GROUND INVESTIGATION AND BASEMENT IMPACT ASSESSMENT REPORT

for the site at

1 SPENCER RISE, CAMDEN, LONDON NW5 1AR

on behalf of

EDWARD WILLIAMS C/O EDWARD WILLIAMS ARCHITECTS

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File Reference: Ground and Water/Project Files/ GWPR2459 1 Spencer Rise, Camden			

CONTENTS

FIGURES

APPENDICES

1.0 INTRODUCTION

1.1 General

Ground and Water Limited were instructed by Edward Williams Architects, on the 30th January 2018, to undertake a Ground Investigation and Basement Impact Assessment on a site at 1 Spencer Rise, Camden, London, NW5 1AR. The scope of the investigation was detailed within the Ground and Water Limited fee proposal ref: GWQ3661.

1.2 Aims of the Investigation

The aim of the investigation was understood to be to supply the client and their designers with information regarding the ground conditions underlying the site to assist them in preparing an appropriate scheme for development.

The investigation was to be undertaken to provide parameters for the design of foundations by means of in-situ and laboratory geotechnical testing undertaken on soil samples recovered from trial holes.

The requirements of the Camden Planning Guidance Basements and Lightwells (CPG4), July 2015, and London Borough of Camden, Camden Geological, Hydrogeological and Hydrological Study, Guidance for Subterranean Development (November 2010) was reviewed with respect to this report.

A Desk Study and full scale contamination assessment were not part of the remit of this report.

The techniques adopted for the investigation were chosen considering the anticipated ground conditions and development proposals on-site, and bearing in mind the nature of the site, limitations to site access and other logistical limitations.

1.3 Conditions and Limitations

This report has been prepared based on the terms, conditions and limitations outlined within Appendix A.

2.0 SITE SETTING/GEOTECHNICAL DESK STUDY

2.1 Site Location

The site comprised a 113m^2 rectangular shaped plot of land, orientated in a north-west to south-east direction, located on the north-western side of Spencer Rise. The site was located ~330m east of Highgate Road, which ran parallel to Hampstead Heath. The site was located in Dartmouth Park, a district in North London within the London Borough of Camden.

The national grid reference for the centre of the site was approximately TQ28877 86014. A site location plan is given within Figure 1. A plan showing the site area is given within Figure 2.

2.2 Site Description

The site comprised a two-storey brick build residential dwelling and was accessed from Spencer Rise via a narrow gate. A small garden with various shrubs was noted at the front of the property with a decked area at the rear. The house was set into a shallow to moderate slope along Spencer Rise, sloping up to the north-east. The slope was measured at an angle of 5 – 7^o. An aerial view of the site is given within Figure 3 and a slope section of Spencer Rise can be seen in Figure 4.

An inspection of an onsite topographical survey, which can be seen in Figure 5, indicated that the front garden of No. 1 Spencer Rise had an elevation of 48.24m AOD and remained relatively level across the site. The rear garden stepped up slightly to an elevation of 48.70m AOD. An existing sectional drawing of the site can be seen in Figure 6.

It was understood that No. 1c Spencer Rise had a lower ground floor/semi-basement at the rear of the building to a depth of ~1.20m bgl. No. 3 Spencer Rise did not appear to have an existing basement. A sectional plan showing the current differential ground floor depths at the rear of the property can be seen in Figure 7.

2.3 Proposed Development

At the time of reporting, April 2018, the proposed development was understood to include the excavation of a single storey basement below the entire footprint of the building. The basement floor was to be constructed at a depth of ~4.00m bgl. A plan view and sectional view of the proposed development can be seen in Figure 8 and Figure 9 respectively.

The proposed development fell within Geotechnical Design Category 2 in accordance with Eurocode 7.

Based on data supplied by the structural engineer, it was understood that the basement will be constructed based on loading bearing retaining wall underpins and a lower ground floor slab. The loads implied by the retaining wall were expected to range between 69.90 – 99.00kN/m^2. The thickened edges were likely to range between 1200mm – 2000mm thick. The remainder of the construction will comprise a semi-ground bearing concrete slab with self weight of ~10kN/m^2.

Foundation exposures undertaken at the front and rear of 1 Spencer Rise, revealed the existing party walls between 1 Spencer Rise and 1c Spencer Rise and 3 Spencer Rise were likely to be founded at a depth of between 0.37m – 0.93m. Both walls were found to have brick corbel footings and between 90 – 250mm wide.

The proposed development was understood not to involve any re-profiling of the site and its immediate environs. It is understood that no trees will be removed to facilitate the construction of the basement. However, trees were noted along the public pavement along Spencer Rise, ~3m from the front of the proposed lightwell.

2.4 Site History

The object of this search was to report on the history of the site and its environs from available County Series, Ordnance Survey and Aerial Photography Maps dating from the mid 19th Century to the present day and downloaded from Groundsure Environmental Insight. In the following sections dealing with individual maps, only features considered to have a potential impact on the site and usually within a notional 250 metre radius of the site boundaries are discussed. Any distances quoted for features remote from the site have been scaled from the maps and are only approximate. The north point and approximate extent of the site are indicated on each figure. The historical maps referred to are given within Appendix B. The implications of the map search are discussed later within this report. The historic map review can be seen tabulated below and overleaf.

Table 1: Environmental Significance of Data From Historical Maps

Date	Scale	Site	Environs
1871	1:1,056	A small structure, assumed to be residential, was noted in the south-eastern portion of site.	An identical, terraced structure was noted directly east of site. A number of similar structures, assumed to be residential, were noted >20m north, east and south-east of site. A railway line was noted ~100m south-east of site. A pond and open land was noted ~50m west.
1896	1:1,056 1:2,500	The structure on site had been demolished and rebuilt into a larger, terraced structure of similar shape and configuration to that noted during the Site Walkover.	The surrounding area was fully developed with residential terraced housing. Cuttings and earthworks associated with the railway line were noted ~100m south-east and an imperial laundry was noted ~150m south-east. Highgate Road Station was constructed ~250m south-west. The pond noted ~50m west had been infilled with residential housing developed in its place. Remainder as previous map.
1915	1:2,500	As previous map.	A nursery was noted ~200m south-east. An Electric Generating Station with associated cuttings/earthworks had been constructed ~230m south of site. A miniature rifle range and nursery was noted ~120m and 240m south-west respectively. Remainder as previous map.
1936	1:2,500	As previous map.	The Electricity Generating Station noted ~230m south became a Harbar Works (Iron Strip and Bar). The miniature rifle range became an Allotment Garden. Remainder as previous map.
1951 – 1952	1:1,250	The site was labelled at 1 Spencer Rise. Remainder as previous map.	A ruin was noted ~150m east of site. The nursery ~200m south-east became an Allotment Garden. A pan factory was established ~180m south. A tunnel was constructed ~230m south/south-east of site and number of drains were noted within the railway line ~100m south-east of site. The allotment garden had been redeveloped with a number of residential homes were developed in its place. Remainder as previous map.
1952	1:2,500	No data	Limited data, assumed as previous map.
1952 – 1954	1:1,250	As previous map.	As previous map.
1962 – 1967	1:1,250	As previous map.	A portion of the railway line ~100m south-east had been rerouted underground and a number of buildings, including a school, had been developed in its pace. The pan factory was labelled as an unspecified factory. The Harbar Works, ~230m south of site, was no longer labelled and a dismantled railway was noted 230m south-east. Remainder as previous map.
1967 – 1968	1:2,500	As previous map.	The previously named Harbar Works ~230m south of had been demolished. Remainder as previous map.
1968 – 1973	1:1,250	No data for the northern portion of the site. Remainder as previous map.	No data to the north and distant south-east. The demolished area ~230m south of site had been redeveloped into residential housing with some associated cuttings. Remainder as previous map.
1970	1:2,500	Poor data, assumed as previous map.	Poor data, assumed as previous map.
1974	1:1,250	No data	No data to the south. Limited data, assumed as previous map.
1975 – 1977	1:1,250	A previous map.	Electricity sub-stations had been constructed ~120m north-east and ~90m north-west. Remainder as previous map.

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Table 1: Environmental Significance of Data From Historical Maps - Cont'd

Date	Scale	Site	Environs
1979 - 1981	1:1,250	No data for the northern portion of the site. Remainder as previous map.	No data to the north, Remainder as previous map.
1981 - 1984	1:1,250	No data for the northern portion of the site. Remainder as previous map.	No data to the north, Remainder as previous map.
1988 - 1991	1:1,250	A previous map.	An electricity sub-station was noted ~240m north-west of site. Remainder as previous map.
1991	1:1,250	A previous map.	An electricity sub-station was noted ~90m south of site. Remainder as previous map.
1991 – 1995	1:1,250	No data for the northern portion of the site. Remainder as previous map.	No data to the north, Remainder as previous map.
1992 - 1995	1:1,250	No data for the northern portion of the site. Remainder as previous map.	No data to the north, Remainder as previous map.

2.5 Geology

The geology map of the British Geological Survey of Great Britain of the Hampstead area (Sheet No. 256 North London) revealed the site to be situated on the London Clay Formation.

Figure 3 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 10 of this report) and the BGS geology maps indicated that no Made Ground or Worked Ground was noted within a close proximity of the site

London Clay Formation

The London Clay Formation comprises stiff grey fissured clay, weathering to brown near surface. Concretions of argillaceous limestone in nodular form (Claystones) occur throughout the formation. Crystals of Gypsum (Selenite) are often found within the weathered part of the London Clay Formation, and precautions against sulphate attack to concrete are sometimes required. The lowest part of the formation is a sandy bed with black rounded gravel and occasional layers of sandstone and is known as the Basement Bed.

A BGS borehole ~288m north-east of site revealed 0.30m bgl of Made Ground overlying a brown clay to 3.60m bgl. A brown and blue mottled clay was then noted to 5.10m bgl, overlying a dark brown clay to the base of the borehole, a depth of 10.66m bgl. No groundwater was encountered.

2.6 Slope Stability and Subterranean Developments

The site was situated within an area where a natural or man-made slope of less than 7^{o} was present (Figure 16 Camden Geological, Hydrogeological and Hydrological Study, Figure 11 of this report). Sectional drawings of Spencer Rise revealed the street sloped between 5 – 7^{o} (Figure 4).

Figure 17 of the Camden Geological, Hydrogeological and Hydrological Study indicated the site was not situated within an area prone to landslides (see Figure 12 of this report).

Figure 18 of the Camden Geological, Hydrogeological and Hydrological Study indicated that the site was located ~90m north of the London Overground (see Figure 13 of this report).

2.7 Hydrogeology and Hydrology

A study of the aquifer maps on the DEFRA website, and Figure 8 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 14 of this report), revealed the London Clay Formation comprised an **Unproductive Strata**. No designation was given for any superficial deposits due to their likely absence.

Superficial (Drift) deposits are permeable unconsolidated (loose) deposits, for example, sands and gravels. The bedrock is described as solid permeable formations e.g. sandstone, chalk and limestone.

Unproductive Strata's are defined as rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

Examination of the DEFRA records and Figure 8 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 14 of this report) showed that the site did not fall within a Groundwater Source Protection Zone as classified in the Policy and Practice for the Protection of Groundwater.

In accordance with Figure 12 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 14 of this report), the nearest surface water feature was Highgate No. 1 Pond, noted ~900m north-west of site. However, online maps showed an unnamed drain ~116m north of site.

In accordance with Figure 11 of the Camden Geological, Hydrogeological and Hydrological Study a historical watercourse was noted ~100m west of site, between the site and Highgate Road (Figure 16 of this report).

Figure 14 of the Camden Geological, Hydrogeological and Hydrological Study revealed the site was not located within the catchment of Hampstead Ponds (see Figure 17 of this report).

The study of the 1871 historic maps revealed a pond ~50m west of site, which was infilled and developed over by 1896. No wells were noted in a 250m radius and a study of BGS borehole records indicated no private water abstraction boreholes in a close proximity of the site.

From analysis of hydrogeological and topographical maps, groundwater was anticipated to be encountered at moderate to deep depth (5 – >10m below existing ground level (bgl)) and it was considered that the groundwater was flowing in a south-easterly direction in accordance with the local topography.

Examination of the Environment Agency records showed that the site was not situated within a floodplain or flood warning area. Figure 15 the Camden Geological, Hydrogeological and Hydrological Study revealed Spencer Rise did not experience any flooding in 1975 and 2002. However, that an area ~200m north experience flooded streets in 2002 and Highgate Road, ~320m east of site, experienced flooded streets in 1975 (see Figure 18 of this report).

A plan showing the location of the site with respect to Environment Agency Flood Maps can be seen in Figure 19.

Data from the Environment Agency website indicated Spencer Rise was not at a risk of surface water flooding. However, York Rise, ~40m west of site, was classified as low risk, where there was a chance of surface water flooding of between 0.1% and 1%. A plan showing the location of the site with respect to Environment Agency Surface Water Flooding Maps can be seen in Figure 20.

2.8 Radon

BRE 211 (2015) Map 5 of London, Sussex and West Kent revealed the site **was not** located within an area where mandatory protection measures against the ingress of Radon were required. The site **was not** located within an area where a risk assessment was required.

2.9 Geotechnical Conceptual Site Model

The following geotechnical concerns have been formulated by this desk-based review and should be analysed by intrusive investigation:

- Soils with the potential for volume change potential are likely to be encountered under the site. Soils volume change potential to be determined along with depth of root penetration with reference to proximity of nearby trees;
- Potential for Made Ground due to construction activities in site history;
- Basement excavation and land stability given neighbouring properties and roads;
- Potential for shallow groundwater to be encountered perched within shallow Made Ground;
- Temporary works whilst underpinning;
- Surface Water Run-off;
- Heave of soils following overburden pressure release;
- Differential foundation depths between No. 1c and 3 Spencer Rise;
- Proximity of pedestrian walkway (~1m) and tree (~3m).

3.0 BASEMENT IMPACT ASSESSMENT

This stage should identify any areas of concern and therefore focus efforts on further investigation.

3.1 Stage 1: Screening

3.1.1 Subterranean (Groundwater) Screening Flowchart

Question 1a. Is the site located directly above an aquifer?

No. A study of the aquifer maps on the DEFRA website, and Figure 8 of the Camden Geological, Hydrogeological and Hydrological Study, revealed the site to be located on an Unproductive Strata relating to the London Clay Formation (see Figure 14 of this report). **No further action.**

Question 1b. Will the proposed basement extend beneath the water table surface?

Unlikely. From analysis of hydrogeological and topographical maps, groundwater was anticipated to be encountered at moderate depth to depth (5 – >10m below existing ground level (bgl)). The basement floor was to be constructed at 4.00m bgl. **However, Ground Investigation could be considered. Take forward to scoping.**

Question 2. Is the site within 100m of a watercourse, well (used/disused) or potential spring line?

No. No current watercourse, wells or potential spring lines are noted within a 100m radius of the site. In accordance with Figure 11 of the Camden Geological, Hydrogeological and Hydrological Study a historical watercourse was noted ~100m west of site, between the site and Highgate Road (Figure 16 of this report). **No further action.**

Question 3. Is the site within the catchment of the pond chains on Hampstead Heath?

No. Figure 14 of the Camden Geological, Hydrogeological and Hydrological Study revealed the site was not located within the catchment of Hampstead Ponds (see Figure 17 of this report). **No further action.**

Question 4. Will the proposed development result in a change in the proportion of hard surface/paved areas?

Marginally. The basement will be excavated below the entire footprint of the existing building. Two small skylights will be constructed at the front and rear of the property. **Take forward to scoping.**

Question 5. As part of the 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)?

Marginally. At the time of reporting, April 2018, no significant change in the amount of surface water discharged into the ground was anticipated. **Take forward to scoping.**

Question 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. As the basement floor was proposed to be founded at 4.00m bgl the lowest point of the proposed excavation will not be in close proximity or lower than the mean water level. **No further action.**

3.1.2 Land Stability Screening Flowchart

Question 1. Does the existing site include slopes, natural or manmade, greater than 7 degrees (approximately 1 in 8)?
No. The site was situated within an area where a natural or man-made slope of less than 7° was present (Figure 16 Camden Geological, Hydrogeological and Hydrological Study, Figure 11 of this report). Sectional drawings of Spencer Rise revealed the street sloped between 5 – 7° (Figure 4). **No further action.**

Question 2. Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7deg (approximately 1 in 8)?
No. No re-profiling of landscaping is anticipated to occur. **No further action.**

Question 3. Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7deg (approximately 1 in 8)?
No. Sectional drawings of Spencer Rise revealed the street sloped between 5 – 7° (Figure 4). There were no railway cuttings in the immediate vicinity. **No further action.**

Question 4. Is the site within a wider hillside setting in which the general slope is greater than 7degrees (approximately 1 in 8)?
No. Sectional drawings of Spencer Rise revealed the street sloped between 5 – 7° (Figure 4). There was an area ~330m south-west, associated with the London Overground, which showed angles of >7° degrees (Figure 16 of the Camden Geological, Hydrogeological and Hydrological Study, see Figure 11 of the report). **No further action.**

Question 5: Is the London Clay the shallowest strata at the site?
Yes, the geological map (sheet 256) indicated that the site was underlain by the London Clay Formation only. **No further action.**

Question 6: Will any tree/s 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? (Note that consent is required from LB Camden to undertake work to any tree/s protected by a Tree Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions).
Yes. No trees are to be felled or planted in the excavation of the basement. However, the proposed front lightwell will be constructed ~3m from trees planted along Spencer Rise. **Take forward to scoping.**

Question 7: Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?
None known. However, the London Clay Formation was indicated as being present at the property, which has the potential for volume change. **Take forward to scoping.**

Question 8: Is the site within 100m of a watercourse or a potential spring line?
No. No current watercourse, wells or potential spring lines are noted within a 100m radius of the site. In accordance with Figure 11 of the Camden Geological, Hydrogeological and Hydrological Study a historical watercourse was noted ~100m west of site, between the site and Highgate Road (Figure 16 of this report). **No further action.**

Question 9: Is the site within an area of previously worked ground?
No. Examination of the geology maps revealed the area was not in the vicinity of worked ground. However, there will be some Made Ground associated with past construction

activities (see Geotechnical Desk Study). **Take forward to scoping.**

Question 10: Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?
No. The London Clay Formation was classified by the DEFRA as an **Unproductive Strata** (rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow). **No further action.**

Question 11: Is the site within 50m of the Hampstead Heath ponds?
No. The Highgate ponds were 900m – 1.3km north-west and the Hampstead ponds were situated ~1.5km west. **No further action.**

Question 12: Is the site within 5m of a highway or pedestrian right of way?
Yes. The nearest highway and pedestrian right of way was noted ~1.9m south-east. **Take forward to scoping.**

Question 13: Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties? Yes. It was understood that No. 1c Spencer Rise had a lower ground floor/semi-basement at the rear of the building to a depth of ~1.20m bgl (below rear garden level). No. 3 Spencer Rise did not appear to have an existing basement. Therefore, it was likely a Ground Movement Analysis (GMA) will be required. **Carry forward to scoping.**

Question 14: Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?
No. The site was approximately 100m north from the nearest railway and 812m of the nearest tunnel. **No further action.**

3.1.3 Surface Water and Flooding Screening Flowchart

1. Is the site within the catchment of the pond chains of Hampstead Heath?
No. Figure 14 of the Camden Geological, Hydrogeological and Hydrological Study revealed the site was not located within the catchment of Hampstead Ponds (see Figure 17 of this report).

2. As part of the of the proposed site drainage, will surface water flows be materially changed from the existing route?
No. The existing surface water routes will be not changed by the development. **No further action**.

3. Will the proposed basement development result in a change to the hard surfaces/paved external areas?
No. The basement will be excavated below the entire footprint of the existing building. Two small skylights will be constructed at the front and rear of the property. **No further action.**

4. Will the proposed basement result in changes to the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses?
No. Surface water that is received by adjacent properties and downstream watercourses is not from the site. This will remain the case with the proposed development. **No further action.**

5. Will the proposed basement result in a change to the surface water being received by adjacent properties or downstream watercourses?
No. Collected surface water will be from building roofs and paving, as before. The quality of the water received downstream will therefore not change. **No further action.**

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 from flooding, for example, because the basement is below the static water level of a nearby surface water feature?

No.

Please see table below:

Flood Risks Overview		
Potential Source	**Potential Flood Risk at Site?**	**Justification**
Fluvial Flooding	No	EA Flood Mapping shows site was not located within a Flood Zone. No surface water features within a close proximity of the site.
Tidal Flooding	No.	EA Flood Mapping shows site was not located within a Flood Zone.
Flooding from Rising/High Groundwater	No.	From analysis of hydrogeological and topographical maps groundwater was anticipated to be encountered at moderate to deep depth (5 - >10m bgl).
Surface Water (Pluvial) Flooding	No	Figure 12 the Camden Geological, Hydrogeological and Hydrological Study revealed that whilst the site was not subject to surface water flooding (See Figure 12 of this report).
Flooding From Infrastructure Failure	No	Figure 12 the Camden Geological, Hydrogeological and Hydrological Study revealed that whilst the site was not subject to surface water flooding (See Figure 12 of this report).
Flooding from Reservoirs, Canals and other artificial sources	No.	There were no reservoirs, canals or other artificial sources in a close proximity of the site that could give rise to a flood risk.

3.2 Stage 2: Scoping

3.2.1 Conceptual Site Model & Matters of Concern

There are nine areas of concerns that the Screening process have highlighted.

1. **Perched water within the Made Ground or the London Clay Formation** – the basement may encounter groundwater, associated with perched groundwater within any Made Ground or sand or silt bands within the London Clay Formation, during construction. This is to be taken forward for further assessment to confirm depth of any perched water;

2. **Soil Moisture** – There was potential for soil moisture content to affect the development. This is to be taken forward for further assessment;

3. **The London Clay Formation/Shrink and Swell** – The basement was anticipated to be founded in soils of the London Clay Formation. The soils were likely to have high plasticity and volume change potential. The concrete mix design should take appropriate account of sulphate levels (testing to BRE Special Digest). Heave on removal of overburden pressure may be a risk;

4. **Potential for Made Ground;** Examination of the geology maps revealed the area was not in the vicinity of worked ground. However, there will be some Made Ground associated with past construction activities;

5. **Differential Foundation Depths** – It was understood that No. 1c Spencer Rise had a lower ground floor/semi-basement at the rear of the building to a depth of ~1.20m bgl (below rear garden level). No. 3 Spencer Rise did not appear to have an existing basement. Therefore, it was likely a Ground Movement Analysis (GMA) will be required.

6. **Retaining Walls** should be appropriately designed**;**

7. **Tree and Bushes.** No trees were located in the garden although there were some bushes and small trees in the rear garden. A tree along Spencer Rise was located ~3m from the location of the proposed front lightwell. Care should be taken to minimise root damage during construction works. Should bushes be removed there is potential for the soils to swell as a result which may affect this and neighbouring properties and this should be accounted for in design and further assessed. **An arboricultural assessment on impact of the tree should be undertaken. The basement is to be constructed outside of the tree canopy so thought to be low risk**;

8. **Surface Water/Drainage.** The basement includes the construction of two small skylights at the front and rear of the basement. Therefore, there will only be a marginal increase in amounts of hardstanding onsite and the lightwells will be drained via a sump. **To be carried forward into structural design;**

9. **Proximity of Pedestrian Pathways.** The structural design of the basement will need to ensure the structural integrity of the pedestrian pathways are not affected. **To be carried forward into structural design.**

A site-specific ground investigation should be undertaken to inform design. The scope of the investigation can be seen within Section 4 of this report. The results of the investigation are given within Sections 5 and 6 with the conclusions and recommendations provided within Section 7 of this report.

A ground movement assessment should be undertaken. The results of ground movement assessments undertaken on the neighbouring properties to the site can be seen within Section 7.7 of this report.

4.0 FIELDWORK

4.1 Scope of Works

Site works were undertaken on the 7th February 2018 and comprised the hand excavation of 2No. Trial Pit Foundations Exposures (TP/FE1 – TP/FE2) to depths of between 0.52m – 1.10m bgl. 2No. Hand Held Window Sampler Boreholes (WS1 – WS2) were drilled through the base of the trial holes, to depths of between 4.50m – 4.70m bgl.

A 50mm groundwater monitoring well was installed in WS1 to 4.70m bgl. The construction of the well installed can be seen tabulated below.

Combined Ground-gas and Groundwater Monitoring Well Construction				
Trial Hole	Depth of Installation (m bgl)	Thickness of slotted piping with gravel filter pack (m)	Depth of plain piping with bentonite seal (m bgl)	Piping external diameter (mm)
WS1	4.70m	3.70m	1.00m	50mm

The approximate locations of the trial holes can be seen within Figure 21.

Prior to commencing the ground investigation, a walkover survey was carried out to identify the presence of underground services and drainage. Where underground services/drainage were suspected and/or positively identified, exploratory positions were relocated away from these areas.

4.2 Sampling Procedures

Small disturbed samples were recovered from the trial holes at the depths shown on the trial hole records. Soil samples were generally retrieved from each change of strata and/or at specific areas of concern. Samples were also taken at approximately 0.5m intervals during broad homogenous soil horizons.

A selection of samples were despatched for geotechnical testing purposes.

5.0 ENCOUNTERED GROUND CONDITIONS

5.1 Soil Conditions

All exploratory holes were logged by Alice Tettmar of Ground and Water Limited, generally in accordance with BS EN 14688 'Geotechnical Investigation and Testing – Identification and Classification of Soil'.

The ground conditions encountered within the trial holes drilled on the site generally conformed to that anticipated from examination of the geology map. A capping of Made Ground was noted to overlie the soils of the London Clay Formation.

The ground conditions encountered during the investigation are described in this section. For more complete information about the Made Ground and the London Clay Formation at particular points, reference must be made to the individual trial hole logs within Appendix C.

The trial hole location plan can be viewed in Figure 21.

For the purposes of discussion, the succession of conditions encountered in the trial holes in descending order can be summarised as follows:

Made Ground
London Clay Formation

Made Ground

Made Ground was encountered from ground level in WS1/TP1 and underlying wooden decking from 0.12m in WS2/TP2 to a depth of between 0.40m - 0.90m bgl. The soils comprised a dark brown/grey clayey gravelly silty sand to a sandy gravelly clay. The sand was fine to coarse grained. The gravel occasional, fine to medium, angular to sub-rounded flints, brick, concrete, plasterboard, glass and plastic. Local pockets of dark brown sand were noted throughout WS2/TP2.

London Clay Formation

Soils of the London Clay Formation were encountered underlying the Made Ground from 0.40m - 0.90m bgl, for the remainder of the both trial holes, a depth of 4.50m – 4.70m bgl. The soils generally comprised a brown/dark orange/dark brown/bluish grey mottled silty sandy clay. The sand was fine to coarse grained. Pockets of orange sand was noted in WS2 between 0.40m – 2.10m bgl. Very fine selenite crystals were also encountered in WS2 between 2.10m – 4.50m bgl and 3.50m – 4.70m bgl in WS1.

Onsite engineer appraisals of the soils recovered from the London Clay Formation indicated the soils to be stiff.

5.2 Foundation Exposures

A description of the foundation layout and ground conditions encountered within the hand dug trial pit/foundation exposures are given within this section of the report.

TP/FE1

Trial pit foundation exposure, TP/FE1, was excavated on the front, south-western, wall of No. 1 Spencer Rise. The exact location of the trial hole can be seen in Figure 21 and a section drawing of the foundation encountered during TP/FE1 can be seen in Figure 22.

The foundation exposure was measured from ground level.

The foundation layout encountered consisted of a brick wall to ground level. From ground level to a depth of 0.60m bgl a brick wall was noted which rested upon two brick steps that stepped out by between 0.10 - 0.15m and were 0.13 - 0.20m thick. The brick steps were noted to rest on soils of the London Clay Formation, comprising a brown/dark orange sandy clay, at 0.93m bgl. The sand was fine to coarse grained. The ground conditions encountered directly surrounding the foundation are shown in Figure 21.

TP/FE2

Trial pit foundation exposure, TP/FE2, was excavated on the rear, north-western, wall of No. 1 Spencer Rise. The exact location of the trial hole can be seen in Figure 21 and a section drawing of the foundation encountered during TP/FE2 can be seen in Figure 23.

The foundation exposure was measured from ground level.

The foundation layout encountered consisted of a brick wall to ground level. From ground level to a depth of 0.30m bgl a brick wall was noted which rested upon a brick foundation that stepped out by 0.04m and was 0.07m thick. The base of the brick foundation was noted at 0.37m bgl constructed on soils of the London Clay Formation, comprising a brown/dark orange sandy clay. The sand was fine to coarse grained. The ground conditions encountered directly surrounding the foundation are shown in Figure 22.

5.3 Roots Encountered

Roots were noted to 1.50m bgl in WS1, with traces of roots noted to 1.00m bgl in WS2. However, the onsite drillers noted roots to 2.10m in WS1 and WS2.

It must be noted that the chance of determining actual depth of root penetration through a narrow diameter borehole is low. Roots may be found to greater depths at other locations on the site, particularly close to trees and/or trees that have been removed both within the site and its close environs.

5.4 Groundwater Conditions

Groundwater observations made during the intrusive investigation and subsequent groundwater monitoring visit can be seen tabulated below.

Depth of Groundwater Strikes/Standing Groundwater Within Trial Holes			
Trial Hole	**Date**	**Depth of Groundwater (m bgl)**	**Depth to Base of Trial Hole/Standpipe (m bgl)**
WS1	07/02/2018	None	-
	12/02/2018	4.00m bgl	4.50m bgl
	21/02/2018	2.30m bgl	4.50m bgl
WS2	07/02/2018	None	-

Changes in groundwater level occur for a number of reasons including seasonal effects and variations in drainage. Exact groundwater levels may only be determined through long term measurements from monitoring wells installed on-site. The investigation was undertaken in

February 2018 when groundwater levels are likely to be at their annual maximum (highest elevation).

Isolated pockets of groundwater may be perched within any Made Ground found at other locations around the site.

5.5 Obstructions

No artificial or natural sub-surface obstructions were noted during excavation/drilling of the trial holes.

6.0 LABORATORY GEOTECHNICAL TESTING

6.1 Laboratory Geotechnical Testing

A programme of geotechnical laboratory testing, scheduled by Ground and Water Limited and carried out by K4 Soils Laboratory and QTS Environmental Limited, was undertaken on samples recovered from the London Clay Formation. The results of the tests are presented in Appendix D.

The test procedures used were generally in accordance with the methods described in BS1377:2016.

Details of the specific tests used in each case are given below:

Standard Methodology for Laboratory Geotechnical Testing		
Test	**Standard**	**Number of Tests**
Atterberg Limit Tests	BS1377:2016:Part 2:Clauses 3.2, 4.3 & 5	4
Water Soluble Sulphate & pH	BS1377:2016:Part 3:Clause 5	1
BRE Special Digest 1 (incl. Ph, Electrical Conductivity, Total Sulphate, W/S Sulphate, Total Chlorine, W/S Chlorine, Total Sulphur, Ammonium as NH4, W/S Nitrate, W/S Magnesium)	BRE Special Digest 1 “Concrete in Aggressive Ground (BRE, 2005).	2

6.1.1 Atterberg Limit Tests

A précis of Atterberg Limit Tests undertaken on four samples of the London Clay Formation can be seen tabulated below.

Atterberg Limit Tests Results Summary							
Stratum/Depth	**Moisture Content (%)**	**Passing 425 µm sieve (%)**	**Modified PI (%)**	**Soil Class**	**Consistency Index (Ic)**	**Volume Change Potential**	
						NHBC	**BRE**
London Clay Formation	30 – 38	99 - 100	47.0 – 54.5	CH	0.88 – 0.98 Stiff	High	High

NB: NP – Non-plastic
BRE Volume Change Potential refers to BRE Digest 240 (based on Atterberg results)
Soil Classification based on British Soil Classification System.
Consistency Index (Ic) based on BS EN ISO 14688-2:2004.

6.1.2 Comparison of Soil’s Moisture Content with Index Properties

6.2.2.1 Liquidity Index Analyses

The results of the Atterberg Limit tests undertaken on four samples of the London Clay Formation were analysed to determine the Liquidity Index of the samples. This gives an indication as to whether the samples recovered showed a moisture deficit and their degree of consolidation. The results are tabulated overpage.

The test results are presented within Appendix D.

Liquidity Index Calculations Summary					
Stratum/Trial Hole/Depth	**Moisture Content (%)**	**Plastic Limit (%)**	**Modified Plasticity Index (%)**	**Liquidity Index**	**Result**
London Clay Formation WS1/2.00m bgl Brown silty CLAY with rare fine gravel	38	31	54.45	0.13	Heavily Overconsolidated.
London Clay Formation WS1/3.00m bgl Brown silty CLAY	30	29	47.00	0.02	Heavily Overconsolidated.
London Clay Formation WS2/3.50m bgl Brown silty CLAY	33	31	50.00	0.04	Heavily Overconsolidated.
London Clay Formation WS2/4.50m bgl Brown silty CLAY	35	33	50.00	0.04	Heavily Overconsolidated.

Liquidity Index testing revealed no evidence for moisture deficit within the heavily overconsolidated samples of the London Clay Formation tested.

6.1.2.2 Liquid Limit

A comparison of the soil moisture content and the liquid limit can be seen tabulated below.

Moisture Content vs. Liquid Limit				
Strata/Trial Hole/Depth/Soil Description	**Moisture Content (MC) (%)**	**Liquid Limit (LL) (%)**	**40% Liquid Limit (LL)**	**Result**
London Clay Formation WS1/2.00m bgl Brown silty CLAY with rare fine gravel	38	86	34.4	MC > 0.4 x LL (No significant moisture deficit)
London Clay Formation WS1/3.00m bgl Brown silty CLAY	30	76	30.4	**MC < 0.4 x LL** **(Potential Moisture Deficit)**
London Clay Formation WS2/3.50m bgl Brown silty CLAY	33	81	32.4	MC > 0.4 x LL (No significant moisture deficit)
London Clay Formation WS2/4.50m bgl Brown silty CLAY	33	83	33.2	MC = 0.4 x LL (No significant moisture deficit)

The results in the table above indicated that a potential significant moisture deficit was present within one sample of the London Clay Formation tested (WS1/3.00m bfgl). The moisture content value was below 40% of the liquid limit. The sample was described as a brown silty clay. Roots were noted to 1.50m bgl upon inspection of the samples, with the on-site drillers noting roots to 2.10m bgl. Consequently, the apparent moisture deficit was likely to be related to the lithology of the soil (heavily overconsolidated soils) rather the water demand of roots from nearby trees.

The results in the table above indicate that the remaining three samples of the heavily overconsolidated London Clay Formation tested showed no evidence of a significant moisture deficit.

6.1.3 Sulphate and pH Tests

A sulphate and pH test was undertaken on one sample from the London Clay Formation (WS1/2.00m bgl). The sulphate concentration was 390mg/l with a pH of 8.20.

6.1.4 BRE Special Digest 1

In accordance with BRE Special Digest 1 'Concrete in Aggressive Ground' (BRE, 2005) two samples of the London Clay Formation (WS1/2.50m bgl and WS2/3.00m bgl) were scheduled for laboratory analysis to determine parameters for concrete specification.

The results are given within Appendix D and a summary is tabulated below.

Summary of Results of BRE Special Digest Testing			
Determinand	**Unit**	**Minimum**	**Maximum**
pH	-	7.5	7.7
Ammonium as NH_4	mg/kg	<0.5	<0.5
Sulphur	mg/kg	0.10	0.57
Chloride (water soluble)	mg/kg	29	31
Magnesium (water soluble)	mg/l	12	76
Nitrate (water soluble)	mg/kg	6	12
Sulphate (water soluble)	g/l	222	2050
Sulphate (total)	%	3021	8191

5.2 Chemical Laboratory Testing – Human Health Risk Assessment

A programme of chemical laboratory testing, scheduled by Ground and Water Limited, and carried out by QTS Environmental Limited, was undertaken on 1No. sample of Made Ground (WS1/0.30m bgl).

A Desk Study and full-scale contamination assessment were not part of the remit of this report. However, one soil sample was sent off for analysis for a broad range of contaminants in accordance with DEFRA/CLEA methodologies. The sample tested and the reasons for testing can be seen tabulated below.

Methodology for Sampling Locations and Chemical Laboratory Testing		
Trial Hole	**Depth (m bgl)**	**Sampling Strategy**
WS1	0.30	Representative sample of Made Ground

The site comprised a rectangular shaped plot of land, 113m^2 in area with two sampling locations, given an unknown hotspot shape, the sampling density means that a hotspot with an area of approximately 84.75m^2 and a radius of approximately 5.19m would be encountered (CLR 4).

Soil sampling depths were chosen to reflect the receptors of concern, human health, and typically comprised a surface or near surface sample and then at approximately 0.50m depth increments thereafter, extending into the underlying natural soils. The receptors relevant to the sampling depths can be seen overpage:

Near surface samples	Direct ingestion, dermal contact and dust inhalation. Protection of end-users and maintenance workers e.g. Landscape Gardeners. Protection of shallow rooted plants. Perched Water/Surface Water Run-off Protection of groundwater/controlled waters
>0.5m below ground level	Protection of deep rooted plants. Perched Water/Surface Water Run-off Protection of groundwater/controlled waters

The depth of soil sampling can be seen within the trial hole logs presented in Appendix C.

The analysis suite is presented below and comprised:

- Semi-metals and heavy metals incl. Arsenic, Cadmium, Chromium (incl. Hexavalent Chromium), Copper, Lead, Mercury, Nickel, Selenium, Vanadium, Zinc (WS1/0.30m);
- Asbestos screen (WS1/0.30m);
- Polycyclic Aromatic Hydrocarbons (PAH's) incl. Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene, Benzo(ghi)perylene: (WS1/0.30m);
- Fuel Oils – Speciated TPH including full aliphatic/aromatic split: (WS1/0.30m);
- BTEX compounds (Benzene, Toluene, Ethylbenzene, Xylene) and MTBE – used as marker compounds for Volatile Organic Compounds (VOCs): (WS1/0.30m).

The chemical laboratory results are presented in Appendix E.

5.2.1 Soil Assessment Criteria

The derivation of Soil Assessment Criteria used within this report can be seen within Appendix F.

5.2.2 Determination of Representative Contamination Concentration

At the time of reporting, April 2018, the proposed development was understood to include the excavation of a single storey basement below the entire footprint of the building. The basement floor was to be constructed at a depth of 4.00m bgl. A plan view and sectional view of the proposed development can be seen in Figure 7 and Figure 8 respectively.

Therefore, the results of the chemical laboratory testing were compared to the LQM/CIEH Suitable 4 Use Levels (S4UL), for a **'Residential with homegrown produce'** land-use scenario, as this was considered the most appropriate land-use scenario.

Where no LQM/CIEH S4UL/C4SL LLTC was available for a particular determinant then preliminary reference was made to the laboratory detection limit of the determinant. If a positive concentration was noted then further risk assessment was undertaken.

Where a contaminant of concern's LQM/CIEH S4UL/C4SL LLTC varies according to the Soil's Organic Matter (SOM), the SOM recorded for each soil sample was used to derive the appropriate SGV/GAC. The SOM of the sample analysed was 2.7%

The results of the comparison of the representative contaminant concentrations are presented in the table below.

Soil Guideline Values and General Acceptance Criteria Results	
Substance	Sample Location Where available LQM/CIEH S4UL/, CSL4 LLTC or GAC were exceeded for relevant land-use scenario
	"Residential with Homegrown Produce" Land-Use Scenario
Arsenic	None
Boron	None
Cadmium	None
Chromium (III)	None
Hexavalent Chromium (VI)	None
Lead	**WS1/0.30m (2580 mg/kg)**
Mercury (Elemental)	None
Nickel	None
Selenium	None
Vanadium	None
Copper	None
Zinc	None
Boron	None
Cyanide (Total)	None
Phenol	None
TPH C5 – C6 (aliphatic)	None
TPH C6 – C8 (aliphatic)	None
TPH C8 - C10 (aliphatic)	None
TPH C10 - C12 (aliphatic)	None
TPH C12 - C16 (aliphatic)	None
TPH C16 - C21 (aliphatic)	None
TPH C21 - C34 (aliphatic)	None
TPH C5 – C7 (aromatic)	None
TPH C7 – C8 (aromatic)	None
TPH C8 - C10 (aromatic)	None
TPH C10 - C12 (aromatic)	None
TPH C12 - C16 (aromatic)	None
TPH C16 - C21 (aromatic)	None
TPH C21 - C35 (aromatic)	None
Naphthalene	None
Acenapthylene	None
Acenapthene	None
Fluorene	None
Phenanthrene	None
Anthracene	None
Fluoranthene	None
Pyrene	None
Benzo(a)anthracene	None
Chrysene	None
Benzo(b)fluoranthene	None
Benzo(k)fluoranthene	None
Indeno(1,2,3-cd)pyrene	None
Benzo(ghi)perylene	None
Benzo(a)pyrene	None
Dibenz(a,h)anthracene	None
Benzene	None
Toluene	None
Ethylbenzene	None
Xylene (o, m & p)	None
MTBE	None
Asbestos Screen	None

Chemical laboratory testing revealed an elevated level of lead in excess of the C4SL LLTC for a **'Residential with Home-grown Produce'** land use scenario of 210mg/kg was detected in one samples of Made Ground tested: WS1/0.30m (2580 mg/kg).

Chemical laboratory testing did not reveal any other elevated levels in excess of the C4SL LLTC for **'Residential without Home-grown Produce'** land use scenario.

Consideration should be given to further testing in the rear garden. This will allow further risk assessment and a remediation strategy to be developed, if required.

7.0 ENGINEERING CONSIDERATIONS

7.1 Soil Characteristics and Geotechnical Parameters

Based on the results of the intrusive investigation and geotechnical laboratory testing the following interpretations have been made with respect to engineering considerations.

- Made Ground was encountered from ground level in WS1/TP1 and underlying wooden decking from 0.12m in WS2/TP2 to a depth of between 0.40m - 0.90m bgl.

  As a result of the inherent variability of Made Ground, it is usually unpredictable in terms of bearing capacity and settlement characteristics. Foundations should, therefore, be taken through any Made Ground and either into, or onto a suitable underlying natural stratum of adequate bearing characteristics.

  Made Ground may be found to deeper depth at other locations on the site, especially close to former structures/foundations and service runs.

- Soils of the London Clay Formation were encountered underlying the Made Ground from 0.90m - 0.40m bgl for the remainder of the both trial holes, a depth of 4.50m – 4.70m bgl.

  The soils generally comprised a brown/dark orange/dark brown/bluish grey mottled silty sandy clay. The sand was fine to coarse grained. Pockets of orange sand were noted in WS2 between 0.40m – 2.10m bgl. Very fine selenite crystals were also encountered in WS2 between 2.10m – 4.50m bgl and 3.50m – 4.70m bgl in WS1.

  The cohesive soils of the London Clay Formation were shown to have a **high** potential for volume change in accordance both BRE240 and NHBC Standards Chapter 4.2.

  Although no in-situ testing was undertaken, onsite engineer appraisals of the soils recovered from the London Clay Formation indicated the soils to be stiff. Consistency Index calculations indicated the London Clay Formation to be stiff. Geotechnical analysis revealed the soils to be heavily overconsolidated.

  A potential lithologically derived moisture deficit was noted in WS1/3.50m bgl.

  The soils of the London Clay Formation were heavily overconsolidated cohesive soils and were therefore likely to be a suitable stratum for the proposed traditional strip or mat foundations associated with the basement. The settlements induced on loading are likely to be moderate.

  The final design of foundations will need to take into account the volume change potential of the soil, the depth of root penetration and/or moisture deficit and the likely serviceability and settlement requirements of the proposed structure. These parameters for design are discussed in the next section of this report.

- Groundwater was not encountered during the intrusive investigation. However, the return monitoring visits on 12th February 2018 and 21st February 2018 revealed groundwater at 4.00m bgl and 2.30m bgl in WS1 respectively. It was likely that these related to perched groundwater within the Made Ground or sand and silt bands within the London Clay Formation accumulating in the base of a standpipe installed in soils of the London Clay

Formation with negligible permeability, rather than being a true representation of the level of a saturated aquifer beneath the site.

- Roots were noted to 1.50m bgl in WS1, with traces of roots noted to 1.00m bgl in WS2. However, the onsite drillers noted roots to 2.10m bgl in WS1 and WS2.

7.2 Basement Foundations

At the time of reporting, April 2018, the proposed development was understood to include the excavation of a single storey basement below the entire footprint of the building. The basement floor was to be constructed at a depth of 4.00m bgl. A plan view and sectional view of the proposed development can be seen in Figure 7 and Figure 8 respectively.

The proposed development fell within Geotechnical Design Category 2 in accordance with Eurocode 7.

Based on data supplied by the structural engineer, it was understood that the basement will be constructed based on loading bearing retaining wall underpins and a lower ground floor slab. The loads implied by the retaining wall were expected to range between 69.90 – 99.00kN/m^2. The thickened edges were likely to range between 1200mm – 2000mm thick. The remainder of the construction will comprise a semi-ground bearing concrete slab with self weight of ~10kN/m^2.

Foundation exposures undertaken at the front and rear of 1 Spencer Rise, revealed the existing party walls between 1 Spencer Rise and 1c Spencer Rise and 3 Spencer Rise were likely to be founded at a depth of between 0.37m – 0.93m. Both walls were found to have brick corbel footings and between 90 – 250mm wide.

Foundations should be designed in accordance with soils of **high volume change potential** in accordance with BRE Digest 240 and NHBC Chapter 4.2.

Given the cohesive nature of the shallow deposits foundations must therefore **not** be placed within cohesive root penetrated and/or desiccated soils and the influence of the trees surrounding the site must be taken into account (NHBC Standards Chapter 4.2). It is recommended that foundations are taken at least 300mm into non-root penetrated strata.

Where trees are mentioned in the text this means existing trees, recently removed trees (approximately 15 years to full recovery on cohesive soils) and those planned as part of the site landscaping. Should trees be removed from the footprint of the proposed building then an alternative foundation system, such as piles or isolated pads should be considered.

Roots were noted to 1.50m bgl in WS1, with traces of roots noted to 1.00m bgl in WS2. However, the onsite drillers noted roots to 2.10m bgl in WS1 and WS2. Made Ground was encountered from ground level in WS1/TP1 and underlying wooden decking from 0.12m in WS2/TP2 to a depth of between 0.40m - 0.90m bgl.

Given the above and the depth of roots noted in the boreholes, it was concluded that a founding depth of 4.00m bgl was considered suitable for the proposed basement.

The formation level for the extension must be carefully inspected for the presence of fresh/live roots. Should live roots be noted at formation level then the formation level should be extended at least 300mm into non-root penetrated soils.

A founding depth of 4.00m bgl would encounter stiff London Clay Formation and therefore can be designed based on a presumed allowable bearing capacity of 125kN/m^2. This is based on trial hole records, inspection of samples recovered, and referral to BS 8004:1986, *Code of Practice for Foundations,* and based on a 5m long by 1m wide foundation and a maximum settlement of 25mm.

Given the existing loading regime and applied load, settlements of the underpins are likely to vary from nothing to <10mm. **The structural engineer will need to take this into account in the final design.**

Heave may occur under the slab if the bearing capacities exceed 60 – 80kPa based on a bulk density of 15 – 20kN/m^3. **The structural engineer will be required to account for this in the final design. Use of clayboard beneath the partially suspended slab is likely to be required, which should be appropriately designed by the structural engineer.**

Excavations must be kept dry and either concreted or blinded as soon after excavation as possible. If water were allowed to accumulate on the formation for even a short time not only would an increase in heave occur resulting from the soil increasing in volume by taking up water, but also the shear strength and hence the bearing capacity would also be reduced.

Groundwater was not encountered during the intrusive investigation. However, the return monitoring visits on 12th February 2018 and 21st February 2018 revealed groundwater at 4.00m bgl and 2.30m bgl in WS1. It was likely that these related to perched groundwater within the Made Ground or sand and silt bands within the London Clay Formation accumulating in the base of a standpipe installed in soils of the London Clay Formation with negligible permeability, rather than being a true representation of the level of a saturated aquifer beneath the site.

Therefore, perched water may be encountered within the Made Ground or/and sand and silty pockets of the London Clay Formation, especially after period of prolonged rainfall. **This should be taken into account in final design.**

The basement must be suitably tanked to prevent ingress of groundwater and also surface water run-off.

If the construction works take place during the winter months, when the groundwater level is expected to be at its higher elevation, perched water could accumulate thus dewatering could be required to facilitate the construction and prevent the base of the excavation blowing before the slab was cast.

7.3 Piled Foundations

Given the results of the investigation a piled foundation scheme was considered unlikely to be required at this site.

7.4 Basement Excavations & Stability

Shallow excavations in the Made Ground and the London Clay Formation are likely to be marginally stable at best. Long, deep excavations, through both of these strata are likely to become unstable.

The excavation of the basement must not affect the integrity of the adjacent structures beyond the boundaries. The excavation must be supported by suitably designed retaining walls. It is considered unlikely that battering the sides of the excavation, casting the retaining walls and then backfilling to the rear of the walls would be suitable given the close proximity of the party walls.

The retaining walls for the basement will need to be constructed based on the cohesive soils encountered with an appropriate angle of shear resistance (Φ') and effective cohesion (C') for the ground conditions encountered, regarding long term considerations, as well using an appropriate undrained shear strength Cu for short term considerations. Visual appraisal of the samples recovered from the site and the consistency index testing revealed the soils to be stiff, which would have likely undrained cohesion of between 75 – 150kPa.

Based on the ground conditions encountered within the boreholes the following parameters could be used in the design of retaining walls. These have been designed based on the visual appraisal of the soils recovered from the site, results of geotechnical classification tests (Stiff London Clay) and reference to literature.

Retaining Wall/Basement Design Parameters					
Strata	**Unit Volume Weight (kN/m³)**	**Cohesion Intercept (c') (kPa)**	**Angle of Shearing Resistance (Ø)**	**Ka**	**Kp**
Made Ground	~13 - 15	0	12	0.66	1.52
London Clay Formation	~15 - 20	0	24	0.42	2.37

As geotechnical testing defined the London Clay Formation as being heavily overconsolidated, a Ko value was unobtainable due to the Overconsolidation Ratio (OCR) being unknown. A Ko range of 1.0 – 2.8 can be used for consolidated London Clay Formation.

The value of K adopted in design calculations should allow for the effects of wall installation. In general, it may be appropriate to adopt a K value of 1.0 from simple elastic (i.e. where the pre-failure deformation of the soil is assumed to be linear) soil-structure interaction analysis on overconsolidated fine-grained soils. **The structural engineer will be required to account for this in the final design.**

Unsupported earth faces formed during excavation may be liable to collapse without warning and suitable safety precautions should therefore be taken to ensure that such earth faces are adequately supported before excavations are entered by personnel.

Perched water maybe encountered within the Made Ground or/and silty pockets of the London Clay Formation, especially after period of prolonged rainfall. **This should be taken into account in final design.**

Should groundwater be encountered across the site, dewatering from sumps introduced into the floor of the excavation may be required, especially after a period of excessive rainfall. Consideration should be given to creating a coffer dam using contiguous piled or sheet piled walls to aid basement construction below the perched water table. The advice of a reputable dewatering company should be sought.

7.5 Hydrogeological Effects

A study of the aquifer maps on the DEFRA website, and Figure 8 of the Camden Geological, Hydrogeological and Hydrological Study (see Figure 11 of this report), revealed the London Clay Formation comprised an Unproductive Strata. No designation was given for any superficial deposits due to their likely absence.

The ground conditions encountered generally comprised a capping of Made Ground over cohesive soils of the London Clay Formation. Based on a visual appraisal of the soils encountered the permeability of the London Clay Formation was likely to be very low to negligible permeability.

Groundwater was not encountered during the intrusive investigation However, the return monitoring visits on 12th February 2018 and 21st February 2018 revealed groundwater at 4.00m bgl and 2.30m bgl in WS1 respectively. It was likely that these relate to perched groundwater within sand and silt bands within the London Clay Formation, rather than being a true representation of the level of a saturated aquifer beneath the site.

Based on the above it is considered unlikely that the basement will be constructed below the groundwater table/or within the saturated aquifer underlying the site.

The basement was therefore considered unlikely to affect the saturated aquifer underlying the site.

Perched water maybe encountered within the Made Ground or/and silty pockets of the London Clay Formation, especially after period of prolonged rainfall. **This should be taken into account in final design.**

In relation to the basement, once constructed, the Made Ground will act as a slightly porous medium for water to migrate however additional drainage should be considered as the London Clay Formation will act as a barrier for groundwater migration.

7.6 Assessment of Ground Movement

At the time of reporting, April 2018, the proposed development was understood to include the excavation of a single storey basement below the entire footprint of the building. The basement floor was to be constructed at a depth of 4.00m bgl. A plan view and sectional view of the proposed development can be seen in Figure 7 and Figure 8 respectively.

The neighbouring footings are likely to be 0.37m – 1.20m deep, therefore with further underpinning to 4.00m bgl, a Ground Movement Analysis (GMA) was required.

An assessment of potential ground movements was therefore necessary to determine whether there would be any detrimental effects on the neighbouring properties from the excavation of the basement.

An assessment of ground movements has been carried out as follows:

Movement has been assessed for the surrounding properties due to the excavation of the basement below the existing property at 1 Spencer Rise, Camden, London NW5 1AR.

Based on the maximum depth of excavation, structures within a 16.00m radius of the proposed basement were considered likely to be influenced by the proposed development. The structures potentially affected can be seen tabulated overleaf.

Parameters of Surrounding Properties			
Property	**Approximate Distance to Closest Wall/Corner (m)**	**Approximate Length (m)**	**Approximate Height (m)**
1c Spencer Rise	0.00m	6.00m	11.30m
3 Spencer Rise	0.00m	5.00m	7.50m
5 Spencer Rise	5.00m	5.50m	7.30m
1b Spencer Rise	6.00m	6.00m	8.00m
1a Spencer Rise	10.50m	5.00m	10.20m
7 Spencer Rise	12.00m	6.00m	8.00m

- The magnitude of ground movements has been assessed for the excavation of the Spencer Rise basement wall and side walls using traditional underpinned retaining wall structures.

- It is important to note that CIRIA Report C580/C760 was written for embedded retaining walls. Therefore, movement calculations for the excavation of soil and installation of the underpinnings does not strictly apply to C580/C760.

The following parameters have been used to inform this assessment:

- The maximum excavation depth is understood to be 4.00m bgl;
- The method of basement construction is understood to be traditional underpinning;
- A high wall stiffness has been assumed;
- In the permanent case the wall should be propped at high level;
- The width of the 6No. neighbouring buildings varies between 5.00m – 6.00m, with the distance from site ranging between 0.00m – 12.00m;
- The assessed buildings were estimated to be ~7.30m – 11.30m;
- Based on the visual appraisal of the soils encountered and the consistency index testing, analysis has been undertaken for stiff clays (London Clay Formation).

Based on reference to C580 the following ground movements have been developed based on of the excavation of soils to form the basement.

Ground Movement Analysis – Excavation Only – Stiff Clays							
Property	**Approx. Horizontal Ground Movement at Closest Wall/Corner (mm)**	**Approx. Horizontal Ground Movement at Furthest Wall/Corner (mm)**	**Horizontal Strain (%)**	**Approx. Vertical Ground Movement at Closest Wall/Corner (mm)**	**Approx. Vertical Ground Movement at Furthest Wall/Corner (mm)**	**Vertical Deflection (%)**	**Category of Damage**
1c Spencer Rise	6.00	3.75	0.03750	1.60	2.28	0.021667	Very Slight
3 Spencer Rise	6.00	4.13	0.03750	1.60	2.57	0.024000	Very Slight
1b Spencer Rise	3.75	1.50	0.03750	2.00	0.40	0.006667	Negligible
5 Spencer Rise	4.13	2.06	0.03764	2.00	0.40	0.008182	Negligible
1a Spencer Rise	1.91	0.04	0.03740	0.90	0.00	0.005200	Negligible
7 Spencer Rise	1.35	0.00	0.02250	0.47	0.00	0.005167	Negligible

Contour plots showing the horizontal and vertical ground movement due to the construction of the basement can be seen within Figures 24 and 25. The Ground Movement Spreadsheets and Calculations can be seen within Appendix G.

In terms of building damage assessment and with reference to Table 2.5 of CIRIA Report C580 (after Burland et al, 1977), the 'Description of typical damage' given the calculated movements it is likely that the damage assessment will fall into Category 1, 'Very Slight', to Category 0, 'Negligible'. Calculations for the potential damage at each property can be seen within Appendix G.

It should be noted that using stiff clay in this assessment could produce less conservative results. However, this offset is countered by the following, which make the results more conservative.

- The size of the developments used to provide the case histories for C580/760 are significantly greater than the scale of works proposed. In practice the range of ground movements (relative to the excavation depth and the building dimensions) is therefore likely to be much smaller for this development.

- CIRIA C580/760 advises that ground movements are influenced by the quality of workmanship. The party wall act will apply to this development and will re-inforce good workmanship. The act provides an effective mechanism for ensuring that structural integrity of the neighbouring property is maintained throughout the construction phase. Amongst other procedures, monitoring proposals will ensure that the actual wall movements are controlled and kept within acceptable limits.

Underpinning proposals were understood to involve a 'hit and miss' approach in stages so each 'panel' is separated by 3-5 others from the next open one. It will be important that the building contractor is closely supervised and is experienced in this type of construction. It will be critical to prevent exposed faces from collapse or significant ground loss into the new excavation and temporary face support should be maintained where practicable. The nature and presence of basements/cellars in the adjoining properties was not known at this stage. Most ground movement should occur during excavation of the basement and construction so the adequacy of temporary support will be critical in limiting ground movements. A number of factors will assist in limiting ground movements:

- Most ground movement will occur during excavation and construction so the adequacy of temporary support will be critical in limiting ground movements;
- The speed of propping and support is key to limiting ground movements;
- Good workmanship will contribute to minimising ground movements;
- The assessment assumes the wall is in competent clay;
- Larger movements will be expected where soft soils are encountered at, above and below formation;
- Ground movement can be minimised by adopting a number of measures, including;
- Ensuring that adequate propping is in place at all times during construction;
- Minimise deterioration of the central soil mass by the use of blinding/covering with a waterproof membrane;
- Installation of the first (stiff) support quickly and early in the construction sequence for each underpin panel;
- Control dewatering to minimise fines removal and drawdown;
- Avoid overbreak;
- Avoid leaving ground unsupported.

Should the above interventions be adopted during construction, and generally good construction/underpinning practice be maintained, then predicted movements will be Category 1 or lower.

7.7 Sub-Surface Concrete

For the classification given below, the “mobile” and “natural” case was adopted given the geology encountered and the residential use of the site.

Made Ground

The water-soluble sulphates in the Made Ground tested (from the chemical laboratory testing) were found to be 1580 mg/kg with a pH of 7.7.

Therefore, sulphate concentrations measured in 2:1 water/soil extracts taken from the man-made ground and total potential sulphate concentrations, fell into Class DS-3 of the BRE Special Digest 1, 2005, ‘Concrete in Aggressive Ground’. Table C1 of the Digest indicated an ACEC (Aggressive Chemical Environment for Concrete) classification of AC-3.

Natural Ground – London Clay Formation

The water-soluble sulphate concentration in the samples (from the chemical and geotechnical laboratory testing) ranged from 222 – 2050mg/l with a pH range of 7.5 – 8.20. The total potential sulphate (3x total sulphur) concentration ranged between 0.30% - 0.57%.

Therefore, sulphate concentrations measured in 2:1 water/soil extracts taken from the natural ground and total potential sulphate concentrations, fell into Class DS-4 of the BRE Special Digest 1, 2005, ‘Concrete in Aggressive Ground’. Table C1 of the Digest indicated an ACEC (Aggressive Chemical Environment for Concrete) classification of AC-4.

Concrete to be placed in contact with soil or groundwater must be designed in accordance with the recommendations of Building Research Establishment Special Digest 1, 2005, *‘Concrete in Aggressive Ground’* taking into account the pH of the soils.

It is prudent to note that pyrite nodules may be present within the London Clay Formation. Pyrite can oxidise to gypsum and this normally only occurs in the upper weathered layer, but excavation allows faster oxidation and water-soluble sulphate values can rapidly increase during construction. Therefore, rising sulphate values should be taken into account should ferruginous staining/pyrite nodules be encountered within the London Clay Formation.

7.8 Surface Water Disposal

Soakaway tests were beyond the scope of this investigation.

Soakaways constructed within the cohesive soils of the London Clay Formation are unlikely to prove satisfactory due to anticipated very low to negligible infiltration rates. Therefore, an alternative method of surface water disposal is required.

Consultation with the Environment Agency must be sought regarding any use that may have an impact on groundwater resources.

The submission of a Sustainable Urban Drainage Scheme (SUDS) is unlikely to be required for this site due to the basement not significantly increasing the amounts of hardstanding.

7.9 Stage 5 Review

The conceptual site model given within Section 3.2.1 identified five matters of concern for the property. These concerns have been assessed within the report and the conclusions can be seen tabulated below and overleaf.

Stage 5 Review		
Highlighted Area	**Site Specific Concern**	**Assessment**
Perched water within the Made Ground or the London Clay Formation	The basement may encounter perched water within the Made Ground or silt bands of the London Clay Formation during construction.	Groundwater was not encountered during the intrusive investigation However, the return monitoring visits on 12th February 2018 and 21st February 2018 revealed groundwater at 4.00m bgl and 2.30m bgl in WS1 respectively. Based on the above it is considered likely the basement will encounter perched water. However, the basement will not affect the saturated aquifer underlying the site. Therefore, the cumulative effects of basements in groundwater is not a consideration at this site.
Soil Moisture/ Trees and Bushes	There is potential for soil moisture content to affect the development.	Geotechnical analysis revealed the soils to be heavily overconsolidated with no potentially root exacerbated moisture deficits. A lithologically controlled moisture deficit was noted at WS1/3.50m bgl.

Cont'd overleaf:

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Stage 5 Review		
Highlighted Area	**Site Specific Concern**	**Assessment**
London Clay Formation/ Shrink and Swell	The basement is anticipated to be founded in the London Clay Formation. The soils are likely to have medium to high plasticity and volume change potential. The concrete mix design should take appropriate account of sulphate levels (testing to BRE Special Digest). Heave on removal of overburden pressure may be a risk.	Geotechnical testing revealed the London Clay Formation to have high volume change potential in accordance with BRE240 and NHBC Standards Chapter 4.2. Sulphate concentrations measured in 2:1 water/soil extracts taken from the London Clay Formation from geotechnical analysis fell into Class DS-4 of the BRE Special Digest 1, 2005, 'Concrete in Aggressive Ground'. **Sub-surface concrete specification is discussed further in Section 7.9 of this report.**
Differential Foundation Depths	It will be important to account for the shallow nature of existing footings at the property and its neighbours. Ground Movement Assessment is required.	Ground movement assessment was carried out on the neighbouring properties within Section 7.7 of this report. In terms of building damage assessment and with reference to Table 2.5 of C580 (after Burland et al, 1977), the 'Description of typical damage' given the calculated movements it is likely to fall within category of damage '0' Negligible to '1' Very Slight. **Mitigation measures to minimise potential movements are provided in Section 7.7. Structural Design will need to take this into account.**
Retaining Walls	Appropriate Design	Parameters for retaining wall design provided in Section 7.4 of this report. **Structural Design will need to take this into account.**
Proximity to Trees and Pedestrian Walkways	Appropriate Design	Structural design will be need to ensure care is taken when constructing basement within an area of roots and that the basement does not structurally impact the existing walkways. **Structural Design will need to take this into account**

7.10 Discovery Strategy

There may be areas of contamination that have not been identified during the course of the intrusive investigation. For example, there may have been underground storage tanks (UST's) not identified during the Ground Investigation for which there is no historical or contemporary evidence.

Such occurrences may be discovered during the demolition and construction phases for the redevelopment of the site.

Groundworkers should be instructed to report to the Site Manager any evidence for such contamination; this may comprise visual indicators, such as fibrous materials within the soil, discolouration, or odours and emission. Upon discovery advice must be taken from a suitably qualified person before proceeding, such that appropriate remedial measures and health and safety protection may be applied.

Should a new source of contamination be suspected or identified then the Local Authority will need to be informed.

7.11 Waste Disposal

The excavation of foundations is likely to produce waste which will require classification and then recycling or removal from site.

Under the Landfill (England and Wales) Regulations 2002 (as amended), prior to disposal all waste must be classified as;

- Inert;
- Non-hazardous, or;
- Hazardous.

The Environment Agency's Hazardous Waste Technical Guidance (WM3) document outlines the methodology for classifying wastes.

Once classified the waste can be removed to the appropriately licensed facilities, with some waste requiring pre-treatments prior to disposal.

Based on a risk phrase analysis of the remaining chemical laboratory test results, in accordance with EC Hazardous Waste Directive and undertaken by Ground and Water Limited, the sample of Made Ground tested (WS1/0.30m) were classified as **HAZARDOUS.** The results of the assessment are given within Appendix H. **Further testing is recommended.**

A Full WAC Solid Suite Test with single batch leachate was undertaken on one sample of the Made Ground (WS2/0.30m) to determine which landfill category the waste conformed to. The results of the WAC test can be seen in Appendix E. The sample fell into the INERT waste category.

It is important to note that whilst we consider our in-house assessment tool to be an accurate interpretation of the requirements of WM3, therefore producing an initial classification in accordance with the guidance, landfill operators have their own assessment tools and can often come to different conclusions. As a result, some landfill operators could refuse to take apparently suitable waste. It is recommended that the receiving landfill views the results of this assessment and the chemical laboratory results to determine their own classification.

7.12 Imported Material

Any soil which is to be imported onto the site must undergo chemical analysis to prove that it is suitable for the purpose for which it is intended.

The Topsoil must be fit for purpose and must either be supplied with traceable chemical laboratory test certificates or be tested, either prior to placing (ideally) or after placing, to ensure that the human receptor cannot come into contact with compounds that could be detrimental to human health. The compounds that are to be tested for are those given in the LQM CIEH Generic Assessment Criteria, which can be viewed in Appendix E of this report.

7.13 Duty of Care

Groundworkers must maintain a good standard of personal hygiene including the wearing of overalls, boots, gloves and eye protectors and the use of dust masks during periods of dry weather.

To prevent exposure to airborne dust by both the general public and construction personnel the site should be kept damp during dry weather and at other times when dust were generated as a result of construction activities.

The site should be securely fenced at all times to prevent unauthorised access. Washing facilities should be provided and eating restricted to mess huts.