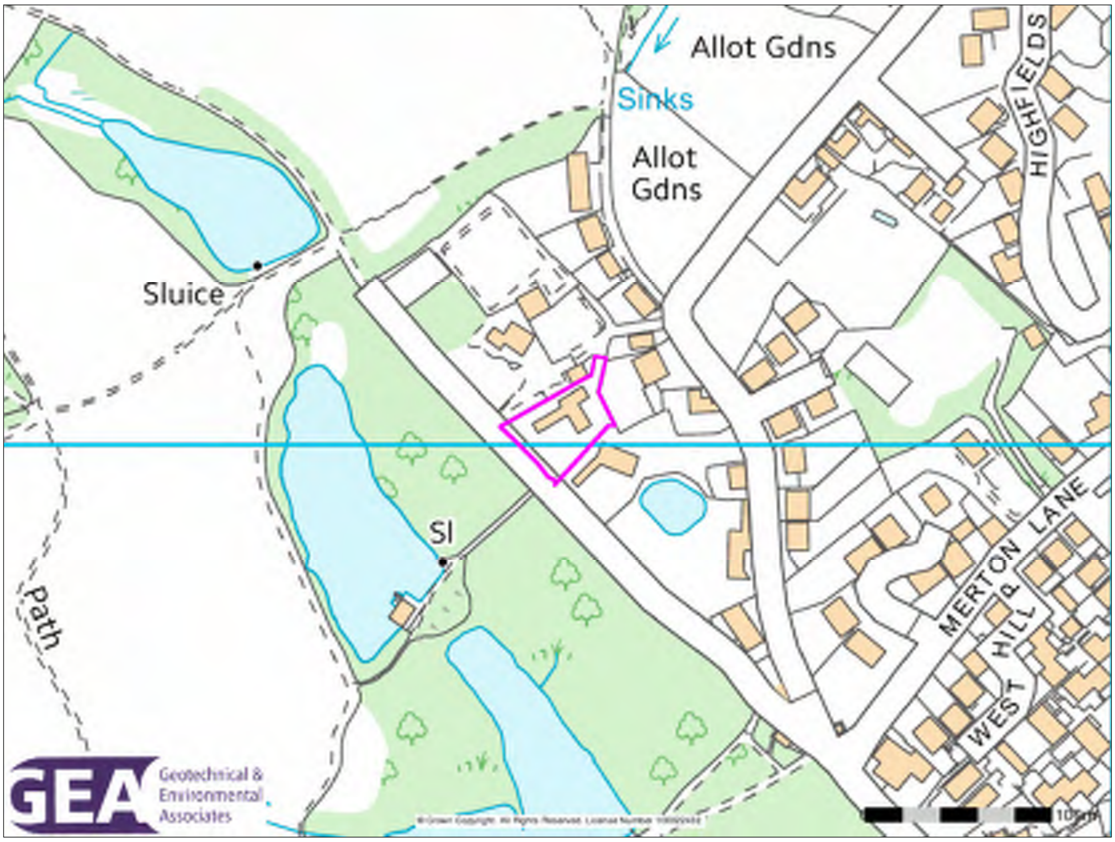
2.0 THE SITE

2.1 Site Description

The site is located in the London Borough of Camden, on the northeastern edge of Hampstead Heath, approximately 1.40 km southwest of Highgate London Underground station and roughly 1.45 km northeast of Hampstead Heath Railway station. It is located roughly 75 m to the northeast of Kenwood Ladies Bathing Pond and roughly 12 m to the south of the North London Bowling Club car park. It fronts onto Fitzroy Park to the north and is bounded to the southwest by Millfield Lane. The site further bounds The Little House, a two-storey residential structure directly to the northeast, and Fitzroy Farm Coach House, a single-storey detached structure to the north. The site is bordered to the east by the Dormers and to the south by The Water House, both of which comprise detached houses. A pond is located in the southern corner of the front garden of Wallace House. Additionally, the site may be located by National Grid Reference 527713, 187018 and is shown on the map extract overleaf.

A walkover survey of the site was carried out by a geotechnical engineer from GEA during the fieldwork and the description below is based on these observations. Selected photographs from the walk-over are included in the appendix.

The site occupies an irregularly shaped parcel of land measuring 30 m north-south by 50 m east-west in maximum dimensions. It lies at the base of a southwest facing slope, at an elevation of around 85 m OD, approximately 10 m above the level of the nearby Kenwood Ladies Bathing Pond, which is one of a line of ponds, together known as the Highgate Points, which are fed by a tributary of the old River Fleet. The site is located on a sloping plot and it appears to have been historically cut or levelled to allow for the development of the existing building. A driveway is present along the eastern boundary of the site; it slopes down from the northeast at a level of roughly 87 m OD to the southwest at a level of roughly 83 m OD. The rest of the site slopes downwards from the east at 85 m OD to the west at roughly 81.5 m OD.



The site is currently occupied by a roughly T-shaped house which is cut into the slope, such that it comprises one storey at the front and two storeys at the rear. The site is on two main levels, with steps between the two levels along the northern and southern elevations of the house. The difference is roughly 3 m between the front of the house and the rear. A single storey pool house extension is adjoined to the southwest of the main house and incorporates a swimming pool as shown in the photograph overleaf.

The main two-storey section of the house has a ground level set roughly 0.5 m below the level of the rear garden. The site reduces further in elevation in its southeastern corner beyond a small pond.

At the time of the walkover, ground level along the northern site boundary appeared raised in part by approximately 0.5 m. The elevated area comprised thick vegetation and the retaining wall appeared to be bowing towards the south. The ground along this northern boundary was noted as being significantly steep.

A number of paving slabs surrounding the existing pool house extension were noted as cracked at the time of the fieldwork.

Vegetation coverage is present primarily around the perimeters of the site. A roughly 20 m high deciduous tree and an approximately 17 m high willow tree are present to the south, as shown in the photographs below and overleaf. Other, typically deciduous trees, between roughly 10 m to 14 m high, are present to the south and to the west of the site. Shrubs are present in the northern end of the driveway as well as around the perimeter. A large deciduous tree, roughly 20 m high also borders the site to the northwest; as shown behind the pool extension in the image above.

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 1870, shows the site to be located to the west of Fitzroypark Farm, with a single square building situated in the centre of the site surrounded by pathways and some trees. The immediate surrounding area is shown to comprise a number of buildings to the north of the site, which also appear to be associated with the farm. A single building is shown to the southeast of the site. A large pond is shown on this map, 35 m to the southeast of the site and the Highgate ponds were constructed by this time, roughly 75 m to the southwest of the site. Online research[4] indicates that the Highgate ponds were formed in the 17th and 18th Centuries as man-made reservoirs fed by the headwater springs of the River Fleet.

By the time of the 1896 map, the footprint of the building on site had changed, and the building appears to have been extended or rebuilt. An outbuilding was present against the northern boundary, which was extended by 1915, and what appears to be two additional buildings are shown to the southeast of the site. On the 1915 map, a miniature rifle range was present 80 m to the south of the site. Between 1915 and 1935, the buildings of Fitzroy Park Farm were demolished and replaced with what appears to be a single irregular shaped building and Bowling Green shown to the north. The building to the south of the site had also been demolished and replaced with an irregular shaped building. The outbuilding along the northern boundary on site had reduced in size by 1935. By 1935 another outbuilding had been constructed in the east of the site.

The irregular shaped building to the south of the site is labelled on the 1952 map as Fitzroy Farm Cottage and the building on site is first labelled as a lodge. A tank is shown on the 1953 map, 60 m to the northeast of the site and is not shown on any subsequent maps. On this map, the closest pond is first labelled as the Women's Bathing Pool. Between 1974 and 1975 the lodge is labelled as The Bungalow. Between the 1991 OS map and the 1999 aerial photograph the existing house was constructed. Online records[5] identify Wallace House as having been rebuilt in its present day configuration in 2000; it is inferred to have since remained unchanged.

A search of the LBC online portal found a number of planning applications that relate to the proposed development site. The main applications are detailed below.

Application Reference	Description	Date of Application	Status
HB/8570003/R2	Demolition of existing house (excluding part of existing S.E. wall) garage and west boundary walls including re-siting of existing timber entry gates. As shown in drawings numbered 1 2 3A 4A 5A 6A 7A and 1 unnumbered. Revised on 5th July and 13th August 1985.	10/09/1985	FINAL DECISION
CEX0200174	Substantial demolition of the front of the property, the erection of an extension at the front of the property and works of alteration and refurbishment As shown on drawing numbers: 13/02 Revision 4 - Proposed sheets 1, 2 & 3 and 12/01 Revision 3	20/05/2002	Grant Conservation Area Consent

4 https://en.wikipedia.org/wiki/Hampstead_Ponds. Accessed June 2017
5 http://ukmoho.co.uk/html/town/Highgate_LB.Camden.html . Accessed June 2017

Application Reference	Description	Date of Application	Status
PEX0200115	Substantial demolition of the front of the property, the erection of an extension at the front of the property and works of alteration and refurbishment. As shown on drawing numbers: 13/02 Revision 4 - Proposed sheets 1, 2 & 3 and 12/01 Revision 3	20/05/2002	Grant Full Planning Permission
2008/2004/P	Erection of new first floor extension above existing garage, and new lower ground floor extension to single family dwelling house (Class C3)	13/05/2008	Granted Subject to a Section 106 Legal Agreement
2008/1303/P	Demolition of existing 2 storey dwelling and single storey swimming pool building, and replacement with new dwelling with accommodation over basement, ground and first floor levels with single room located within roof space at second floor level.	23/05/2008	Withdrawn
2009/4345/P	Amendment to planning permission 2008/2004/P (dated 02/06/2009) comprising excavations to enlarge the lower ground level to the area beneath the existing garage, conversion of the garage at ground floor level into a habitable room and associated alterations to the dwelling house, in association with the original permission for 'Erection of new first floor extension above existing garage, and new lower ground floor'. extension to single family dwelling house (Class C3).	12/04/2010	Granted Subject to a Section 106 Legal Agreement

2.3 Preliminary UXO Risk Assessment

A preliminary UXO risk assessment has been carried out by 1st Line Defence and their report (ref EP4796-00, issue 1, dated 8 May 2017) is included in the appendix. The risk assessment has been carried out in accordance with the guidelines provided by CIRIA, which state that the likelihood of encountering and detonating unexploded ordnance (UXO) below a site should be assessed along with establishing the consequences that may arise. The first phase comprises a preliminary risk assessment, which should be undertaken at an early stage of the development planning. If such an assessment identifies a high level of risk then a detailed risk assessment should be carried out by a UXO specialist, which will identify an appropriate course of action with regard to risk mitigation.

Preliminary research has identified a minimal/low risk of encountering items of UXO at the site. It is therefore not considered likely that carrying out additional research would result in a significant change to the assessed level of risk, based on the information that is currently available to 1st Line Defence. It is therefore recommended that no further action needs to be taken for this site.

2.4 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 operational or historic landfills, or any licensed waste transfer, treatment or disposal sites within 1 km of the site. No records of potentially infilled land exist within 700 m of the site.

The search has not indicated any contaminated land register entries or notices within 1 km of the site. Two accounts of pollution incidents to controlled waters are recorded within 500 m of the site, 245 m to the north and 372 m to the west of the site. A single substantiated pollution incident has been recorded 451 m to the south. No contemporary trade directory entries indicating active businesses are listed within 100 m of the site. In addition, there are no listed fuel stations within 250 m of the site.

The site is not located within a nitrate vulnerable zone or any other sensitive land use, but the site is located within the Highgate Village Conservation Area.

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.

Information obtained from the main utility companies on buried services does not indicate any potentially sensitive infrastructure that could be adversely affected by the proposed development. Copies of the service search information are included within the appendix.

2.5 Geology

The British Geological Survey (BGS) map of the area (sheet 256) indicates that the site is directly underlain by the London Clay Formation with the site and much of the surrounding area also shown as having ‘Head Propensity’. Head propensity is denoted on the BGS map as areas 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 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. The geological boundary of the Claygate Member and London Clay is shown roughly 12 m to the northwest of the site shown in the appendix.

According to the British Geological Society memoir the London Clay Formation is homogenous, slightly calcareous silty clay to very silty clay, with some beds of clayey silt grading to silty fine grained sand, whereas the Claygate Member comprises alternating beds of clayey silt, very silty clay, sandy silt and glauconitic silty fine sand. The lower part of the Claygate Member is generally more bioturbated. A bed of calcareous concretions is present near the base in many places.

A borehole has been drilled by the BGS to a depth of 66.74 m (61.97 m OD) on Hampstead Lane, about 1.63 km to the west of the site at National Grid Reference 526455, 186890, and is generally referred to as the Hampstead Heath borehole. This borehole found the Bagshot Formation to extend to a level of 109.71 m OD and penetrated the full thickness of the Claygate Member. This borehole found the base of the Claygate Member at a level of 93.71 m OD, where the London Clay Formation was encountered. The highest site level is about 87.00 m OD in the north of the site and therefore some depth below the anticipated base of the Claygate in this area. The BGS borehole database includes a record of a deeper borehole drilled roughly 270 m to the northeast of the site. The borehole encountered made ground over the London Clay to a depth of 127 m, below which the Thanet Sand extended to a depth of 144 m and was underlain by Chalk with flints to the full depth investigated, of 206 m.

GEA has previously carried out a number of site investigations within the nearby area. An investigation undertaken to the southwest, found between 0.4 m and 1.8 m of made ground or topsoil, over London Clay to the full depth of the investigation at 15.0 m.

2.6 Hydrology and Hydrogeology

According to the Envirocheck report the site is directly underlain by an Unproductive Stratum (London Clay), which refers to deposits that have low permeability and negligible significance for water supply or river base flow. The Claygate Member, which outcrops on the northwest boundary of the site, is classified as a Secondary 'A' Aquifer, which refers to permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

A private pond is located in the southeast of the site and a private pond is located in the garden of the neighbouring site to the east. Beyond this, the nearest surface water feature is the Kenwood Ladies' Bathing Pond of the Highgate Chain of Ponds. The Highgate Ponds are manmade and it is assumed any other private ponds within the London Clay are also man-made.

The site is located close to a tributary of the Highgate Chain of Ponds, formerly known as the Highgate Brook, which historically[6] formed one of the sources of the River Fleet, one of London's "lost rivers". The Fleet originated to the northwest and southwest of the site and flowed in a southeasterly direction towards Clerkenwell, beyond which it joined with the River Thames. Today the Fleet is entirely covered and culverted and forms part of the surface water sewerage system.

Within Hampstead Heath, three of the more than 25 ponds exist within relatively close proximity to the site. The nearest is the Kenwood Ladies Bathing Pond, situated approximately 75 m southwest of the site. The ponds on the Heath are fed by springs which drain the Bagshot Formation sands which cap the higher ground beneath Hampstead Heath. Some of the ponds are natural but the Hampstead and Highgate Chains are artificial and were created in the 18th Century by damming tributaries of the Fleet, to provide drinking water for London.

The site lies outside the catchment of the Hampstead Heath chain of ponds, although it does lie within the Highgate Chain catchment area.

There are no EA designated Source Protection Zones (SPZs) on the site and there are no listed water abstraction points within 500 m of the site.

With reference to the Envirocheck database and Figure 11 of the Arup report, the nearest surface water feature is a pond located 38 m to the southeast of the site within a private garden.

The site itself is not located in an area at risk of flooding from rivers or the sea, as defined by the EA. It is also shown on Figure 15 of the Arup report[7] and the EA surface water flood maps, as not being in an area with the potential to be at high risk from surface water flooding.

The London Clay is cohesive and therefore has a negligible permeability. The permeability will be predominantly secondary (ie not intergranular), through fissures in the clay. 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. Head Deposits also have low permeability rates in the range of 1×10^{-8} m/s.

6 Nicholas Barton and Stephen Myers (2016) *London's Lost Rivers. Revised Edition.* Historical Publications Ltd
7 Ove Arup & Partners (2010) *Camden geological, hydrogeological and hydrological study. Guidance for Subterranean Development.* For London Borough of Camden November 2010

The London Clay comprises predominantly clay soils that cannot support groundwater flow and as such do not support a "water table" or continuous piezometric surface. Boreholes constructed within clays do fill with water due to the often high water content of shallow clays or by the collection of surface water drainage which is unable to drain through the clay. However, this is not reflective of the type of groundwater flow that would occur in a porous and permeable saturated stratum. Although shallow Head Deposits are more sandy than the in-situ London Clay, they comprise predominantly transported clay material and therefore have a cohesive matrix which would not be able to sustain groundwater flow to support water courses or other water features. The local ponds have been constructed within the clay dominated Head Deposits and are therefore able to prevent the collected water from draining.

2.7 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.

2.7.1 Source

The desk study research has indicated that the site was already developed by 1870 with a square building, of unknown but presumably residential use. By 1896, the footprint of the building had changed and an outbuilding had been constructed along the northern boundary. By 1935, another outbuilding had been constructed to the east of the site. From 1952, the main building was labelled as lodge, and from 1975, this building was labelled as The Bungalow. Between 1991 and 1999 the buildings were demolished and replaced with the existing house.

Demolition of the previous buildings on the site is likely to have resulted in the presence of a moderate thickness of made ground. This would mostly be inert rubble, but is likely to include small quantities of contaminants such as lead, present in paintwork, other metals and potentially asbestos containing materials.

A tank was located 60 m to the northeast of the site in 1953. The contents of the former tank are not known, but are unlikely to have impacted upon the site.

There are no historical or existing landfill sites within 1 km of the site and no infilled land has been identified within 700 m of the site. Made ground associated with demolition of the house previously present on the site is likely to be predominantly inert demolition rubble without a potential for soil gas generation.

2.7.2 Receptor

The continued use of the site for residential purposes represents a relatively high sensitivity end-use and end users are considered to be sensitive receptors. Buried services are likely to come into contact with any contaminants present within the soils through which they pass and site workers are likely to come into direct contact with any contaminants present in the soil and through inhalation of vapours during basement excavation and construction. The site is likely to be directly underlain by unproductive strata, therefore groundwater is not considered to be a receptor.

2.7.3 Pathway

The presence of negligibly permeable London Clay will limit the potential for groundwater percolation into the underlying chalk, and thus a pathway is not considered likely to exist to the major aquifer.

Within the site, end users will be largely isolated from direct contact with any contaminants present within the made ground by the continued presence of the buildings and the extent of the hardstanding. However, in proposed areas of soft landscaping potential contaminant exposure pathways exist with respect to end users.

Except for the pathway of direct contact for site workers, no new pathways will be created by the basement excavation and services will come into contact with any contamination within the soils in which they are laid.

There is thus considered to be limited potential for a significant contaminant pathway to be present between any potential contaminant source and a target for the particular contaminant beneath the new building and extent of any hardstanding. A moderate potential exists within any proposed soft landscaped or garden areas.

2.7.4 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, 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 Wallace House
1a. Is the site located directly above an aquifer?	No. The site is directly underlain by the London Clay which is classified by the EA as an unproductive stratum. The site is located close to the boundary with the Claygate Member in the northwest and is located within an area of Head Propensity.
1b. Will the proposed basement extend beneath the water table surface?	*Unlikely.* The London Clay and Head Deposits cannot support groundwater flow and do not have a water table consistent with a permeable water bearing strata.

2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	*Yes. A private pond is present in the southwest of the site, and another is located 38 m to the southeast. Additionally, Kenwood Ladies Bathing Pond and associated headwaters of the River Fleet are located roughly 75 m to the southwest of the site.*
3. Is the site within the catchment of the pond chains on Hampstead Heath?	*Yes. Figure 14 of the Camden geological, hydrogeological and hydrological study – Guidance for subterranean development dated 2010, confirms that the site is located within the Highgate Chain Catchment area.*
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	*Yes. Although the basement will be constructed entirely beneath the footprint of the existing garage structure, the extension of the existing pool house building to the northwest will result in a reduction in soft landscaped area.*
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. Given that the site is underlain by clay soils and is unlikely to be suitable for a soakaway or similar SUDS based system, the site drainage will be directed to public sewers. Site drainage will therefore be designed to generally maintain the existing situation.
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. Based on the contour levels shown in the Geological Plan Figure.

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

Q2 The site is located within 100 m of a watercourse

Q3 The site exists within the Highgate Chain Catchment area.

Q4 The proposed extension will slightly increase the proportion of hard surfaced/paved areas to the north of the existing pool house.

3.1.2 Stability Screening Assessment

Question	Response for Wallace House
1. Does the existing site include slopes, natural or manmade, greater than 7°?	No. Topographical maps, Figures 16 and 17 of the Arup report and the site walkover indicate slopes of between 0°-7° on the site. The site plan imposed over Figure 16 of the Arup report is shown in the appendix of this report.
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	No. The details of the proposed development provided do not include the re-profiling of the site to create new slopes.
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	No. Topographical maps, Figures 16 and 17 of the Arup report and the site walkover indicate the neighbouring sites to be in areas with slopes of between 0°-7°.
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	No. Topographical maps, Figures 16 and 17 of the Arup report and the site walkover confirm this.
5. Is the London Clay the shallowest strata at the site?	*Yes. Geological maps show the site to be directly underlain by London Clay. The site is also shown to be in an area with potential Head Deposits, and therefore reworked soils of the London Clay may be encountered. The geological boundary defining the presence of the Claygate Member is further shown to exist within roughly 12 m southwest of the site.*
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. It is understood that no trees will be felled as part of the proposals.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	*Yes. The area is prone to these effects as a result of the presence of shrinkable clay soils. At the time of the fieldwork, cracking was noticed within slabs surrounding the pool extension, potentially caused due to the movement of the*

Question	Response for Wallace House
	underlying clay soils.
8. Is the site within 100 m of a watercourse or potential spring line?	*Yes.*
9. Is the site within an area of previously worked ground?	No. Geological maps and Figures 3, 4 and 8 of the Arup report confirm this.
10a. Is the site within an aquifer?	No. Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 4 and 8 of the Arup report, confirm this. The site is directly underlain by unproductive stratum.
10b. Will the proposed basement extend beneath the water table such that dewatering may be required during construction?	*Unlikely.* The London Clay cannot support groundwater flow and does not have a water table consistent with a permeable water-bearing stratum. The Head Deposits have a cohesive clay matrix and will behave hydraulically as a clay. Therefore these deposits cannot support groundwater flow, even if they are slightly more permeable in lab tests than the in situ London Clay. Localised bodies of perched groundwater may be encountered which are likely to be controllable via sump pumping.
11. Is the site within 50 m of Hampstead Heath ponds?	*Yes. The proposed basement development is within the Highgate Chain catchment.*
12. Is the site within 5 m of a highway or pedestrian right of way?	*Yes. The site is within 5 m of a highway of Fitzroy Park and Millfield Lane. However, the proposed basement excavation is located in excess of 5 m from the highways.*
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	*Possibly. The configuration of the foundations to The Little House to the north of the site is not known and should be confirmed.*
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:

Q5 The site is directly underlain by London Clay.
Q7 The area is prone to seasonal shrink-swell subsidence.
Q8 The site is within 100 m of a watercourse.
Q11 The site is located within the Highgate Chain Catchment.
Q12 The site is within 5 m of two highways.
Q13 The proposed basement may increase the differential depth of foundations relative to neighbouring properties.

3.1.3 Surface Flow and Flooding Screening Assessment

Question	Response for Wallace House
1. Is the site within the catchment of the pond chains on Hampstead Heath?	*Yes. Figure 14 of the Camden geological, hydrogeological and hydrological study – Guidance for subterranean development dated 2010, confirms that the site is located within the Highgate Chains catchment area.*
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. The proposed basement will be entirely beneath the footprint of the existing garage, therefore the 1m distance between the roof of the basement and ground surface as recommended by the Arup report and para 2.16 of the CPG4 does not apply.

Question	Response for Wallace House
	Any additional surface water from the increase in hardstanding area associated with the 1.8m single-storey extension will be attenuated and discharged into the Thames Water sewers to ensure the surface water flow regime will be unchanged.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	*Yes. There will be an increase in impermeable area in the area of the 1.8m single storey extension to the existing pool house.*
4. Will the proposed basement development result in changes to the profile of the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?	No. The proposed basement will be entirely beneath the footprint of the existing garage, therefore the 1m distance between the roof of the basement and ground surface as recommended by the Arup report and para 2.16 of the CPG4 does not apply. Any additional surface water from the increase in hardstanding area associated with the 1.8m single-storey extension will be attenuated and discharged into the Thames Water sewers to ensure the surface water flow regime will be unchanged.
5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No. The proposed development is very unlikely to result in any changes to the quality of surface water being received by adjacent properties or downstream watercourses. It is proposed to allow for new SUDS measures to control how water is dealt with from additional hardstanding areas and it will be unpolluted roof water or low pollution hazard land uses draining from the site.
6. Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk of flooding, for example because the proposed basement is below the static water level of nearby surface water feature?	No. The findings of this BIA together with the Camden Flood Risk Management Strategy dated 2013 and Figures 3iii, 4e, 5a and 5b of the SFRA dated 2014, in addition to the Environment Agency online flood maps show that the site has a very low flooding risk from surface water, sewers, reservoirs (and other artificial sources), groundwater and fluvial/tidal watercourses. It is possible that the basement will be constructed within a perched water table and the recommendations outlined in the BIA with regards to water-proofing and tanking of the basement will reduce the risk to acceptable levels. In accordance with paragraph 5.11 of the CPG a positive pumped device will be installed in the basement in order to further protect the site from sewer flooding. The site is located within the Critical Drainage Area Group3_001, but not in a Local Flood Risk Zone as identified in the Camden SWMP and Updated SFRA Figure 6/Rev 2.

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

Q1 The site is located within the pond chains on Hampstead Heath.

Q3 The proposed basement development may result in a change in the proportion of hard surfaced / paved areas.

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 nearest surface water feature is 38 m southeast of the site	A new basement development may impact the current catchment regime maintaining the nearby surface water feature.
The site exists within the Highgate Chain Catchment area and there is a private pond on site.	The proposed pool may affect the groundwater flow regime. Flow from a spring if diverted or restricted could affect flow elsewhere.
The proposed extension will slightly increase the proportion of hard surfaced/paved areas to the north of the existing pool house	An increase in hard surfaced cover may potentially impact the current surface drainage regime.
London Clay is the shallowest stratum on the site	The London Clay is prone to shrink and swell at ground level, which gives rise to subsidence and heave.
The site is within an area likely to be affected by seasonal shrink-swell	If a new basement is dug to below the depth likely to be affected by tree roots this could lead to damaging differential movement between the subject site and adjoining properties.
The development is within 5 m of a public highway	Excavation of a basement may result in structural damage to the road or footway.
The proposed basement may increase the differential depth of foundations relative to neighbouring properties	Differential depths in foundations relative to neighbouring properties may cause significant damage to nearby structures.

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, a single cable percussion borehole was advanced to a depth of 15.0 m (68.20 m OD) on the front driveway, and supplemented by two open-drive sampler boreholes advanced to a depth of 7.45 m (73.95 m OD and 75.95 m OD). Standard Penetration Tests (SPTs) were carried out at regular intervals in the boreholes in order to provide quantitative data on the strength of soils encountered. Disturbed and undisturbed samples were also recovered for subsequent laboratory examination and testing.

In addition, a total of seven shallow trial pits were excavated by hand to expose the configuration of the existing foundations.

Three groundwater monitoring standpipes were installed to depths of 5.00 m and 6.00 m (76.40 m OD and 77.40 m OD) and have been monitored on five occasions to date, over a period of roughly seven weeks.

At the time of the second groundwater monitoring visit, rising head tests were carried out in each of the boreholes to provide preliminary information on inflow rates of groundwater.

A selection of the samples recovered from the boreholes were submitted to a soil mechanics laboratory for a programme of geotechnical testing and an analytical laboratory for a programme of contamination testing.

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

The Ordnance Datum (OD) levels on the borehole and trial pit records have been interpolated from drawings provided by the consulting engineers (drawing ref; Construction Sequence, SK/001, by SOUP, dated 5 June 2017).

4.3 Sampling Strategy

The borehole and trial pit locations were specified by the consulting engineers and positioned on site by GEA whilst avoiding known buried services.

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, and soluble sulphate and pH level analysis.

Three samples of the made ground were subjected to analysis for a range of common industrial contaminants and contamination indicative parameters. For this investigation the analytical suite for the soil included a range of metals, speciation of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), total cyanide and monohydric phenols. All three of these samples were also subject to asbestos screening analysis as a precautionary measure.

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

5.0 GROUND CONDITIONS

The investigation has encountered a moderate thickness of made ground, overlying the London Clay, which has been encountered to the full depth investigated, of 15.00 m (68.20 m OD). Soils interpreted as Head Deposits locally overlie the London Clay.

5.1 Made Ground

Below the existing surfacings, the made ground generally comprised brown silty sand or brown mottled orange-brown clay with flint, rootlets, shell fragments, concrete, brick and ash, which extended to depths of between 0.82 m and 1.30 m (80.58 m OD and 81.90 m OD). A 0.20 m thickness of black silty clay with fine rootlets, decaying wood and fragments of red brick was also encountered at a depth of 0.52 m (82.88 m OD) in Borehole No 3.

With the exception of occasional fragments of extraneous material, no visual or olfactory evidence of significant contamination was observed within the made ground. However, three samples of the made ground have been subject to contamination testing as a precautionary measure and the results are presented in Section 5.5.

5.2 Head Deposits

Directly beneath the made ground in Borehole Nos 2 and 3, soils interpreted as Head Deposits were encountered and extended to depths of between 2.00 m and 2.70 m (81.40 m OD and 78.70 m OD). The material generally comprised soft orange-brown mottled grey silty clay or firm brown or brown mottled grey silty clay, with a reworked texture.

5.3 London Clay

Directly beneath the made ground in Borehole No 1 or Head Deposits in Borehole Nos 2 and 3, the London Clay was found to comprise firm becoming stiff fissured brown mottled grey silty clay with occasional fine selenite crystals, rare fine claystones and rare partings of silt and fine sand, extending to a depth of 11.0 m (72.20 m OD). Below this depth, stiff fissured grey silty clay with occasional carbonaceous material and occasional partings of light grey sand and silt was encountered and proved to a depth of 15.00 m (68.20 m OD). Live rootlets were observed to a maximum depth of 2.70 m (80.70 m OD) and decayed rootlets to a maximum depth of 4.70 m (78.50 m OD).

In Borehole No 3, grey silt was encountered between depths of 7.23 m and 7.28 m (76.17 m OD and 76.12 m OD), and, in Borehole No 2, a pocket of brown silt was encountered between depths of 6.30 m and 6.32 m (75.1 m OD and 75.08 m OD). These coincided with groundwater strikes encountered during drilling, resulting in the material being recovered as soft.

The fieldwork did not identify desiccation within any of the shallow soils sampled and subsequent laboratory testing has affirmed this.

The results of laboratory Atterberg Limit tests have indicated the clay to be of high volume change potential.

The results of undrained triaxial tests indicate shear strengths of medium strength becoming high strength.

These soils were found to be free from evidence of contamination.

5.4 Groundwater

Groundwater was encountered during drilling in Borehole Nos 2 and 3, at depths of 6.20 m and 7.20 m (75.20 m OD and 76.2 m OD) respectively. Monitoring of the standpipes installed in each of the boreholes has been carried out on five occasions over a period of roughly seven weeks since the date of the fieldwork. The results are shown in the table below.

Date	Borehole No	Depth to water (m)	Level of water (mOD)
10/05/2017	1	Not installed	
	2	3.63	77.77
	3	5.55	77.85
17/05/2017	1	3.75	79.45
	2	1.85	79.55
	3	2.64	80.76
01/06/2017	1	1.16	82.04
	2	Not monitored	
	3	3.28	80.12
14/06/2017	1	0.84	82.36
	2	1.73	79.67
	3	2.61	80.79
27/06/2017	1	1.14	82.06
	2	1.79	79.61

Date	Borehole No	Depth to water (m)	Level of water (mOD)
	3	2.27	81.13

Rising head tests were also carried out in each of the three boreholes at the time of the second monitoring visit to provide a preliminary assessment of the permeability of the nearby soils, and of potential groundwater inflows into the basement excavation. The results of the tests are appended. The testing indicated inflow rates of 7.58×10^{-6} m/s and 1.15×10^{-5} m/s in Borehole Nos 1 and 2 respectively, with no groundwater inflow recorded in Borehole No 3 over a period of 80 minutes. Despite the anticipated impermeable nature of the soils, it is inferred by the results that isolated and perched groundwater exists throughout the site, and that inflows and elevated permeability values probably arise from localised silt and sand partings within the London Clay. It is also possible that higher than anticipated readings represent reworked head material present on site.

5.5 Soil Contamination

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

Determinant	BH2: 0.40 m	TP2: 0.40 m	BH3: 0.60 m
pH	9.3	8.5	8.0
Arsenic	21	11	30
Cadmium	<0.2	0.3	0.9
Chromium	32	21	30
Copper	39	31	76
Mercury	0.3	0.5	0.8
Nickel	20	16	26
Lead	**310**	97	**690**
Selenium	<1.0	<1.0	<1.0
Zinc	140	140	510
Total Cyanide	<1	<1	<1
Total Phenols	<1.0	<1.0	<1.0
Sulphide	1.4	7.2	**79**
Total PAH	12.4	17.2	37.9
Benzo(a)pyrene	1.1	1.7	3.5
Naphthalene	0.08	0.10	0.25
TPH (C8 - C10)	<0.1	<0.1	<0.1
TPH (C10 - C12)	<2.0	<2.0	8.2
TPH (C12 - C16)	<4.0	7.7	26
TPH (C16 - C21)	4.6	53	83

Determinant	BH2: 0.40 m	TP2: 0.40 m	BH3: 0.60 m
TPH (C21 - C35)	18	230	220
Total organic carbon %	1.6	0.9	3.6

5.5.1 Generic Quantitative Risk Assessment

The use of a risk-based approach has been adopted to provide an initial screening of the test results to assess the need for subsequent site-specific risk assessments. To this end, contaminants of concern are those that have values in excess of generic human health risk based guideline values which are either those of the CLEA[8] Soil Guideline Values where available, or are Generic Screening Values calculated using the CLEA UK Version 1.06[9] software assuming a residential end use with plant uptake, or are based on the DEFRA Category 4 Screening values[10]. The key generic assumptions for this end use are as follows;

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

It is considered that these assumptions are considered acceptable for this generic assessment of this site, with the exception of that made on groundwater, which is considered to be a sensitive receptor at this site. The tables of generic screening values derived by GEA and an explanation of how each value has been derived are included in the Appendix.

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

- additional testing to zone the extent of the contaminated material and thus reduce the uncertainty with regard to its potential risk;
- site specific risk assessment to refine the assessment criteria and allow an assessment to be made as to whether the concentration present would pose an unacceptable risk at this site; or

8 *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.
9 Contaminated Land Exposure Assessment (CLEA) Software Version 1.06 Environment Agency 2009
10 CL:AIRE (2013) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Final Project Report SP1010 and DEFRA (2014) *Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination* Policy Companion Document SP1010

- soil remediation or risk management to mitigate the risk posed by the contaminant to a degree that it poses an acceptable risk.

The contamination testing has revealed elevated concentrations of lead in Borehole Nos 2 and 3 in the made ground. In addition, asbestos screening in the laboratory under electron microscope identified asbestos in the form of Chrysotile in samples of the made ground taken from Trial Pit 2 and Borehole No 3 in the form of loose fibres and bitumen.

A single elevated concentration of sulphide was recorded within Borehole No 3. However, concentrations of sulphide are not considered a risk to human health and will therefore be discussed in Section 8.6 of this report, with regard to their impact on structures.

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

5.6 Existing Foundations

The trial pit findings are summarised in the table below and the trial pit records and associated site plan can be found in the appendix.

Trial Pit No	Structure	Foundation detail	Bearing Stratum
1	Western elevation of house	Concrete Base – extends to a depth of at least 0.60 m No lateral projection Pit abandoned due to drainage trench	Not known
2	Northern elevation of house Section A – A'	Concrete Base – extends to a depth of at least 0.90 m No lateral projection Pit abandoned due to numerous service pipes	Not known
	Northern elevation of house Section B – B'	Concrete Base – extends to a depth of at least 0.46 m No lateral projection Pit abandoned due to numerous service pipes	Not known
2A	Northern elevation of garage	Concrete Base 0.55 m No lateral projection	MADE GROUND
3	Eastern elevation of garage	Concrete Base 0.42 m No lateral projection	MADE GROUND
4	Northern elevation of pool house	Concrete Base – extends to a depth of at least 0.18 m No lateral projection Pit abandoned due to numerous service pipes	Not known
4A	Northern elevation of pool house	Concrete Base – extends to a depth of at least 0.10 m No lateral projection Pit abandoned due to numerous service pipes	Not known
5	Northern edge of paving slabs around pool house	Concrete Base 0.18 m Lateral projection 130 mm	TOPSOIL

Part 2: DESIGN BASIS REPORT

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

6.0 INTRODUCTION

It is understood that it is proposed to construct a single storey extension along the northern elevation of the existing pool house building and to replace the existing garage with a two-storey structure with a single level basement, extending to a depth of roughly 2.80 m (80.84 m OD). Information provided by the consulting engineer, Elliott Wood, indicate loads for each part of the development of between 90 kN and 160 kN.

7.0 GROUND MODEL

The desk study has revealed that the site was developed with the existing house in the 1990s and prior to this was occupied by a square building in the centre of the site and a couple of outbuildings, presumably with a residential use. The site and immediate surrounding area have not had a potentially contaminative history and on the basis of the fieldwork, the ground conditions at this site can be characterised as follows:

- the investigation has encountered a moderate thickness of made ground overlying the London Clay, encountered to the full depth investigated of 15.00 m (68.20 m OD). The London Clay is locally overlain by Head Deposits;
- made ground extends to depths of between 0.82 m and 1.30 m (80.58 m OD and 81.90 m OD);
- directly beneath the made ground in Borehole Nos 2 and 3, Head Deposits were encountered and generally comprised soft orange-brown mottled grey silty clay or firm brown or brown mottled grey silty clay, with a reworked texture. These soils extended to depths of between 2.00 m and 2.70 m (81.40 m OD and 78.70 m OD);
- the London Clay initially comprises firm becoming stiff fissured medium strength becoming high strength brown mottled grey silty clay, to a depth of 11.0 m (72.20 m OD);
- the initial layer is underlain by stiff fissured high strength grey silty clay with occasional carbonaceous material and occasional partings of light grey sand and silt, which was proved to the maximum depth investigated of 15.00 m (68.20 m OD);
- live rootlets were observed to a maximum depth of 2.70 m (80.70 m OD) and decayed rootlets to a maximum depth of 4.70 m (78.50 m OD), although desiccated clay soils were not encountered;
- silt horizons were encountered in Borehole Nos 2 and 3 at depths of 7.23 m and 6.30 m respectively (76.17 m OD and 75.10 m OD);

- groundwater was encountered during drilling within silt horizons in Borehole Nos 2 and 3, at depths of 6.20 m and 7.20 m, (75.20 m OD and 76.2 m OD) respectively;
- monitoring of installed standpipes over a period of roughly seven weeks, has measured water in the pipes at depths of between 0.84 m and 5.55 m (82.36 m OD and 77.77 m OD);
- rising head test results undertaken within the standpipes indicate that there is localised perched groundwater within the Head Deposits and London Clay beneath the site.
- the results of the contamination testing have revealed elevated concentrations of lead and sulphide; and
- Chrysotile asbestos was detected in samples of made ground from Trial Pit 2 and Borehole No 3 in the form of loose fibres and / or bitumen fragments.

8.0 ADVICE AND RECOMMENDATIONS

It is understood that piles are proposed to support the new extensions, which would provide a suitable foundation solution.

Formation level for the proposed 2.80 m (80.84 m OD) deep basement and single storey pool house extension is likely to be within either the Head Deposits or London Clay.

Some form of groundwater control is likely to be locally required to construct the basement and inflows should be expected from within the sandier layers of the Head Deposits. However, given the results of the groundwater monitoring any inflows are anticipated to be localised.

Excavations for the proposed basement structure will require temporary support to maintain stability and to prevent any excessive ground movements.

All new foundations will need to bypass the made ground and any potentially desiccated clay soils and NHBC guidelines should be followed in this respect.

8.1 Basement Construction

It is understood that the proposed basement will extend to a depth of 2.80 m (80.84 m OD) below existing ground level. Formation level is therefore likely to be within the firm clay of the Head Deposits or London Clay.

The investigation has indicated that groundwater is likely to be encountered within the basement excavation. However, whilst monitoring should be continued, it is not possible to draw entirely meaningful conclusions from the measurements made in the standpipes, as the level of the water present within the installation is not indicative of the volume of water that may flow into the excavation. For example, a high level of water measured in a standpipe may not be significant if this represents only a small volume of water.

Inflows of perched water may be encountered from within the made ground, Head Deposits and London Clay, but the predominantly clayey nature of the shallow soils suggests that the rate of groundwater inflow is likely to be very slow and potential inflows are unlikely to be significant. Rising head tests carried out in each of the three boreholes reiterated this, indicating inflow rates of 7.58×10^{-6} m/s and 1.15×10^{-5} m/s in Borehole Nos 1 and 2 respectively, with no groundwater inflow recorded in Borehole 3 over a period of 80 minutes. These results demonstrate the localised and isolated nature of groundwater within the clay soils beneath the site.

There are a number of methods by which the sides of the basement excavation could be supported in the temporary and permanent conditions. The choice of wall may be governed to a large extent by whether it is to be incorporated into the permanent works and have a load bearing function. The final choice will depend on the need to protect nearby structures from movements, the required overall stiffness of the support system, and the need to control groundwater movement through the wall in the temporary condition. In this respect, the stability of the existing and nearby buildings will be paramount.

It is understood that, following demolition of the existing garage, it is proposed to form the new basement in an open cut excavation. This should be feasible on the basis of the groundwater monitoring results to date, provided that localised slipping can be tolerated and that the excavations are managed to ensure that they do not have an adverse effect on the stability of the site. However, it would be prudent to undertake trial excavations to confirm the likely groundwater conditions. In any case, inflows could conceivably occur from perched water tables, particularly in the vicinity of existing foundations, but should be adequately dealt with through sump pumping. The contractor should have a contingency in place to deal with any groundwater inflows that are more significant than anticipated.

In situ retaining walls will then be constructed in front of the excavation and the area behind the walls backfilled on completion.

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 and in this respect the timing of the provision of support to the wall will have an important effect on movements. The stability of the adjacent foundations will need to be ensured at all times and the retaining walls will need to be designed to support the loads from these foundations. These aspects are considered in more detail in the further ground movement assessment carried out as part of the report.

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
Head Deposits / London Clay	1850	Zero	23
London Clay	1950	Zero	23

Monitoring of installed standpipes over a period of roughly seven weeks has measured water in the pipes at depths of between 0.84 m and 5.55 m (82.36 m OD and 77.77 m OD), but this represents isolated perched water. At this stage, it is therefore recommended that a design water level of two-thirds of the excavation depth is adopted, unless a fully effective drainage system can be ensured. Reference should be made to BS8102:2009[11] with regard to requirements for waterproofing and design with respect to groundwater pressures.

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

8.1.2 Basement Heave

The excavation will result in a net unloading of around 55 kN/m^2, which will result in elastic heave and long term swelling of the London Clay. The effects of the longer term swelling movement will to a certain extent be counteracted by the applied loads from the development, but further consideration is given to heave movements within the ground movement analysis in Part 3 of this report.

8.2 Spread Foundations

All new foundations should bypass the made ground, soft clay and any potentially desiccated clay soils. Groundwater may be encountered within the basement excavation as perched water.

Provided that a dry excavation can be maintained, spread foundations excavated to bear within the firm clay of the Head Deposits or London Clay may be designed to apply a net allowable bearing pressure of 120 kN/m^2 below the proposed basement. These values incorporate an adequate factor of safety against bearing capacity failure and should ensure that settlement remains within normal tolerable limits. An allowable bearing pressure of 120 N/m^2 may be adopted for the single storey extension, at a minimum depth of 1.00 m.

The depth of new foundations is expected to be such that foundations will be placed below the depth of actual or potential desiccation, but this should be checked once the proposals have been finalised, with the survey drawing showing former and existing trees. Notwithstanding NHBC guidelines, all foundations should extend beyond the zone of any potential desiccation. In this respect, it would be prudent to have all foundation excavations inspected by a suitably experienced engineer. Due allowance should be made for future growth of existing / proposed trees. The requirement for compressible material alongside foundations should be determined by reference to the NHBC guidelines. High volume change potential soils should be assumed at the site. The requirement for compressible material alongside foundations should be determined by reference to the NHBC guidelines.

If for any reason spread foundations are not considered appropriate, piled foundations would provide a suitable alternative.

8.3 Piled Foundations

For the ground conditions at this site some form of bored pile is likely to be the most appropriate. A conventional rotary augered pile may be appropriate but consideration will need to be given to the possible instability and water ingress in the made ground and within any silty or sandy zones within the London Clay. The use of bored piles installed using continuous flight auger (cfa) techniques may therefore be the most appropriate.

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

Stratum	Depths m	kN / m²
Ultimate Skin Friction		
Made Ground	GL to 1.00 m	Ignore
Head Deposits / London Clay	1.00 m to 2.50 m	Increasing linearly from 14 to 25
London Clay	2.50 m to 15.00 m	Increasing linearly from 25 to 75
Ultimate End Bearing		
London Clay	1.00 m to 15.00 m	Increasing linearly from 252 to 1350

In the absence of pile tests, guidance from the London District Surveyors Association (LDSA)[12] suggests that a factor of safety of 2.6 should be applied to the above coefficients in the computation of safe theoretical working loads. On the basis of the above coefficients and a factor of safety of 2.6, the below table shows the estimated safe working loads for 300 mm and 450 mm piles at various depths below ground level.

Given the variation in site levels, safe working loads have been determined from two general levels. The upper driveway level is considered to indicate conditions at the level of the proposed basement excavation and two-storey structure, and the lower garden level is assumed to indicate conditions at the single-level pool house extension. The variation in ground level was estimated as 1.8 m based on plans provided.

Pile diameter mm	Depth Below Ground Level at upper driveway level (m)	Depth Below Ground Level at lower garden level (m)	Safe Working Load (kN)
300	6.0	4.2	60
	8.0	6.2	95
	10.0	-	135
	12.0	-	185
450	4.0	2.2	60
	6.0	4.2	105
	8.0	6.2	160

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 an appropriate piling scheme and their attention should be drawn to potential groundwater inflows within the made ground and silt and sand partings within the London Clay.

Desiccation was not observed during fieldwork and this was later confirmed by laboratory testing. The pile design should however take into account of the possible effects of trees and

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

be designed to take into account any potential loss of shaft friction due to clay shrinkage in the vicinity of trees, and the possibility of heave if any trees are removed.

The presence of obstructions within the made ground, such as cobbles of concrete, encountered in Trial Pit No 2, should be noted.

8.4 Ground and Basement Floor Slabs

Following the excavation of the basement, it is likely that the floor slab for the proposed basement will need to be suspended over a void to accommodate the anticipated heave, unless the slab can be suitably reinforced to cope with these movements.

Where no basement is proposed the floor slab will need to be suspended in view of the high volume change potential soils.

Further consideration is given to heave movements in Part 3 of this report.

8.5 Basement Raft Foundation

Depending on the loads and whether they can be relatively uniformly distributed, it may be feasible to adopt a basement raft foundation for the proposed development.

It is likely, as a result of the weight of the soil excavated to form the proposed basement, that a raft would be subject to a net unloading. However, further consideration will need to be given to possible movements if this foundation solution is to be considered once the loads have been finalised.

8.6 Shallow Excavations

On the basis of the borehole and trial pit findings it is considered likely that it will be feasible to form relatively shallow excavations for services extending through the made ground without the requirement for lateral support, although localised instabilities may occur. However, should deeper excavations be considered, or if excavations are to remain open for prolonged periods it is recommended that provision be made for battered side slopes or lateral support. Where personnel are required to enter excavations, a risk assessment should be carried out and temporary lateral support or battering of the excavation sides considered in order to comply with normal safety requirements.

Significant groundwater inflows into shallow excavations are not generally anticipated due to the clayey nature of the underlying soils, although seepages may be encountered from perched water tables within the made ground, particularly within the vicinity of existing foundations; such inflows should, however, be suitably controlled by sump pumping.

8.7 Effect of Sulphates

Chemical analyses carried out on selected samples of the made ground and underlying natural soils for water soluble sulphate have been compared with of Table C2 of BRE Special Digest 1: SD1 Third Edition (2005) in order to determine the sulphate class and are summarised in the table below. The assessment has been based on static groundwater conditions and the guidelines contained in the above digest should be followed in the design of foundation concrete.

Stratum	No of samples	pH	SO_4 (mg/l)	Design Sulphate Class	ACEC Class
Made Ground	3	8.0 to 9.3	102 to 1750	DS-1 to DS-3	AC-1 to AC-3
Head Deposits / London Clay	3	7.70 to 7.80	590 to 3360	DS-2 to DS-4	AC-1s to AC-3s

The samples of the London Clay tested are likely to have contained selenite crystals, which probably contributed to the elevated concentrations, and it is therefore possible that the classification can be downgraded, although further testing may be advisable in this respect. The British Standard EN 206-1, which relates to the BRE Special Digest, contains a table that allows a relaxation of one DC class in some circumstances, assuming that some degree of chemical attack is acceptable. Table A.9 states that where a section thickness of greater than 450 mm is used and some surface chemical attack is acceptable, a relaxation of one step in CS-class may be applied. The advice within the guidance should be followed, and appropriate additional protective measures (APMs) incorporated, as in Table D4 from the BRE Special Digest.

8.8 Site Specific Risk Assessment

The desk study has indicated that the site has not had a contaminative history, having been occupied with the existing house in the 1990s and prior to this only by a square building in the centre of the site and a couple of outbuildings. The results of the contamination testing have revealed elevated concentrations of lead within samples from Borehole Nos 2 and 3. In addition to this, Chrysotile asbestos was detected in samples from Trial Pit 2 and Borehole 3 in the form of loose fibres and as bitumen.

The source of the metal contamination and asbestos is likely to be from extraneous fragments in the made ground. The lead is considered to be non-volatile or of a low volatility and does not thus present a significant vapour risk. In addition, the compounds are considered likely to be of low solubility and a plausible risk to groundwater has therefore not been identified.

End users will be effectively isolated from direct contact with the identified contaminants by the proposed buildings and areas of external hardstanding. No new soft landscaped areas are proposed.

Asbestos contamination was identified in two locations. Asbestos containing material may be present elsewhere within the made ground in areas that have not been investigated. Site workers should be made aware of this and a programme of working should be identified to protect workers handling any soil. The method of site working should be in accordance with guidelines set out by HSE[2] and CIRIA[3]. Any materials containing asbestos that could become airborne should, where possible, be kept damp and should be double bagged and labelled with asbestos warnings and deposited in covered locked skips.

A single elevated concentration of sulphide was also recorded within Borehole 3. However, concentrations of sulphide are not considered a risk to human health.

It is recommended that a watching brief be maintained during ground works by the contractor and any suspected contamination, especially in areas not covered by the investigation, should be brought to the attention of a geoenvironmental engineer.

8.8.1 Site Workers

Site workers should be made aware of the contamination, including the potential presence of asbestos, and a programme of working should be identified to protect workers handling any soil. The method of site working should be in accordance with guidelines set out by HSE and CIRIA and the requirements of the Local Authority Environmental Health Officer. A watching brief should also be maintained during the groundwork, and if suspicious soils are encountered then a suitably qualified engineer should inspect the soils and further testing should be carried out if required.

8.9 Waste Disposal

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 classification is a staged process and this investigation represents the preliminary sampling exercise of that process. Once the extent and location of the waste that is to be removed has been defined, further sampling and testing may be necessary. The results from this ground investigation should be used to help define the sampling plan for such further testing, which could include WAC leaching tests where the totals analysis indicates the soil to be a hazardous waste or inert waste from a contaminated site. It should however be noted that the Environment Agency guidance WM3[13] states that landfill WAC analysis, specifically leaching test results, must not be used for waste classification purposes.

Any spoil arising from excavations or landscaping works, which is not to be re-used in accordance with the CL:AIRE[14] guidance, will need to be disposed of to a licensed tip. Waste going to landfill is subject to landfill tax at either the standard rate of £86.10 per tonne (about £155 per m^3) or at the lower rate of £2.70 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 soil and stones, which are accurately described as such in terms of the 2011 Order, would qualify for the 'lower rate' of landfill tax.

Based upon on the technical guidance provided by the Environment Agency it is considered likely that the soils encountered during this ground investigation, as represented by the three chemical analyses carried out, would be generally classified as follows;

Soil Type	Waste Classification (Waste Code)	WAC Testing Required Prior to Landfill Disposal?	Comments
Made ground	Non-hazardous (17 05 04)	Yes	If it contains asbestos the soil may be classified as hazardous. Asbestos quantification tests are recommended at this stage, along with additional asbestos screening on made ground to be removed from the site.
Head Deposits / London Clay	Inert (17 05 04)	Should not be required but confirm with receiving landfill	-

Any soils containing asbestos may be classified as HAZARDOUS waste if the concentration is over 0.1 %. Asbestos quantification has not been undertaken to date, but it is recommended that additional sampling and testing is carried out to confirm the concentration to assist in the waste classification.

13 Environment Agency 2015. *Guidance on the classification and assessment of waste.* Technical Guidance WM3 First Edition
14 CL:AIRE March 2011. *The Definition of Waste: Development Industry Code of Practice* Version 2

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[15] which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be segregated onsite prior to excavation by sufficiently characterising the soils insitu prior to excavation.

The above opinion with regard to the classification of the excavated soils 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.

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

Part 3: GROUND MOVEMENT ANALYSIS

This section of the report comprises an analysis of the ground movements arising from the proposed basement and foundation scheme discussed in Part 2 and the information obtained from the investigation, presented in Part 1 of the report.

9.0 INTRODUCTION

The sides of an excavation will move to some extent regardless of how they are supported. The movement will typically be both horizontal and vertical and will be influenced by the engineering properties of the ground, groundwater level and flow, the efficiency of the various support systems employed during underpinning and the efficiency or stiffness of any support structures used.

An analysis has been carried out of the likely movements arising from the proposed excavation and the results of this analysis have been used to predict the effect of these movements on surrounding structures.

9.1 Construction Sequence

It is understood that it is proposed to construct a new basement structure, to a depth of approximately 2.8 m (80.84 m OD), beneath the footprint of the existing garage on the north-western part of the site, and that it will be formed in an open cut excavation. This should be feasible provided that localised slipping can be tolerated and that the excavations are managed to ensure that they do not have an adverse effect on the stability of the site. In situ retaining walls will then be constructed in front of the excavation and the area behind the walls backfilled on completion.

The following sequence of operations has been provided by Elliott Wood and has been used to enable analysis of the ground movements around the excavation both during and after construction. Full details of the proposed construction sequence are included within Elliott Woods Structural & Civil Engineering Planning Report (report ref 2170310, dated February 2018), which should be read in conjunction with this report.

In general, the sequence of works for excavation and construction, as outlined in the Sequence Drawings included in the appendix, will comprise the following stages.

1. Underpin the existing foundations of the adjacent property, known as the Little House, to a depth of at least 1.6 m;
2. demolish the existing garage structure;
3. install piles at existing ground level;
4. excavate ground to basement level with all sides battered back in stages, as outlined in the proposed sequence drawings;
5. construct new basement structure in stages, breaking back piles, installing new drainage system and providing additional temporary support to the Little House, as the above excavations proceed;

6. internally prop the new basement structure and backfill surrounding excavation;

7. construct ground floor slab and remove internal props; and

8. Install new superstructure over RC basement box.

Suitable angles for the battered sides of the excavation are expected to be approximately 45º for the London Clay, although further consideration is given to the stability of these excavations in Section 10.0 below.

Care should be taken to protect the sides 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.

10.0 SLOPE STABILITY

The proposed development will include the use of cut slopes in order to form the proposed basement structure and an analysis of the short-term and long-term stability of the proposed slopes has been undertaken to confirm that the proposed batter angle of 45º is suitably conservative.

As the site is not located within an area of historical instability, with no natural slopes in excess of 7°, or any evidence of localised instability, it would seem reasonable to adopt parameters for the underlying soils that were closer to peak shear strength values than residual. An effective cohesion of 5 kN/m^2 has been adopted for the London Clay, which is slightly lower than typically reported values and is therefore considered conservative.

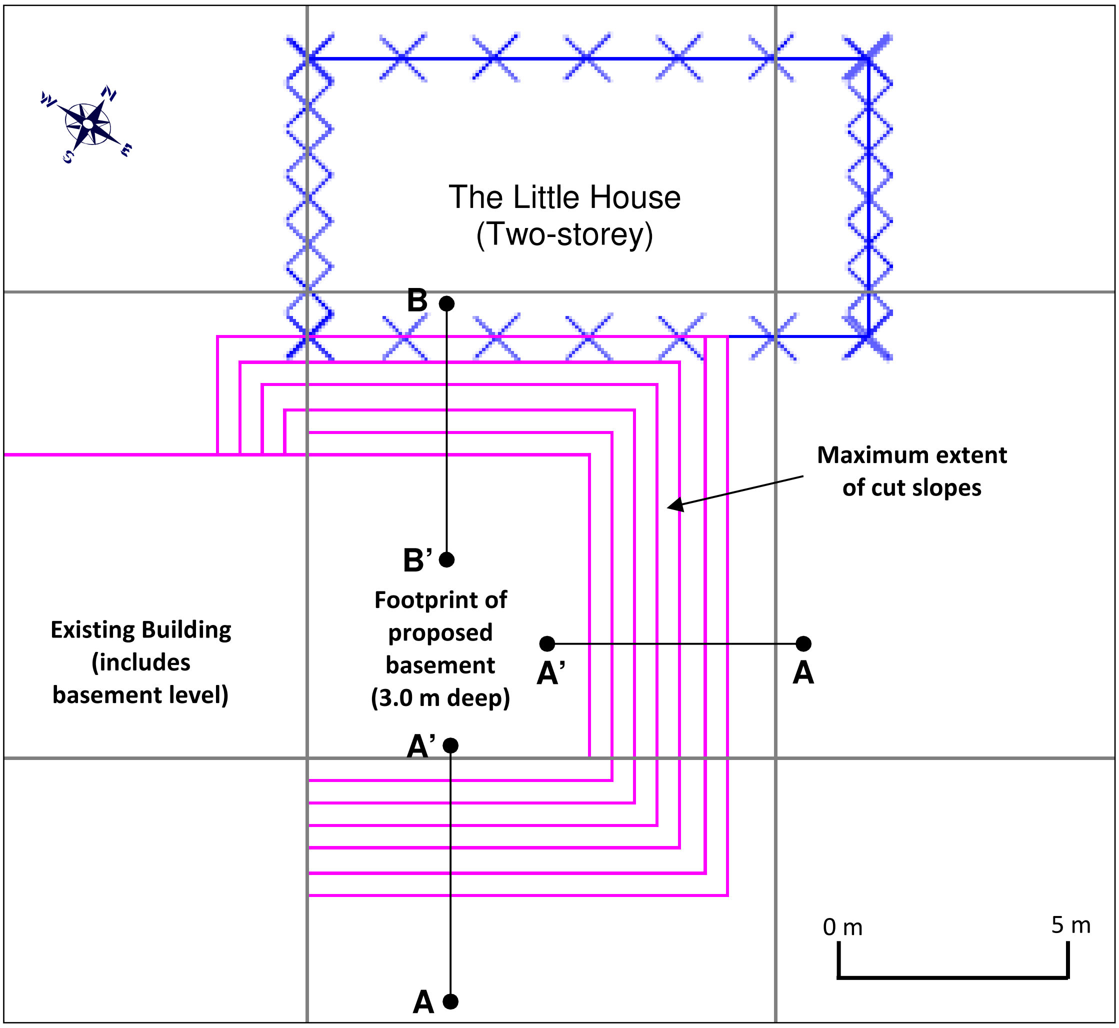
10.1 Long-term Stability

An analysis has been carried out using the Geostudio™ 2018 Slope/W© software and is based on the following input parameters. In the absence of a water table within the cohesive soils beneath the site, a pore pressure ratio (ru) of 0.3 has been adopted in the analysis to represent the global pore water pressure conditions.

Stratum	Unit Weight (kN/m^3)	Effective Cohesion (c' – kN/m^2)	Effective Friction Angle (Φ' – degrees)
Made ground	17.0	Zero	27
Head Deposits / London Clay	18.5	Zero	23
London Clay	19.5	5.0	23

The factor of safety given in the analysis is the lowest from the Morgenstern-Price, Bishop, Janbu and Ordinary methods and outputs of the analysis are included in the appendix.

Whilst the development comprises a number of different stages, as shown in the appended sequence drawings, it is during the final stage of the excavations, when the most critical slopes are expected to be formed; either comprising the slopes with the maximum height of 3.0 m (Section A-A' on the plan overleaf), or where the excavations are formed against the boundary with the Little House (Section B-B' on the plan overleaf).



Analysis of Section A-A', demonstrates that these slopes have a minimum factor of safety of 0.64 and will therefore be marginally unstable in the long-term, which would be expected for an unsupported excavation of this nature. The analysis of Section B-B' shows that this slope will have a minimum factor of safety of 1.0, indicating that it is likely to be marginally stable in the long-term.

It should be noted that the analysis does not take any account of the mitigating effects of the proposed piles that will be installed within the footprint of the excavation, the existing loads on the foundations of the Little House, the proposed basement construction and the temporary support outlined in the sequence drawings. The above analysis therefore provides a conservative assessment of the actual factors of safety for the long-term stability of the proposed excavations.

10.2 Short-term Stability

The short-term stability of excavations in clay soils is much higher than the long-term stability because of effects such as suction and there are a number of semi-empirical methods for estimating the short-term factor of safety of these slopes.

For the purpose of this site, a series of calculations have been undertaken based on the method proposed by Taylor[16] and updated by Steward et al[17], for a slope formed in an undrained clay soil with a stability number, N_s, defined as:

$$Ns = \gamma HF / C_u$$

Where γ = unit weight of the clayey soils; F = factor of safety; H = height of excavation; and C_u = undrained cohesion of clayey soil.

For the critical slopes discussed above in Section 10.1, the table below summarises the factors of safety that have been estimated, which are based on a maximum slope angle of 45°. A lower bound cohesion of 30 kN/m^2 and an average unit weight of 18.5 kN/m^2 have been adopted to represent the clay soils within which the slope will be formed.

Slope Section	Unit Weight of clay soil, γ (kN/m^3)	Undrained cohesion, C_u (kN/m^2)	Stability number, N_s	Height (m)*	Factor of safety
A-A'	18.5	30.0	5.5	3.0	3.0
B-B'	18.5	30.0	5.5	1.5	5.9

*Proposed heights are well below the critical height, H_c, for an excavation in clay soil with a C_u of 30 kN/m2, which has been separately assessed as 6.5 m (based on $H_c = 4C_u/\gamma$).

Whilst the above factors of safety indicate that the proposed slopes should remain stable during the period of construction, it is important to note that the short-term stability of the temporary excavations is difficult to assess and can be affected by heavy rainfall and plant movements. It is therefore recommended that heavy plant is prevented from loading the tops of the slopes, that protection is applied to slope faces to reduce water ingress, and a regime of daily monitoring is established, with a protocol in place for the provision of additional support if movement is observed.

11.0 GROUND MOVEMENTS

An assessment of ground movements within and surrounding the excavations has been undertaken using the P-Disp computer programme licensed from the OASYS suite of geotechnical modelling software from Arup. This programme is commonly used within the ground engineering industry and is considered an appropriate tool for this analysis.

The analysis of potential ground movements, as a result of the proposed open-cut excavation and resulting unloading of the underlying soils, has been carried out using the Oasys P-Disp Version 19.2 – Build 12 software package and is based on the assumption that the soils behave elastically, which provides a reasonable approximation of soil behaviour at small strains.

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction approximately parallel with the orientation east-west, whilst the y-direction is approximately parallel with the orientation of north-south. Vertical movement is in the z-direction. Wall lengths of less than 10 m have been modelled as 1 m long structural elements, while greater than 10 m wall lengths have been modelled as 2 m elements to reflect the greater stiffness of the longer walls.

16 Taylor, D,W (1937). *Stability of earth slopes*. J. Boston Soc. Civ. Eng., 24, 197-246.
17 Steward, T, et al (2011). *Taylor's Slope Stability Charts Revisited*. Technical Note, Int. J. of Geomechanics., 348-352.

The full outputs of all the analyses are included within the appendix.

11.1 Ground Movements – Resulting from the Excavation

11.1.1 Model Used

Unloading of the underlying soils, particularly the clay soils of the London Clay, will take place as a result of the excavation of the proposed basement and the reduction in vertical stress will cause heave to take place. Undrained soil parameters have been used to estimate the potential short-term movements, which include the "immediate" or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total long-term movement.

The elastic analysis requires values of soil stiffness at various levels to calculate displacements. Values of stiffness for the soils at this site are readily available from published data and we have used a well-established method to provide our estimates. This relates values of E_u and E', the undrained and drained stiffness respectively, to values of undrained cohesion (Cu), as described by Padfield and Sharrock[18] and Butler[19] and more recently by O'Brien and Sharp[20]. Relationships of $E_u = 500\ C_u$ and $E' = 300\ C_u$ for the cohesive soils have been used to obtain values of Young's modulus.

More recent published data[21] indicates stiffness values of 750 x Cu for the London Clay and a ratio of E' to Cu of 0.75, but it is considered that the use of the more conservative values provides a sensible approach for this stage in the design.

The excavation of an approximately 3.0 m thickness of soil for the proposed 2.8 m deep basement structure will result in a net unloading of around 55 kN/m^2, assuming a unit weight of 17 kN/m^3 for the made ground and an average of 19 kN/m^3 for the Head Deposits and London Clay.

The soil parameters used in this analysis are tabulated below.

Stratum	Depth Range (m)	Eu (MPa)	E'(MPa)
Made Ground	GL – 1.0	12.5	7.5
Head Deposits / London Clay	1.0 – 20.0	15.0 to 95.0	9.0 to 57.0

The proposed cut slopes that will be used to form the basement excavation have been sub-divided into a series of steps to reflect the variation in stress relief that will occur as the depth of these excavations increase from ground level to proposed formation level. For the purpose of the analysis, the final stage of the excavations, when the cut slopes have reached their maximum extent, has been chosen as the most critical stage and the results of this analysis are presented below.

A rigid boundary for the analysis has been set within the London Clay at a depth of 20.0 m below ground level.

18 Padfield CJ and Sharrock MJ (1983) *Settlement of structures on clay soils.* CIRIA Special Publication 27

19 Butler FG (1974) *Heavily overconsolidated clays: a state of the art review.* Proc Conf Settlement of Structures, Cambridge, 531-578, Pentech Press, Lond

20 O'Brien AS and Sharp P (2001) *Settlement and heave of overconsolidated clays - a simplified non-linear method.* Part Two, Ground Engineering, Nov 2001, 48-53

21 Burland JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension. CIRIA Special Publication 200

11.1.2 Results

The predicted movements are summarised in the table below; the results are presented below and in subsequent tables to the degree of accuracy required to allow predicted variations in ground movements around the structure(s) to be illustrated, but may not reflect the anticipated accuracy of the predictions.

Location	Movement (mm)		
	Short-term Heave (Excavation Phase)	Long-term Heave (post construction)	Total Heave
Centre of excavations	9	7	16
Edge of excavations	2 to 3	3	5 to 6
At 5 m from edge of excavations	<1	<1	≤1

The P-Disp analysis indicates that, by the time the basement construction is complete, up to 9 mm of heave is likely to have taken place at the centre of the proposed excavations, reducing to 2 mm to 3 mm at the edges. In the long term, following completion of the basement construction, a further 7 mm of heave is estimated as a result of long term swelling of the underlying London Clay.

If a compressible material is used beneath the slab, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect, potential heave pressures are typically taken to equate to around 40% of the total unloading pressure.

12.0 DAMAGE ASSESSMENT

In addition to the above assessment of the likely movements that will result from the proposed development, any neighbouring buildings within the zone of influence of the excavations are considered to be sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 6.4 of CIRIA report C760[22].

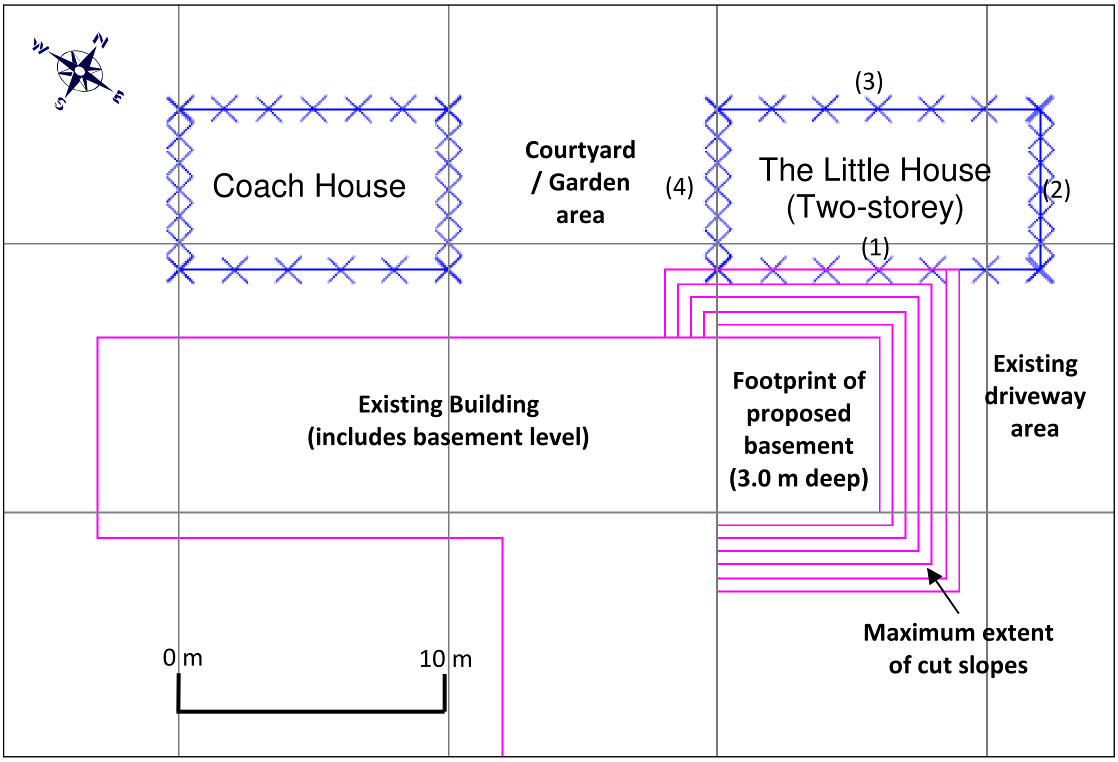
The sensitive structures outlined below have been modelled as displacement lines in the analysis along which the damage assessment has been undertaken. For clarity, these critical lines are shown on the plan overleaf.

- An adjoining two-storey house, known as The Little House, located to the north of the proposed basement.

For the analyses, it has been assumed that the foundations of The Little House generally extend to a depth of approximately 0.5 m below existing ground level, as per the information contained within the sections provided by the consulting engineer, Elliott Wood. The exception to this is southern elevation, which will be underpinned to a depth of 1.6 m prior to construction of the proposed basement.

All other nearby structures, such as the Fitzroy Farm Coach House (shown on above plan for reference purposes), located just over 10 m from the new basement structure, have been confirmed as being at sufficient distances to not be affected by the proposed excavations and the resultant ground movements.

22 Gaba, A, Hardy, S, Powrie, W, Doughty, L and Selemetas, D (2017) *Embedded retaining walls – guidance for economic design* CIRIA Report C760



The foundation depths, wall lengths and building heights of the nearby sensitive structures are summarised in the following table.

Sensitive Structure	Structure Reference	Level of foundations (m below ground level)	Wall Length, L (m)	Building Height, H (m)	L/H
The Little House	Line 1	-1.6	12.0	8.0	1.5
	Line 2	-0.5	6.0	7.0	0.9
	Line 3	-0.5	12.0	7.0	0.9
	Line 4	-0.5	6.0	7.0	0.9

12.1 Damage to Neighbouring Structures

The ground movements calculated using the P-Disp modelling software have been used to carry out an assessment of the likely damage to adjacent properties, whereby the vertical heave movements along each sensitive structure have been used to estimate the deflection ratio of the nearby sensitive structures.

Line graphs of the short-term and long-term heave movements and associated calculations for each sensitive structure are included in the appendix and the results are summarised in the table below.

Building Damage Assessment				
Sensitive Structure	Structure Reference	Max change in vertical movement, Δ along structure (mm)	Deflection Ration (Δ x 100 / L x 1000)	Category of Damage*
The Little House	Line 1	1.90	0.02	Category 0 (Negligible)
	Line 2	1.50	0.03	Category 0 (Negligible)
	Line 3	0.18	<0.01	Category 0 (Negligible)
	Line 4	0.04	<0.01	Category 0 (Negligible)

**From Table 6.4 of C760: Classification of visible damage to walls.*

The building damage reports for sensitive structures highlighted in the above table predict that the damage to the adjoining and nearby structures would generally be Category 0 (negligible).

12.2 Monitoring of Ground Movements

The predictions of ground movement based on the ground movement analysis should be checked by monitoring of the adjacent properties and structures. The structures to be monitored during the construction stages should include the existing property and the neighbouring structure assessed above. Condition surveys of the above existing structures should be carried out before and after the proposed works.

The precise monitoring strategy will be developed at a later stage and it will be subject to discussions and agreements with the owners of the adjacent properties and structures. Contingency measures will be implemented if movements of the adjacent structures exceed predefined trigger levels. Both contingency measures and trigger levels will need to be developed within a future monitoring specification for the works.

13.0 GMA CONCLUSIONS

The analysis has concluded that the proposed open-cut excavations will remain stable during the period of construction and that the predicted damage to the neighbouring properties from the construction of the basement retaining walls and excavation would be ‘Negligible.

On this basis, the damage that has been predicted to occur as a result of the construction the proposed basement falls within the acceptable limits, although careful construction, including the careful control of the proposed open-cut excavations, and monitoring will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

Part 4: BASEMENT IMPACT ASSESSMENT

14.0 BASEMENT IMPACT ASSESSMENT

The screening identified several 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 nearest surface water feature is 38 m southeast of the site	Although the nearest water feature has been identified within close proximity of the site, it is inferred that groundwater encountered within the investigation correlates to perched groundwater within more granular material, and that the nature of the soil is unlikely to sustain any regional groundwater regime. It is therefore not considered that the proposed basement will impact any nearby water course and will not restrict any regional groundwater flow. It should be noted however that localised perched groundwater may affect the construction process and this should be managed appropriately.
The site exists within the Highgate Chain Catchment area	As the site is underlain directly by London Clay, any water moving to the nearby watercourse is likely to do so primarily as surface water flow, given the soils inability to support regional groundwater flow. Due to this, it is not considered that the proposals will have any significant effect on the current drainage regime, given the nature of the shallow clay soils.
The proposed extension will slightly increase the proportion of hard surfaced/paved areas to the north of the existing pool house	As the site is underlain directly by London Clay, any water moving to the nearby watercourse is likely to do so primarily as surface water flow, given the soils inability to support regional groundwater flow. Due to this, it is not considered that the proposals will have any significant effect on the current drainage regime, given the nature of the shallow clay soils.
London Clay is the shallowest stratum on the site	Despite trees existing across the site, the London Clay was not visually assessed as being desiccated, which was confirmed through the laboratory testing.

Potential Impact	Site Investigation Conclusions
The site is within an area likely to be affected by seasonal shrink-swell	The London Clay is the shallowest stratum at the site and laboratory testing has indicated a high volume change potential. Shrinkable clay is present within a depth that can be affected by tree roots, however, desiccation was not observed and in any case the foundations for the proposed basement would be expected to bypass any desiccated soils. Furthermore, the Ground Movement Assessment undertaken as Part 3 of this report considers the proposed basement excavation to fall within the acceptable damage limits.
The development is within 5 m of a pedestrian right of way	The investigation has not indicated any specific problems, such as weak or unstable ground, voids or a high water table that would make working within 5 m of public infrastructure particularly problematic at this site. In addition, although the site exists within 5 m of the highway, the proposed development is beyond this zone.
The proposed basement may increase the differential depth of foundations relative to neighbouring properties	The Ground Movement Assessment undertaken as Part 3 of this report considers the proposed basement excavation to fall within the acceptable damage limits.

The results of the site investigation and GMA 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.

London Clay is the Shallowest Stratum / Seasonal Shrink-Swell

The proposed basement will extend to a depth such that new foundations will be expected to bypass any desiccated soils.

Provided that foundations extend below the required depths in accordance with NHBC guidelines, and subject to inspection of foundation excavations in the normal way to ensure that there is not significant unexpectedly deep root growth, it is not considered that the occurrence of shrink-swell issues in the local area has any additional bearing on the proposed development.

The GMA analysis has concluded that the proposed open-cut excavations will remain stable during the period of construction and that predicted damage to the neighbouring properties from the construction of the proposed basement would be 'Negligible'. Nevertheless, careful construction, including the careful control of the proposed open-cut excavations, and monitoring will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

Perched Groundwater may exist

Despite the London Clay not being capable of supporting regional scale groundwater conditions, it may be that localised perched groundwater exists within granular pockets. Measures should be taken to mitigate this and any water bodies encountered during construction should be monitored and managed throughout and after the development is completed.

14.1 BIA Conclusion

A Basement Impact Assessment has been carried out following the information and guidance published by the London Borough of Camden.

Information from a Site Investigation and Ground Movement Assessment have been used to assess potential impacts identified by the screening process.

It is concluded that the proposed development is unlikely to result in any specific land or slope stability issues, groundwater or surface water issues.

15.0 NON-TECHNICAL SUMMARY

This section provides a short summary of the evidence acquired and used to form the conclusions made within the BIA.

15.1 Screening

The following table provides the evidence used to answer the surface water flow and flooding screening questions.

Question	Evidence
1. Is the site within the catchment of the pond chains on Hampstead Heath?	Figures 12 and 14 of the Arup report.
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?	A site walkover and existing plans of the site have confirmed the proportions of hardstanding and soft landscaping, which have been compared to the proposed drawings to determine the changes in the proportions.
3. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	
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?	A site walkover and review of plans.
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?	Flood risk maps acquired from the Environment Agency as part of the desk study, Figure 15 of the Arup report, the Camden Flood Risk Management Strategy dated 2013 and the North London Strategic Flood Risk Assessment dated 2008.

The following table provides the evidence used to answer the subterranean (groundwater flow) screening questions.

Question	Evidence
1a. Is the site located directly above an aquifer?	Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 5 and 8 of the Arup report.
1b. Will the proposed basement extend beneath the water table surface?	Observations during the site investigations.
2. Is the site within 100 m of a watercourse, well (used/ disused) or potential spring line?	Historical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report.
3. Is the site within the catchment of the pond chains on Hampstead Heath?	Figures 12 and 14 of the Arup report.
4. Will the proposed basement development result in a change in the proportion of hard surfaced / paved areas?	A site walkover and existing plans of the site have confirmed the proportions of hardstanding and soft landscaping, which have been compared to the proposed drawings to determine

Question	Evidence
	the changes in the proportions.
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)?	The details of the proposed development do not indicate the use of soakaway drainage.

The following table provides the evidence used to answer the subterranean (groundwater flow) screening questions.

Question	Evidence
1. Does the existing site include slopes, natural or manmade, greater than 7°?	Site survey drawing and Figures 16 and 17 of the Arup report and confirmed during a site walkover
2. Will the proposed re-profiling of landscaping at the site change slopes at the property boundary to more than 7°?	The details of the proposed development provided do not include the re-profiling of the site to create new slopes
3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7°?	Topographical maps and Figures 16 and 17 of the Arup report and confirmed during a site walkover
4. Is the site within a wider hillside setting in which the general slope is greater than 7°?	
5. Is the London Clay the shallowest strata at the site?	Geological maps and Figures 3, 5 and 8 of the Arup report
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?	A site walkover confirmed that there are trees on site. An arboriculturist should be consulted if any trees are to be removed from the site.
7. Is there a history of seasonal shrink-swell subsidence in the local area and / or evidence of such effects at the site?	Knowledge on the ground conditions of the area was used to make an assessment of this, in addition to a visual inspection of the buildings carried out during the site walkover
8. Is the site within 100 m of a watercourse or potential spring line?	Topographical maps acquired as part of the desk study and Figures 11 and 12 of the Arup report
9. Is the site within an area of previously worked ground?	Geological maps and Figures 3, 5 and 8 of the Arup report
10. Is the site within an aquifer?	Aquifer designation maps acquired from the Environment Agency as part of the desk study and Figures 3, 5 and 8 of the Arup report.
11. Is the site within 50 m of Hampstead Heath ponds?	Topographical maps acquired as part of the desk study and Figures 12 and 14 of the Arup report.
12. Is the site within 5 m of a highway or pedestrian right of way?	Site plans and the site walkover.
13. Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	Camden planning portal and the site walkover confirmed the position of the proposed basement relative to the neighbouring properties.
14. Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Maps and plans of infrastructure tunnels were reviewed.

15.2 Scoping and Site Investigation

The questions in the screening stage that required further assessment, were taken forward to a scoping stage and the potential impacts discussed in Section 4.0 of this report, with reference to the possible impacts outlined in the Arup report.

A ground investigation was carried out, which has allowed an assessment of the potential impacts of the basement development on the various receptors identified from the screening and scoping stages. Principally the investigation aimed to establish the ground conditions, including the groundwater level, and the engineering properties of the underlying soils, to enable suitable design of the basement development and the configuration of existing party wall foundations. The findings of the investigation are discussed in Section 5.0 of this report and summarised in both Section 7.0 and the Executive Summary.

15.3 Impact Assessment

Section 13.0 of this report summarises whether or not, on the basis of the findings of the investigation, the potential impacts still need to be given consideration and identifies ongoing risks that will require suitable engineering mitigation. Section 8.0 of this report also provides recommendations for the design of the proposed development.

A Ground Movement Analysis including a building damage assessment has been completed and the results are presented in Part 3 of this report.

16.0 OUTSTANDING RISKS AND ISSUES

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

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

As discussed throughout the report, groundwater is likely to be encountered during the basement excavation although groundwater monitoring should be continued, and trial excavations should be considered to assess the extent of inflows to be expected within the proposed basement excavations.

Asbestos was identified in two samples of made ground tested. It is recommended that asbestos quantification tests are undertaken on the positive asbestos results in order to assist in waste disposal costs. With this exception, the investigation has not identified the presence of any other significant contamination, and as the made ground will be removed from this site through the excavation of the proposed basement, remedial measures should not be required, other than where areas of soft landscaping are to be formed. However, as with any site there is a potential for further areas of contamination to be present within the made ground beneath parts of the site not covered by the investigation it is recommended that a watching brief is maintained during any groundworks for the proposed new foundations and that if any suspicious soils are encountered that they are inspected by a geoenvironmental engineer and further assessment may be required.

As only a limited number of samples have been tested, it would be prudent to carry out contamination testing on additional samples of made ground / topsoil recovered from the areas of the site that are to remain as soft landscaped gardens, in order to ensure the absence of any significant contamination.

The GMA analysis has concluded that the proposed open-cut excavations will remain stable during the period of construction and that predicted damage to the neighbouring properties from the construction of the proposed basement falls well within acceptable limits.

Nevertheless, careful construction, including the careful control of the proposed open-cut excavations, and monitoring will be required to ensure that no excessive movements occur that would lead to damage in excess of these limits.

These items should be drawn to the attention of prospective contractors and further investigation will be required or sufficient contingency should be provided to cover the outstanding risk.

APPENDIX

Site Plan

Borehole Records

Trial Pit Records

Results of Rising Head Tests

Geotechnical Laboratory Test Results

Chemical Analyses (Soil)

Generic Risk Based Screening Values

Envirocheck Report Summary

Site Plan Over Arup Figure 16

Historical Maps

Preliminary UXO Risk Assessment

Service Search Records

Proposed Construction Sequence

SLOPE-W ANALYSIS

Section Plots for Critical Slopes

P-DISP ANALYSIS

Short Term Movement

Total Movement

BUILDING DAMAGE ASSESSMENT

Displacement (Line) Graphs