150 HOLBORN

LONDON EC1N 2NS

PHASE 1 PRELIMINARY RISK ASSESSMENT AND PHASE 2 ENVIRONMENTAL AND GEOTECHNICAL SITE INVESTIGATION REPORT

FOR

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June 2016

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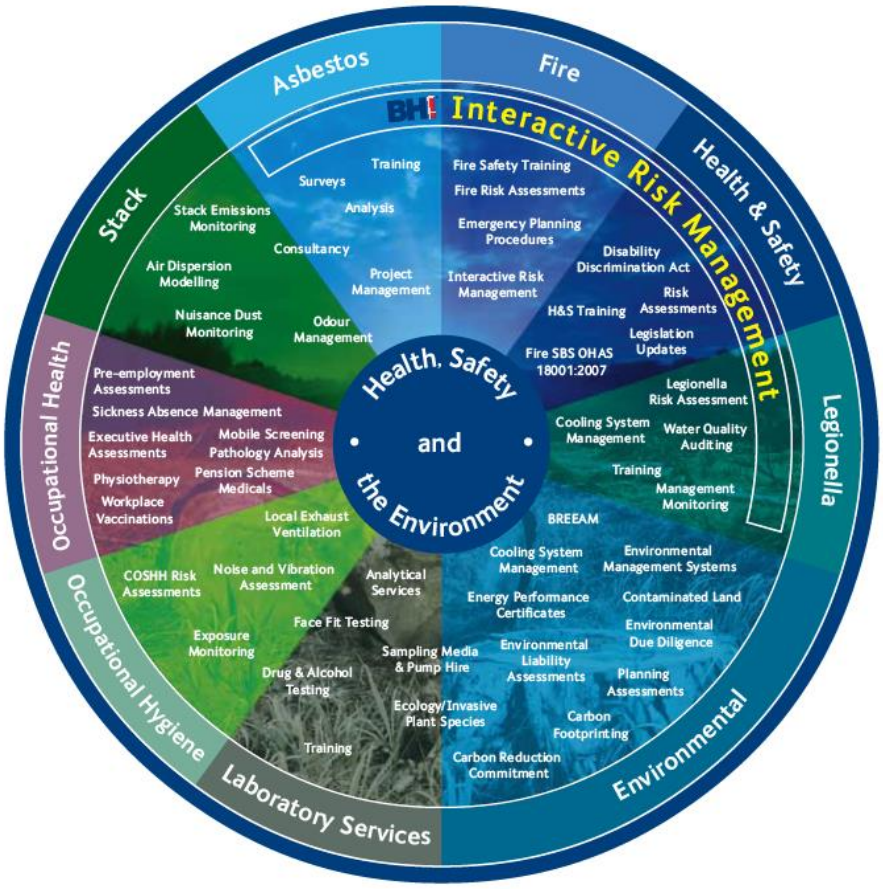

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EXECUTIVE SUMMARY

RPS Health, Safety & Environment (RPS) was commissioned by Clarke Nicholls Marcel to undertake a Phase 1 Preliminary Environmental Risk Assessment and a Phase 2 Environmental and Geotechnical Site Investigation at 150 Holborn, London EC1N 2NS. The report has been commissioned in relation to the proposed redevelopment of the site as a nine storey mixed use residential and retail building, with a single storey of basement.

The Phase 1 Preliminary Risk Assessment for the site identified a number of potential pollutant linkages to human health receptors associated with the site. A Phase 2 Site Investigation was therefore undertaken to determine whether these linkages were active.

The Phase 2 Site Investigation comprised concrete coring through the basement floor slab in six locations (BH1 to BH3 and Core 1 to Core 3), three cable percussion boreholes (BH1 to BH3) to depths of up to 35.00m below basement slab level (bbl), in situ geotechnical testing and sampling throughout the depth of each borehole, installation of groundwater/gas monitoring wells in each borehole, a series of probes to determine a profile of the basement slab thickness in seven locations (T1 to T5, T8 and T9) and one machine excavated trial pit (T10) adjacent to the northern wall of the building from ground level to a depth of 2.40m below ground level (bgl).

The basement floor slab was directly underlain by Hackney Gravel Member in the north of the site. A limited thickness of Made Ground was encountered beneath the floor slab in the north. The Hackney Gravel Member was underlain by the London Clay Formation and the Lambeth Group. Trial pit T10, completed from ground level, encountered tarmac and concrete hardstanding overlying Made Ground to a maximum proven depth of 2.40m bgl.

Based on the available information, the potential risk to human health receptors from concentrations of contaminants of concern detected within soils and groundwater sampled from beneath the site is considered to be ***LOW.***

Total petroleum hydrocarbon (TPH) compounds were detected at concentrations in excess of the UK Drinking Water Standards (DWS) screening value within groundwater sampled from monitoring well BH3. Contaminants of concern were not recorded within groundwater analysed from other monitoring wells on site at concentrations in excess of adopted assessment criteria (AC). The site does not lie within a groundwater source protection zone (SPZ) and there are no groundwater licensed potable groundwater abstractions within a 1km radius of the site. The UK DWS screening criteria are therefore considered to be conservative in this case. Based on the available information, the potential risk to controlled waters receptors from concentrations of contaminants of concern detected within groundwater sampled from beneath the site is considered to be ***LOW.***

Based on the ground gas monitoring undertaken on site as part of the current investigation CIRIA Characteristic Situation 1 (CS1) is applicable to the site, whereby ground gas protection measures are not required. Therefore, the risk posed by ground gas to human health receptors and infrastructure is considered to be ***LOW.***

Results of the waste characterisation exercise showed that of the two samples of Made Ground submitted for waste acceptance criteria (WAC) testing one would be suitable for disposal to a Stable Non-Reactive Hazardous Waste (SNRHW) landfill and one would be suitable for disposal to a non-hazardous waste landfill. The two samples of Hackney Gravel Member and two samples of London Clay Formation submitted for WAC testing would all be suitable for disposal to an inert waste landfill.

Whilst it is considered that a basement raft foundations would be feasible at the site, information from the structural engineer indicates that it is proposed to support the proposed development on piled foundations. Bored or Continuous Flight Auger (CFA) piles, terminating in the deeper layers of the London Clay Formation or Lambeth Group are likely to be suitable from a geotechnical perspective.

It is understood that a single storey basement is proposed beneath the new development. In this case, it is likely that ground conditions immediately underlying the floor slab of this structure will comprise Hackney Gravel Member. Ground bearing floor slabs are therefore likely to be suitable for the proposed development. Should Made Ground or cohesive material be encountered at slab formation level, this should be removed and replaced with granular fill, compacted to an end product specification.

Testing has indicated that a Design Sulphate Class of DS-2 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC2 would be appropriate for buried concrete structures in contact with the Made Ground. A Design Sulphate Class of DS-1 and an ACEC Classification of AC1 would be appropriate for buried concrete structures in contact with the Hackney Gravel Member, London Clay Formation and Lambeth Group only.

1 INTRODUCTION

1.1 Preamble

RPS Health, Safety & Environment (RPS) was commissioned by *Clarke Nicholls Marcel* to undertake a Phase 1 Preliminary Environmental Risk Assessment and a Phase 2 Environmental and Geotechnical Site Investigation at 150 Holborn, London EC1N 2NS. The report has been commissioned in relation to the proposed redevelopment of the site as a nine storey mixed use residential and retail building, with a single storey of basement.

1.2 Objectives

The principal objectives of this assessment were as follows:

- To determine the engineering properties of the underlying soils and to provide geotechnical parameters to assist preliminary foundation, basement and floor slab design, as well as input into a Ground Movement Report, produced by OTB under separate cover;
- To determine details of the existing basement floor slab;
- To determine the contamination status of soil and groundwater beneath the site;
- To assess whether contamination is present within soil and/or groundwater beneath the site at concentrations that could impact future site users/occupiers and the wider environment;
- To assess the suitability of the site for its proposed use and to support the discharge of the planning conditions pertaining to the investigation of potentially contaminated land; and
- To characterise soil arisings for potential disposal off-site.

1.3 Legislation and Guidance

This report has been produced in general accordance with:

- *Contaminated Land (England) Regulations 2006 (as amended);*
- *DEFRA Environmental Protection Act 1990: Part 2A - Contaminated Land Statutory Guidance (2012);*
- *Environment Agency (EA) Contaminated Land Report 11 (CLR 11): Model Procedures for the Management of Land Contamination;*
- *National Planning Policy Framework (2012)*;
- CIRIA Document C665: *Assessing Risks Posed by Hazardous Ground Gases to Buildings;*
- British Standard requirements for the *'Investigation of potentially contaminated sites - Code of practice' (ref. BS10175:2011)*;

- British Standard requirements for the *'Code of practice for ground investigations' (ref. BS5930:2015)*; and
- EN 1997-1 (2004): Eurocode 7: Geotechnical design - Part 1: General rules; and
- EN 1997-2 (2007): Eurocode 7: Geotechnical design - Part 2: Ground investigation and testing.

Where appropriate, consideration has also been given to the following:

- The potential for environmental liabilities to occur under other associated regimes, for example the *Water Resources Act (1991)* and the *Environmental Damage Regulations (2009)*; and
- Key constraints on site redevelopment.

Details of the limitations of this type of assessment are described in Appendix A.

1.4 Previous Reports

RPS has been provided with the following previous report for the site for review:

Ground Investigation Report for a Proposed Development at 150 Holborn, EC1, by Ground Engineering, dated May 2013, reference C12950.

The report is summarised as follows:

- The report was commissioned in relation to the proposed redevelopment of the site for an unspecified use. The investigation comprised the advancement of three cable percussion boreholes from basement level to depths of up to 20m below ground level (bgl), the installation of groundwater and ground gas monitoring wells, two hand excavated foundation inspection pits and four 150mm cores through the basement floor slab;
- Ground conditions encountered beneath the basement floor slab comprised a limited thickness of Made Ground, up to 1.50m in thickness, overlying Hackney Gravel Member to depths of up to 5.10m bgl. This was underlain by the London Clay Formation to the base of each borehole;
- Subsequent monitoring recorded groundwater at depths of approximately 2.30m bgl within the Hackney Gravel Member;
- Chemical laboratory analysis of soil samples collected beneath the site did not record contaminants of concern at concentrations significantly in excess of adopted assessment criteria, protective of future residential site users. A controlled was risk assessment was not undertaken;

- The report states that Made Ground would not provide a suitable bearing stratum for traditional foundations. However, the Hackney Gravel Member would provide an allowable bearing pressure of up to 250kN/m^2 for strip foundations up to 1.20m in width for low rise buildings;
- Piled foundations, terminating in the London Clay Formation were recommended for taller structures; and
- Analysis of soil and groundwater samples indicated that a design sulphate class of DS2 would be appropriate for buried concrete structures beneath the site.

RPS cannot vouch for the accuracy of information provided by other consultancies and legal reliance should be sought from the original author of the report where its content is considered material to the characterisation of the site.

2 PRELIMINARY RISK ASSESSMENT: SITE RECONNAISSANCE AND DESK STUDY

2.1 Site Reconnaissance

This section of the report is based upon observations made during a site walkover carried out on 1st March 2016. The site location and site boundary plans are shown as Figure 1 and Figure 2 respectively.

General view of the site (facing northeast).

2.1.1 The Site

Table 1 – Summary of on-site activities

Section	Description
Background:	The site was located in commercial area of central London at National Grid Coordinates 531164,181652 and occupied an area of approximately 0.23ha.
Site Layout:	The site was occupied by a six storey commercial building, with a single storey of basement. At the time of the walkover, ground floor units were occupied by a number of retail premises and a bank. Upper floors were used as office space. A courtyard area was present to the rear of the structure, accessed from Brooke Street on the eastern boundary of the site.
Activity / Operations:	Retail premises, including a number of cafes, a courier service and a bank formed the ground floor level of the building, with shopfronts facing Holborn and Grays Inn Road. These businesses also used parts of the basement for storage and a vault for the bank. A courtyard area to the rear of the building was used for parking and deliveries. Where occupied, the upper floors of the building were used as office space.
Building Structure(s):	The building comprised a concrete framed structure, with a courtyard present at ground level to the rear. A single storey of basement extended beneath the courtyard area and occupied the entire site footprint.

Section	Description
Surface Cover:	The basement floor slab comprised reinforced concrete and was observed to range from approximately 0.45m to 1.00m in thickness in test locations completed by RPS.
Drainage:	A number of surface water drains and manhole covers were noted within the courtyard area to the rear of the building. Manhole covers were also present at basement level beneath the building. No oil/water interceptors were noted on the site.
Bulk Storage / Tanks:	No above or below ground or underground storage tanks were observed during the site walkover.
Waste:	A number of bins, used for general waste and recycling were observed in the courtyard area, used by retail units facing Holborn and Grays Inn Road.
Electrical Substations /Transformers:	No electricity substations or transformers were noted during the site walkover.
Visual Evidence of Contamination:	No visual or olfactory evidence of contamination was noted during the site walkover.
Statutory Nuisance:	RPS was not informed of any complaints relating to the site.
Other Issues:	No Japanese Knotweed or Giant Hogweed (invasive plant species) were readily identified on the site at the time of the survey. *(It should be noted that not all areas of the site were accessible at the time of this assessment and that the identification of such species can be limited by the seasons and in areas of dense vegetation growth).* Given the age of the structure on site, it is possible that asbestos containing materials (ACMs) have been used in its construction and/or maintenance. If an up-to-date asbestos register is not available for the site, it is recommended that an asbestos survey is undertaken, so that any ACMs present can be managed accordingly. Prior to the redevelopment of the site, a full (destructive) asbestos survey will be required prior to demolition. RPS can provide further specialist advice on these issues upon request.

2.1.2 The Surrounding Area

The site is located in an area of predominantly retail and commercial land uses. At the time of the site inspection, neighbouring land consisted of the following:

Table 2 – Neighbouring Land Uses

Direction	Description
North:	Office building (Fox Court) with basement car parking.
East:	Brooke Street, beyond which were masonry commercial buildings.
South:	Chancery Lane Tube Station and Holborn, beyond which were office and retail buildings.
West:	Grays Inn Road, beyond which were retail units, with residential apartments above.

2.2 Site History

2.2.1 Historical Map Review

The following review is based on past editions of readily available Ordnance Survey (OS) maps. These include scales of 1:1,250, 1:2,500 and 1:10,000 dated 1875 to present. Extracts from selected and historical maps are given as Figures 3 to 8.

Table 3 – Historical Site Uses

On-site Land Use and Features	Dates
The site was occupied by a number of buildings of unspecified use (likely residential or commercial), with very limited external areas. A building in the southwest of the site was labelled as a bank from 1951.	1875 - c.1980
Structures in the centre and north of the site were no longer indicated to be present.	1980 - c.1990
The site resembles its current form.	1990 - Present

Table 4 – Historical Neighbouring Site Uses

Surrounding Land Uses (250m radius)	Orientation	Distance	Dates	
			From	To
Ruins	North	From 90m	1951	c.1963
Distillery	Southeast	105m	1875	c.1916
Tinfoil works	North	110m	1878	c.1896
Electricity substation	West	130m	1916	c.1951
Gold refinery (including substation) *Then* works	Northeast	140m	1897 1957	c.1957 c.1992
Ruins	Southeast	150m	1951	c.1974
Ruin	South	200m	1951	c.1957
Print works	South	240m	1897	c.1967
Ruins	Northeast	250m	1951	c.1963

In addition to the land uses summarised above, it is known that a London Underground Tube Tunnel runs from east to west a short distance to the south of the site. This feature was not highlighted in historical mapping.

Historical mapping shows ruins within the nearby vicinity of the site from c.1951 until c.1974. This would suggest that the immediate area was subject to bombing during the Second World War.

2.2.2 Site Planning History

Relevant planning records for the site, obtained from the London Borough of Camden Planning Department website are summarised below:

- Ref: 2011/4198/P, dated 30th August 2011 ï Refurbishment and alterations to the property, including extension to 5th and 6th floor and additional floor at 7th level for Class B1 offices on Holborn and Grays Inn Road elevations, extension at 3rd, 4th and 5th floor level for Class B1 offices and Class C3 residential on Brooke Street elevation, creation of 5 new residential units with 1 x existing unit (Class C3) and new residential entrance core off Brooke Street and associated elevation alterations, replacement plant and enclosures at roof levels, recladding to exterior elevations, alterations to main entrance including associates partial change of use from shops (Class A1) to offices (Class B1) at ground floor, partial change of use from offices (Class B1) to financial and professional services (Class A2) at 1st floor level, creation of enclosed service yard to rear with amenity space above, green/brown roofs and cycle parking. Granted Subject to a Section 106 Legal Agreement;

- Ref: 2011/4609/P, dated 20th September 2011 ï Change of use of part of retail unit (Class A1) to office use (Class B1) at ground floor level, including alterations to main office entrance to create extended double height entrance. Granted; and
- Ref: 2015/1442/P, dated 21st May 2015 ï Confirmation of the implementation of application ref 2011/4198/P granted 25/02/2012. Granted.

The above planning records did not contain conditions relating to the investigation of potentially contaminated land.

2.3 Proposed Development

It is proposed to redevelop the site as a nine storey mixed use building with a single storey of basement. Office and retail units will face Holborn on the southern side of the building and residential apartments will form the northern side, facing Fox Court. It has been assumed that no areas of soft landscaping are proposed as part of the development. An extract from drawings by Perkins and Will, received by Clarke Nicholls Marcel on 23rd November 2015 is presented as Figure 9.

2.4 Environmental Setting

2.4.1 Geology

Based on British Geological Survey (BGS) mapping (1:50,000-scale), EA Groundwater Vulnerability mapping (1:100,000-scale), and the previous 2013 report by Ground Engineering (reference C12950), the stratigraphic sequence and aquifer classifications beneath the site are as follows:

Table 5 – Descriptions of Geological Strata

Strata	Description & approximate thickness	Aquifer Classification
Made Ground	Clay, sand and gravel of anthropogenic material. Present to depths of up to 1.50m below basement level (bbl).	
Hackney Gravel Member	Sand and gravel. Present to depths of up to 5.10m bbl.	Secondary A
London Clay Formation	Clay, silt and sand. Present to depths of approximately 20.00m bgl	Unproductive Stratum
Lambeth Group	Clay, silt and sand. Present to depths of approximately 45.00m bgl	Secondary A
Thanet Formation	Clayey, silty sand. Present to depths of approximately 48.00m bgl	Secondary A
White Chalk Subgroup	Chalk with flint. Present to depths in excess of 200m bgl	Principal

2.4.2 Hydrogeology

Groundwater was encountered from depths of 2.30m bbl during monitoring visits as part of the previous investigation by Ground Engineering.

The site is indicated to be located above a Secondary A Aquifer relating to the Hackney Gravel Member. The deeper Lambeth Group and Thanet Formation are also Secondary A Aquifers. These formations are formed of permeable layers capable of supporting water supplies at a local scale, in some cases forming an important source of base flow to rivers.

The London Clay Formation is classified as an Unproductive Stratum. These formations have a low permeability and have negligible significance for water supply or base flow.

The White Chalk Subgroup is classified as a Principal Aquifer. These are layers of rock or drift deposits that have high intergranular and/or fracture permeability, meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale.

According to EA data, the site is not located in a groundwater Source Protection Zone (SPZ).

Information provided by the EA indicates that there are records of three active licensed groundwater abstractions within 1.00km of the site. These are detailed in the table below:

Table 6- Groundwater abstractions

Licence Holder	Source	Use	Approx. Distance and Direction from Site
City and Guilds of London Institute	Thames Groundwater - Chalk	Heat pump	570m East
Urban Hotels UK LLP	Thames Groundwater - Unspecified	Potable supply	665m Northeast
Global Grange Ltd	Thames Groundwater - Unspecified	Potable supply	965m Southeast

2.4.3 Surface Water

The River Thames is located approximately 835m to the south of the site.

Information provided by the EA indicates that there are no records of any active licensed surface water abstractions within 1km of the site.

2.4.4 Fluvial / Tidal Flood Risk

According to the EA flood map, the site is located within Flood Zone 1, whereby there is less than a 0.1% (1 in 1000) chance of flooding from rivers or the sea occurring each year.

2.4.5 Ecologically Sensitive Sites

Natural England data indicates that there are no ecologically sensitive sites that constitute environmental receptors as defined within Table 1 of the DEFRA Environmental Protection Act 1990: Part 2A - Contaminated Land Statutory Guidance (2012), located within a 1km radius of the site.

2.4.6 Radon

According to the Indicative Atlas of Radon in England and Wales published by the Health Protection Agency and the British Geological Survey, the site is not located in an area at risk from radon gas.

2.4.7 Coal Authority

According to Coal Authority data, the site is not located in an area potentially affected by coal mining activities.

2.5 Authorised Processes and Pollution Incidents

2.5.1 Landfills and Waste Sites

Information provided by the EA, Local Authority and BGS show that there are no records of landfills or other treatment waste sites within 500m of the site.

2.5.2 Environmental Permits

EA and Local Authority data indicates that there are seven active processes regulated by an Environmental Permit (under the Environmental Permitting Regulations 2010) within 500m of the subject site. These are outlined in the table below:

Table 7 – Environmental Permits

Licence Holder	Approx. Distance and Direction from Site	Permitted Activity
Sue Smart	295m North	Part B: Dry Cleaning
Mastermelt	335m Northeast	Part B: Metal Processing
Pentonville Plating Co Ltd	355m North	List 1 Dangerous Substances: Mercury and Cadmium
Matthew Daniel Dry Cleaners	425m Northwest	Part B: Dry Cleaning
Citigen (London) Ltd	450m East	Part A1: Combustion of fuel >50MW
Dianas Dry Cleaners	470m North	Part B: Dry Cleaning
Cancer Research UK	480m Southwest	Radioactive Substance Licence: Disposal Of Radioactive Waste

2.5.3 COMAH Sites

There are no records of any operations under the Control of Major Accident Hazards (COMAH) Regulations 1999, located within 500m of the site.

2.5.4 Pollution Incidents

EA data indicates that there are no records of any ómajorô or ósignificantô pollution incidents within 500m of the site.

2.6 Regulatory Consultations

The Environmental Health Department at the London Borough of Camden was contacted regarding any known contamination issues at the site. The council had no specific concerns regarding the site relating to potentially contaminated land and confirmed that the site was not on their list of sites prioritised for investigation under Part 2A of the Environmental Protection Act (1990).

RPS contacted London Fire Brigade regarding records of flammable storage / bulk underground storage tanks at the site. London Fire Brigade held no records indicating that the site had been used for the bulk storage of flammable materials.

3 OUTLINE CONCEPTUAL SITE MODEL

3.1 Background

An outline conceptual site model (CSM) consists of an appraisal of the *source-pathway-receptor* 'contaminant linkages' which is central to the approach used to determine the existence of 'contaminated land' according to the definition set out under Part 2A of the Environmental Protection Act 1990. For a risk to exist (under Part 2A), all three of the following components must be present to facilitate a potential 'pollutant linkage'.

- ***Source*** *referring to the source of contamination.*
- ***Pathway*** *for the contaminant to move/migrate to receptor(s).*
- ***Receptor*** *that could be affected by the contaminant(s).*

Receptors include human beings, other living organisms, crops, controlled waters and buildings / structures. The National Planning Policy Framework, used to address contaminated land through the planning process, follows the same principles as those set out under Part 2A. Further details on the Part 2A regime are presented within Appendix B.

3.2 Potential Pollutant Linkages

Each stage of the potential pollutant linkages have been assessed individually on the basis of information obtained during the site reconnaissance and desk study exercise and is discussed in the following section.

3.2.1 Potential Contaminant Sources

Current and historical uses of the site are not considered to represent potentially significant sources of contaminants of concern. However, a limited thickness of Made Ground is known to be present beneath the site.

Former potentially contaminative land uses in the vicinity of the site include a distillery, a tinfoil works, a gold refinery and a print works. An electricity substation was also indicated on mapping from 1916 until 1951, located approximately 130m to the west of the site. However, given its distance, it is considered unlikely that potential polychlorinated biphenyls (PCBs) from this source pose a significant risk to on site receptors.

Several dry cleaners, a metal works, an electroplating company and a medical research facility dealing with radioactive substances are currently present within 500m of the site. However, these are operated under environmental permits and are in excess of 250m from the site boundary. On this

basis, the potential risks posed to the site from these sources are considered to be negligible and have not been considered further as part of this assessment.

3.2.2 Potential Pathways

The entire site footprint is currently occupied by a single storey of basement. It is understood that this will also to be the case following redevelopment. On this basis, the risks to future users from potential contaminants of concern *via* the dermal contact and ingestion pathways will be mitigated. The risks to neighbouring site users from potential contaminants of concern via the ingestion of airborne soil/dust, having migrated off-site, will also be mitigated.

There is the potential for ground gas and volatile contaminants of concern in soil and/or groundwater beneath the site to impact future site users *via* the inhalation pathway in indoor areas.

Groundwater within granular horizons of Made Ground and Hackney Gravel Member beneath the site may constitute a potential pathway for the on or off-site migration of contaminants of concern. These may impact neighbouring site users *via* the pathways of direct contact, ingestion and vapour inhalation.

Potential contaminants associated with historical land uses in the vicinity of the site also have the potential to migrate onto site *via* groundwater within the underlying Made Ground and Hackney Gravel Member.

3.2.3 Potential Receptors

Potential human health receptors include future commercial and residential site users and neighbouring commercial and residential properties.

Providing construction workers adopt appropriate levels of hygiene and personal protective equipment, they are not considered to be at significant risk from potential contaminants of concern and have not been considered further as part of this assessment.

The site is situated on a Secondary A Aquifer, relating to the Hackney Gravel Member. The site is not located within a SPZ and the nearest groundwater abstraction is approximately 570m to the east and from the White Chalk Subgroup, at depth.

Deeper Secondary A and Principal Aquifers (relating to the Lambeth Group, Thanet Formation and White Chalk Subgroup) are considered to be afforded a significant degree of protection by the overlying thickness of impermeable London Clay Formation. Therefore these have not been considered further as potential receptors.

The nearest surface water feature is the River Thames, which is located approximately 835m to the south of the site. Given its distance from the site, this watercourse has not been considered further as part of this assessment.

3.3 Outline Conceptual Site Model

An outline CSM has been developed on the basis of the site reconnaissance and desk study. The CSM is used to identify potential sources, pathways and receptors (i.e. potential pollutant linkages) on site and is summarised in the table below:

Table 8 - Outline Conceptual Site Model

Potential Source	Contaminants of Concern	*Via*	Potential Pathways	Linkage Potentially Active?	Receptors
On site – historical: N/A **On site – current:** Made Ground	Metals, hydrocarbons and asbestos	Soil	Direct contact/ingestion	**x**	Future site users
			Inhalation of volatiles	✓	Future site users
			Airborne migration of soil or dust	**x**	Off-site users
			Leaching of mobile contaminants	✓	Secondary A Aquifer
		Groundwater	Direct contact/ingestion	**x** **x**	Future site users Off-site users
			Inhalation of volatiles	✓ ✓	Future site users Off-site users
			Vertical and lateral migration in permeable strata	✓	Secondary A Aquifer
Off-site – historical: Distillery, tinfoil works, gold refinery and print works **Off-site – current:** N/A	Metals and hydrocarbons	Groundwater	Direct contact/ingestion	**x**	Future site users
			Inhalation of volatiles	✓	Future site users
On and off-site – Made Ground / natural strata or bio-degradation of contamination	Carbon dioxide and methane	Ground Gas	Inhalation of ground gas	✓ ✓	Future site users Off-site users
			Explosive risks	✓ ✓	Future site users Off-site users

4 INTRUSIVE SITE INVESTIGATION

4.1 Introduction

An intrusive site investigation has been carried out in order to provide information on ground conditions and data for the assessment geotechnical properties of the strata underlying the site. The investigation also provided a preliminary assessment of whether pollutant linkages identified within the outline CSM (presented as Table 8) are currently active or will be made active upon redevelopment of the site.

4.2 Description of Works

The scope for the intrusive investigation was designed in conjunction with Clarke Nicholls Marcel. Site investigation works were carried out in two phases, from 1st to 14th March and from 29th March to 7th April 2016 and comprised:

- Concrete coring through the basement floor slab in six locations (BH1 to BH3 and Core 1 to Core 3);
- Three cable percussion boreholes (BH1 to BH3) to depths of 35.00m bbl (-17.18m to -19.60m AOD);
- In situ geotechnical testing and sampling throughout the depth of each borehole;
- Installation of groundwater/gas monitoring wells in each borehole;
- A series of probes to determine a profile of the basement slab thickness in seven locations (T1 to T5, T8 and T9); and
- One machine excavated trial pit (T10) adjacent to the northern wall of the building from ground level to a depth of 2.40m bgl.

The rationale for the scope of works was as follows:

- Boreholes BH1 to BH3 were undertaken in order to provide geotechnical soil parameters to enable foundation and basement design, as well as to feed into the Ground Movement Report, produced under separate cover;
- Trial Pit T10 was undertaken in order to determine soil conditions from ground level to the north of the proposed development area in to enable the design of a proposed below ground rainwater attenuation tank;
- Groundwater/ground gas monitoring wells were installed in order to monitor the ground gas regime, to determine groundwater level beneath the site, as well as to collect groundwater samples for chemical laboratory analysis;

- Soil samples were also collected from each borehole and trial pit for chemical laboratory analysis;
- Concrete cores were collected in order to enable borehole drilling, as well as to confirm the structure of the basement floor slab; and
- A series of six probes were advanced through the basement slab at 0.50m intervals from the basement wall in seven locations across the site. This was completed in order to determine a profile of the basement slab thickness in these locations.

The soil arisings from each hole were carefully examined for visual and olfactory evidence of contamination. Headspace testing was undertaken on site for ionisable volatile organic compounds (iVOCs) using a portable Photo-Ionisation Detector (PID).

A return visit for groundwater sampling was carried out on 14th April 2016. The monitoring wells were inspected for the presence of free-phase hydrocarbon product using an oil/water interface probe and the depth to groundwater was recorded prior to sampling.

Ground gas monitoring has been undertaken on six occasions, from 14th April to 2nd June 2016. Installations were monitored for concentrations of methane, carbon dioxide, carbon monoxide, hydrogen sulphide, oxygen and iVOCs. In addition, the flow rate and barometric pressure were recorded.

4.3 Laboratory Testing

4.3.1 Environmental Laboratory Testing - Soil

Two samples of Made Ground, three samples of Hackney Gravel Member and two samples of the London Clay Formation were submitted to a UKAS/MCERTS accredited laboratory and analysed for a number of determinands including:

Inorganic Determinands:

pH, arsenic, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, sulphide, total cyanide, sulphate, sulphur, selenium, zinc and asbestos.

Organic Determinands:

Polycyclic aromatic hydrocarbons (PAH), benzene, toluene, ethylbenzene and xylenes (BTEX), methyl tert-butyl ether (MTBE), speciated total petroleum hydrocarbons (TPH CWG), volatile organic compounds (VOCs) and monohydric phenol.

4.3.2 Waste Classification

Two samples of Made Ground, two samples from the Hackney Gravel Member and two samples from the London Clay Formation were submitted for Waste Acceptance Criteria (WAC) analysis.

4.3.3 Environmental Laboratory Testing - Groundwater

Three groundwater samples were collected during the first monitoring visit from monitoring wells installed within boreholes BH1 to BH3, screened in the Hackney Gravel Member and analysed by a UKAS/MCERTS accredited laboratory for some or all of the following potential contaminants:

Inorganic Determinands:

pH, arsenic, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium, zinc, sulphate, sulphide and total cyanide.

Organic Determinands:

Total organic carbon, PAH, TPH CWG including BTEX and MTBE, monohydric phenols and VOCs.

4.3.4 Geotechnical Laboratory Testing

Samples of the Hackney Gravel Member, London Clay Formation and Lambeth Group were submitted to a UKAS accredited geotechnical testing laboratory and analysed for soil classification, total and effective stress parameters, consolidation characteristics, pH and water soluble sulphate content.

5 SITE INVESTIGATION FINDINGS

5.1 Ground Conditions

5.1.1 Geology

The strata encountered during the intrusive investigation are summarised in the table below, and described in the following section.

Table 9 – Encountered Strata – from Basement Level

Strata	Depth to Top of Strata m bbl (m AOD)	Thickness (m)
Concrete basement slab	Ground level (GL)	0.38 to 0.90 (where proven)
Made Ground	0.90 (15.93)	0.50
Hackney Gravel Member	0.38 to 1.40 (15.02 to 15.43)	3.32 to 5.00
London Clay Formation	3.70 to 5.90 (10.93 to 11.70)	16.10 to 18.70
Lambeth Group	20.40 to 24.60 (-5.00 to -7.78)	Not proven to a maximum depth of 35.00m bbl (-19.60m AOD)

The basement floor slab was directly underlain by Hackney Gravel Member in the north of the site. A limited thickness of Made Ground was encountered beneath the floor slab in the north. The Hackney Gravel Member was underlain by the London Clay Formation and the Lambeth Group.

Trial pit T10, completed from ground level, encountered tarmac and concrete hardstanding overlying Made Ground to a maximum proven depth of 2.40m bgl.

General descriptions of the strata encountered during the intrusive investigation are summarised below. Reference should be made to the borehole logs within Appendix C of this report for full descriptions of ground conditions underlying the site.

Concrete cores and probes undertaken through the concrete floor slab indicated it to range from approximately 0.32m to in excess of 1.70m in thickness. This is discussed further in Section 8.4.

Made Ground

Made Ground was encountered beneath the basement floor slab in borehole BH3, located in the south of the site at a thickness of 0.50m. Made Ground was also encountered beneath hardstanding within trial pit T10, undertaken from ground level adjacent to the northern end of the building on site, to a maximum proven depth of approximately 2.40m bgl.

Made Ground was variable in nature, but generally comprised brown and grey silty, gravelly, cobbly sand, with pieces of wood, metal and plastic. Gravel and cobbles comprised brick, flint and ceramic.

Hackney Gravel Member

The Hackney Gravel Member was encountered directly beneath the basement floor slab. The stratum was encountered to depths ranging from approximately 3.70m to 5.90m bbl (15.02m to 15.43m AOD) and was encountered as orange-brown, sandy gravel of fine to coarse, subrounded to angular flint.

Standard Penetration Test (SPT) results obtained from within the Hackney Gravel Member at depths ranging from approximately 1.00m to 5.00m bbl (10.40m to 14.83m AOD) gave results ranging from N = 10 to N = 27, which is indicative of a medium dense material.

Particle Size Distribution (PSD) testing was undertaken on four samples collected from the Hackney Gravel Member at depths ranging from approximately 1.00m to 3.50m bbl (12.40m to 14.40m AOD). The constituents of the samples are summarised below:

- Gravel: 28% to 66%;
- Sand: 33% to 71%; and
- Silt/Clay: 1% to 2%.

Geotechnical laboratory certificates are presented as Appendix D.

Shear box tests were undertaken on two samples collected from the Hackney Gravel Member at depths of approximately 2.00m and 1.00m bbl (13.40m and 14.40m AOD) within boreholes BH1 and BH2, respectively, giving results of Ø = 37º and Ø = 40º for Angle of Shearing Resistance and 4kN/m^2 for effective cohesion.

London Clay Formation

The London Clay Formation was encountered beneath the Hackney Gravel Member to depths ranging from approximately 20.40m to 24.60m bbl (10.93m to 11.70m AOD). The stratum was generally encountered as dark grey, silty clay. A layer of red-brown, silty, sandy clay, ranging in thickness from 0.20m to 0.40m was encountered at the top of the stratum.

Atterberg Limit testing was undertaken on seven soil samples collected from the London Clay Formation at depths ranging from 4.50m to 14.50m bgl (0.90m to 10.90m AOD). This testing was undertaken to determine values for Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI). The results for LL ranged from 67% to 75%. The results for PL ranged from 28% to 31%. The results for PI ranged from 39% to 44%. This is indicative of a high to very high plasticity clay. Modified plasticity index values indicate that London Clay Formation samples analysed have a moderate volume change potential. The natural moisture content of these samples ranged from 25% to 35%.

SPT results obtained from within the London Clay Formation at depths ranging from approximately 4.00m bgl to 24.00m bbl (-7.17m to 11.40m AOD) gave results ranging from N = 14 to N = 33.

Approximate undrained shear strengths were calculated from SPT results using the correlation by Stroud:

$$C = f_1 \times N$$

Where, for high plasticity clays, $f_1 = 4.5$.

SPT results correspond approximately to undrained shear strength values ranging from 63kN/m^2 to 149kN/m^2, which is indicative of a medium, ranging to a high strength cohesive material.

Quick undrained triaxial compression testing was undertaken on four samples collected from the London Clay Formation at depths ranging from 9.50m to 20.00m bgl (-4.60m to 5.90m AOD). Undrained shear strength results ranged from 190kN/m^2 to 252kN/m^2 and generally increased with depth. These results were higher than those derived from SPT results at similar depths.

Two oedometer consolidation tests were undertaken on samples collected from the London Clay Formation at depths ranging from 6.50m to 17.00m bbl (-1.60m to 8.90m AOD). Between a pressure range of 100kN/m^2 to 200kN/m^2, coefficient of compression (m_v) values of 0.099m^2/MN and 0.156m^2/MN were obtained. This is indicative of a low to medium compressibility material.

Lambeth Group

The Lambeth Group was encountered beneath the London Clay Formation to a maximum proven depth of approximately 35.00m bbl (-19.60m AOD). The stratum was generally encountered as grey, red, blue, yellow and orange, mottled, slightly sandy, silty clay. Bands of blue, grey and yellow, silty sand were encountered at depths ranging from approximately 28.20m to 28.80m bbl (-13.40m to -12.80m AOD) and ranged in thickness from 1.20m to 1.70m. A band of dark grey, clayey, sandy, medium to coarse rounded flint and angular limestone gravel was also encountered from approximately 34.00m to 34.80m bbl (-19.40m to -18.60m AOD) within borehole BH2.

Atterberg Limit testing was undertaken on six soil samples collected from the Lambeth Group at depths ranging from 22.00m to 34.00m bgl (-18.60m to -6.60m AOD). The results for LL ranged from 61% to 74%. The results for PL ranged from 26% to 30%. The results for PI ranged from 35% to 44%. This is indicative of a high to very high plasticity clay. Modified plasticity index values indicate that Lambeth Group samples analysed have a low to moderate volume change potential. The natural moisture content of these samples ranged from 20% to 28%.

SPT results obtained from within the Lambeth Group at depths ranging from approximately 21.50m to 35.00m bbl (-19.60m to -6.10m AOD) gave results ranging from N = 45 to in excess of N = 50.

Approximate undrained shear strengths were calculated from SPT results using the correlation by Stroud:

$$C = f_1 \times N$$

Where, for high plasticity clays, $f_1 = 4.5$.

SPT results correspond approximately to undrained shear strength values ranging from 203kN/m^2 to in excess of 225kN/m^2, which is indicative of a very high strength cohesive material.

5.2 Groundwater

The depth to groundwater could not be accurately determined during intrusive works, due to water added to assist drilling through granular strata. Groundwater levels recorded during subsequent monitoring visits to site are summarised in the table below:

Table 10 - Groundwater Data

Bore hole ID	Well Screen Depth m bgl	Strata	Depth to Groundwater m bbl (m AOD)					
			14/04/16	22/04/16	09/05/16	16/05/16	23/05/16	02/06/16
BH1	1.00 to 3.70	Hackney Gravel Member	0.90 (14.50)	0.86 (14.54)	0.90 (14.50)	0.83 (14.57)	0.89 (14.51)	0.89 (14.51)
BH2	1.00 to 4.30	Hackney Gravel Member	0.90 (14.50)	0.88 (14.52)	0.80 (14.60)	0.87 (14.53)	0.89 (14.51)	0.89 (14.51)
BH3	1.40 to 5.90	Hackney Gravel Member	1.54 (15.29)	-	2.23 (14.60)	2.23 (14.60)	2.23 (14.60)	2.22 (14.59)

- Borehole silted up. Unable to determine groundwater level

Free-phase product was not observed within groundwater during monitoring visits.

The results of groundwater monitoring above appear to be representative of a continuous groundwater body within the Hackney Gravel Member at approximately 0.90m bbl (14.50m AOD).

5.3 Field Evidence of Contamination

5.3.1 Visual and Olfactory Evidence of Contamination

No visual or olfactory evidence of contamination was noted within soils or groundwater during intrusive works or subsequent monitoring visits.

5.4 Ground Gas Monitoring

Ground gas monitoring has been undertaken in the three monitoring wells on six occasions from 14th April to 2nd June 2016. Installations were monitored for concentrations of methane, carbon dioxide and oxygen. In addition, the flow rate and barometric pressure were recorded. The results of the

ground gas monitoring are presented in Appendix E. Monitoring data indicates that the response zones for monitoring wells BH1 and BH2 were flooded during each of the visits. The response zone for monitoring well BH3 remained un-flooded.

Methane was not recorded at concentrations in excess of the instrument limit of detection (<0.1% by volume (v/v)). Carbon dioxide was recorded at concentrations of up to 0.4% v/v within monitoring well BH2, screened within the Hackney Gravel Member on 14th April and 9th May 2016. A maximum peak flow rate of 0.9l/hr was recorded in borehole BH1 on the 23rd May 2016, falling to less than the instrument limit of detection (<0.1l/hr) after approximately one second.

The lowest recorded oxygen concentration was 18.8% v/v within monitoring well BH3 on 14th April 2016. Atmospheric pressure ranged from 1017mb to 1005mb during the monitoring visits.

The CIRIA Report C665 ó*Assessing risks posed by hazardous ground gases to buildings'* outlines indicative guideline concentrations for carbon dioxide and methane in association with gas flow rates for which gas protection measures may be required in new residential or commercial developments. The methodology is based on the Modified Wilson and Card approach that characterises the gas regime into a series of Characteristic Situations (1 to 5), with corresponding indicative gas protection measures. Using this methodology, the ground gas regime at this site corresponds to Characteristic Situation 1 (CS1), whereby no gas protection measures are required.

6 CHEMICAL RESULTS AND ASSESSMENT

The field investigation findings indicate that pathways are present by which contaminants of concern can impact identified receptors. Chemical analysis has been carried out on soils sampled from beneath the site. The concentrations of contaminants of concern within soil can be compared to assessment criteria (AC) to determine whether these represent an unacceptable risk to identified receptors. The derivation of AC to be used and the comparison of these criteria to the results of the chemical analyses are presented below.

6.1 Human Health Assessment Criteria

In order to assess risks to future site users, concentrations of contaminants of concern have been compared to Suitable 4 Use Levels (S4UL) generic Assessment Criteria (AC) published by Land Quality Management: Chartered Institute of Environmental Health (LQM:CIEH) in 2015. In accordance with the copyright notice the Publication Number for RPS Group is S4UL3177.

The assessment has been based upon a residential land use without the potential for homegrown produce to be grown / consumed, based on the proposed redevelopment of the site as a hotel and office pavilion.

Soil Organic Matter (SOM) for soil samples collected on site ranged from <0.10% to 1.60%, so concentrations of contaminants of concern have been compared to S4UL (1.00% SOM) values.

A notable exclusion from the S4ULs is lead. In the absence of a S4UL for lead, the Category 4 Screening Level (C4SL) has been selected, published by DEFRA in 2014. It is noted that the C4SL are based on the acceptance of a low level of toxicological concern, rather than the more conservative standard adopted in the derivation of S4ULs, which are based on a tolerable or minimal level of risk.

The potential risk posed to controlled waters from contaminants of concern within soils beneath the site is not addressed by these screening criteria.

6.2 Comparison of Soil Analyses to Human Health Assessment Criteria

Chemical analysis was undertaken on two samples of Made Ground, three samples of Hackney Gravel Member and two samples of the London Clay Formation. Analytical certificates for soils are presented in Appendix F. A comparison of soil analyses to the relevant assessment criteria is summarised below and presented as Appendix G.

6.2.1 *Inorganic Determinands*

Lead was recorded at concentrations in excess of adopted AC in a sample of Made Ground collected from trial pit T10 at a depth of 1.00m bgl (980mg/kg). The adopted AC for lead is 310mg/kg.

Inorganic contaminants were not recorded within any of the other soil samples analysed from beneath the site at concentrations in excess of adopted AC.

6.2.2 *PAH*

PAH contaminants were not recorded within soil samples analysed from beneath the site at concentrations in excess of adopted AC.

6.2.3 *TPH CWG (incl. BTEX/MTBE)*

TPH contaminants were not recorded within soil samples analysed from beneath the site at concentrations in excess of adopted AC.

6.2.4 *VOCs*

VOCs were not recorded within soil samples analysed from beneath the site at concentrations in excess of the laboratory limit of detection.

6.2.5 *Other Organic Determinands*

Total phenols were not recorded within other soil samples analysed from beneath the site at concentrations in excess of adopted AC.

6.2.6 *Asbestos*

Asbestos containing materials (ACMs) were not identified in any of the four soil samples submitted for screening.

6.3 Groundwater Assessment Criteria

The preliminary conceptual site model identified a Secondary A Aquifer, relating to the Hackney Gravel Member, to be present beneath the site that would be sensitive to contaminants of concern (if present). However, the site does not lie within a groundwater source protection zone and the closest licensed groundwater abstraction is indicated to be located approximately 570m to the east of the site from the chalk at depth. As such, the results of the groundwater analysis have been compared to the

Environmental Quality Standards (EQS) for freshwater. The potential risk to on site human health receptors from contaminants of concern in groundwater is not addressed by these screening values. Where such values are not available, the UK Drinking Water Standard (DWS) values have been used.

6.4 Comparison of Groundwater Analysis to Controlled Waters Assessment Criteria

Three groundwater samples were collected from monitoring wells BH1 to BH3 installed on site on a single occasion and submitted to a UKAS and MCERTS accredited laboratory for chemical testing. Analytical certificates for groundwater are presented in Appendix F.

A comparison of groundwater analyses to the relevant assessment criteria is summarised below and presented as Appendix G.

6.4.1 Inorganic Determinands

No inorganic contaminants were recorded at concentrations in excess of their relevant screening criteria.

6.4.2 PAH

No PAH contaminants were recorded at concentrations in excess of their relevant screening criteria.

6.4.3 TPH CWG (incl. BTEX/MTBE)

Aliphatic and aromatic TPH compounds in the C16 to C35 range were detected at concentrations in excess of the UK DWS screening value (10µg/l) within groundwater sampled from monitoring well BH3 (1,800µg/l),located in the south of the site, with the most elevated concentration from the aliphatic C21 to C35 fraction (1,300µg/l). No EQS screening criteria for TPH compounds are currently available.

Concentrations of TPH compounds in groundwater sampled from monitoring well BH3 correspond to elevated concentrations of these compounds with Made Ground at this location (although not in excess of screening criteria protective of human health).

TPH compounds were not recorded in other samples at concentrations in excess of the laboratory limit of detection.

6.4.4 VOCs

No VOCs were recorded at concentrations in excess of the laboratory limit of detection.

6.4.5 Other Organic Determinands

Monohydric phenol was not recorded at concentrations in excess of the laboratory limit of detection.

7 REVISED CONCEPTUAL SITE MODEL

The UK approach to the management of land contamination through the development process is risk-based, as was formerly implemented by Planning Policy Statement Number 23 (PPS23). PPS23 was formally withdrawn on 27th March 2012 and replaced by the National Planning Policy Framework.

The Local Authority is likely to have based their strategy for the implementation of the National Planning Policy Framework on the withdrawn PPS23. Therefore, this risk assessment will be based primarily on the withdrawn PPS23, with broad consideration for the contents of the National Planning Policy Framework.

The risk assessment methods adopted by PPS23 reflected those adopted by Part 2A of the Environmental Protection Act (1990). Part 2A identifies that harm to human health and the environment arises not solely from the presence of contaminating substances or ósourcesô, but from their migration along a ópathwayôto where they can impact a ôreceptorô.

The potential pollutant linkages identified as part of the outline CSM have been assessed in light of the findings of the site investigation and are discussed below for each of the individual receptors identified.

7.1 Future Site Users

Only lead was recorded within a sample of Made Ground analysed from beneath the site at a concentration in excess of adopted AC for residential end-use without plant uptake. The main drivers for the lead assessment criteria are the direct contact and ingestion pathways. The entire development area is to be covered by building footprint, or hardstanding. The pathways of direct contact and ingestion to future site users would therefore be broken.

Volatile contaminants of concern were not recorded within soils or groundwater analysed from beneath the site. Therefore, the vapour inhalation pathway to future site users is not considered to be active.

Based on the available information and the recommended mitigation measures being implemented, the potential risk to future site users from concentrations of contaminants of concern detected within soil and groundwater sampled from beneath the site is considered to be **LOW.**

7.2 Construction/ Maintenance Workers

S4ULs or C4SLs cannot be used to assess the acute (short term exposure) risk that personnel in close contact with exposed soils may experience during demolition, redevelopment or site maintenance duties.

Potential risks to construction workers can easily be controlled in most site areas by the use of appropriate personnel protective equipment (disposable coveralls, gloves and particulate/vapour masks) and by adopting high levels of personal hygiene.

Providing contractors undertake and implement a site specific risk assessment and resulting mitigation measures are taken, based on the available information, the potential risk to ground workers is considered to be **LOW.**

7.3 Off-site Human Health Receptors

Only lead was recorded within Made Ground sampled from beneath the site at a concentration in excess of adopted AC. However, following development, building cover and hardstanding across the site will limit the potential for air-borne migration of soil or dust to impact neighbouring receptors via the ingestion pathway.

Although concentrations of TPH compounds in excess of UK DWS screening criteria were recorded in groundwater sampled from monitoring well BH3, these concentrations are not considered to represent a significant risk to human health receptors. The direct contact and ingestion pathways are unlikely to be active given the significant depth to groundwater and the presence of hardstanding at the site and in the immediate surrounding area. The inhalation pathway is not considered to be active as no significant concentrations of volatile contaminants of concern were recorded within groundwater.

Based on the available information, the potential risk to off-site human health receptors from concentrations of contaminants of concern detected within soil and groundwater sampled from beneath the site is considered to be **LOW.**

7.4 Controlled Waters Receptors

TPH compounds in the C16 to C35 range were detected at concentrations in excess of the UK DWS screening value (10µg/l) within groundwater sampled from monitoring well BH3. Contaminants of concern were not recorded within groundwater analysed from other monitoring wells on site at concentrations in excess of adopted AC. It is considered likely that TPH compounds recorded in groundwater sampled from monitoring well BH3 may be representative of marginally elevated concentrations of TPH recorded in Made Ground sampled from this location.

The site does not lie within a groundwater SPZ and there are no groundwater licensed potable groundwater abstractions within a 1km radius of the site. The UK DWS screening criteria are therefore considered to be conservative in this case. No EQS screening criteria for TPH compounds are currently available.

Based on the available information, the potential risk to controlled waters receptors from concentrations of contaminants of concern detected within groundwater sampled from beneath the site is considered to be **LOW.**

7.5 Structures and Infrastructure

7.5.1 Buildings (on site and off site)

Based on ground gas monitoring undertaken on site as part of the current investigation CIRIA CS1 is applicable to the site, whereby ground gas protection are not required.

Therefore, the risk posed by ground gas to human health receptors and infrastructure is considered to be **LOW**.

7.5.2 Polymeric Utility Pipes

Elevated concentrations of hydrocarbon contaminants were recorded within samples collected from soils and groundwater beneath the site. Standard polymeric utility pipes are therefore unlikely to be suitable for the proposed development. Barriers may be required for new underground utilities, or service pipes laid in dedicated trenches and backfilled with clean, inert material.

Requirements should be discussed with service providers before the development stage. Providing the recommended mitigation measures are adopted, the risk posed to buried services is considered to be **LOW.**

7.6 Revised Conceptual Site Model

The potential source-pathway-receptor linkages and associated risks upon completion of the proposed development at the site, as identified following completion of the assessment, are summarised in the table below.

Table 11 - Revised CSM

Potential Source	*Via*	Potential Pathways	Linkage Potentially Active?	Receptors
On site – historical: N/A **On site – current:** Made Ground	Soil	Direct contact/ingestion	**x**	Future site users
		Inhalation of volatiles	**x**	Future site users
		Airborne migration of soil or dust	**x**	Off-site users
		Leaching of mobile contaminants	**x**	Secondary A Aquifer
	Groundwater	Direct contact/ingestion	**x** **x**	Future site users Off-site users
		Inhalation of volatiles	**x** **x**	Future site users Off-site users
		Vertical and lateral migration in permeable strata	**x**	Secondary A Aquifer
Off-site – historical: Distillery, tinfoil works, gold refinery, electricity substation and print works **Off-site – current:** N/A	Groundwater	Direct contact/ingestion	**x**	Future site users
		Inhalation of volatiles	**x**	Future site users
On and off-site – Made Ground / natural strata or bio-degradation of contamination	Ground Gas	Inhalation of ground gas	**x** **x**	Future site users Off-site users
		Explosive risks	**x** **x**	Future site users Off-site users

The risk assessment is based upon the available information relating to the site and recommended mitigation measures being implemented. Should ground conditions inconsistent with those outlined in this report be encountered RPS should be contacted to enable further assessment.

8 GEOTECHNICAL ANALYSIS

8.1 Introduction

It is proposed to redevelop the site as a nine storey mixed use building with a single storey of basement. Office and retail units will face Holborn on the southern side of the building and residential apartments will form the northern side, facing Fox Court.

A provisional drawing and schedule of pile groups provided by Clarke Nicholls Marcel, dated 21st March 2016, indicates that pile group loads for the new development will range from approximately 1,225kN to 48,330kN. Should the structural loads or details of the development change, the contents of this section of the report should be reappraised.

8.2 Preliminary Geotechnical Risk Register

The table below summarises the potential geotechnical hazards associated with the development. The table provides an assessment of whether the site is likely to be affected by the hazard and the possible consequences and engineering considerations.

Table 12 – Geotechnical Risk Register

Hazard Description	Is hazard likely to be present / affect the site? (H / M / L / NA?)	Comments / possible engineering requirements where hazard present
Sudden lateral / vertical changes in ground conditions	L/M	The ground conditions from basement level are generally consistent with Hackney Gravel Member overlying the London Clay Formation above the Lambeth Group. Made Ground was encountered in trial pit T10, undertaken from ground level outside the building footprint. The main variations in ground conditions (if present) are likely to be associated with the depth and composition of the Made Ground and the weathering of the London Clay Formation.
Highly compressible / low bearing capacity soils, (including peat and soft clay)	L	It is understood that the proposed development is to be supported on piles, terminating in the Lambeth Group, which is of low compressibility. Strata beneath proposed basement slab level are likely to comprise the Hackney Gravel Member, which are medium dense to dense and of low compressibility.
Ground dissolution features / natural cavities	L	Ground conditions beneath the site are not consistent with this feature.
Shrinking and swelling clays	L	Made Ground and Hackney Gravel Member, present to at least 4.00m bbl (11.40m AOD) are granular and non-plastic.

Hazard Description	Is hazard likely to be present / affect the site? (H / M / L / NA?)	Comments / possible engineering requirements where hazard present
Slope stability issues	L	Whilst no significant slopes are present on site, any temporary or permanent slopes created as part of the development should be subject to appropriate geotechnical design based on site-specific site investigation information.
High groundwater table (including waterlogged ground)	M/H	Groundwater was encountered at depths from 0.80m bbl (15.29m AOD) during subsequent monitoring visits. Groundwater exclusion and control measures will therefore be required during the proposed basement construction. The basement foundation and floor slab design will have to take uplift/buoyancy pressures into account if founded in the water bearing Hackney Gravels.
Filled and Made Ground (including embankments)	M	Made Ground was encountered in trial pit T10, undertaken from ground level outside the building footprint. However, it was absent beneath the existing basement slab.
Obstructions (including foundations, services, basements, tunnels and adjacent sub-structures)	M/H	The site has a significant development history. Buried obstructions, including relic concrete foundations should therefore be anticipated and programmed for. Heavy construction plant may be required to remove some larger obstructions or to cut down existing piled foundations.
Underground mining	L	The ground conditions encountered are not consistent with this hazard.
Concrete classification	L/M	Testing has indicated that a Design Sulphate Class of DS-2 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC2 would be appropriate for buried concrete structures in contact with the Made Ground. A Design Sulphate Class of DS-1 and an ACEC Classification of AC1 would be appropriate for buried concrete structures in contact with the Hackney Gravel Member, London Clay Formation and Lambeth Group only.
Seismic Activity	L	The Eurocode 8 seismic hazard zoning maps for the UK (Musson and Sargeant, 2007) indicate that horizontal Peak Ground Acceleration (PGA) values with 10% probability of being exceeded in 50 years (475 year return period) are between 0.00g and 0.02g, which is considered very low.

8.3 Concrete Cores

Six concrete cores were drilled through the existing basement floor slab in order to determine details of its construction. Details of concrete cores are summarised in the table below:

Table 13 – Concrete Core Details

Core ID	Location	Diameter (mm)	Thickness (mm)	Depth of Reinforcement (mm)	Thickness of reinforcement (mm)
BH1	Southern basement area	250	400	103	15
BH2	Northeast of basement centre	250	450	100 and 300	15 and 15
BH3	Western basement area	250	900	80, 100, 280, 300 and 500	15, 15, 25, 25 and 30
Core 1	East of basement	150	450	110 and 300	15 and 15

Core ID	Location	Diameter (mm)	Thickness (mm)	Depth of Reinforcement (mm)	Thickness of reinforcement (mm)
	centre				
Core 2	Northeastern basement area	150	>1700	60, 100, 130, 170 and 200	5, 20, 35, 20 and 20
Core 3	Northwest of basement centre	150	320	None observed	N/A

Core positions are indicated on Figure 2.

8.4 Basement Slab Thickness

Several probe holes were drilled through the basement floor slab at varying distances from the basement wall in seven locations on site. Details of slab thicknesses at these locations are summarised in the table below:

Table 14 – Slab Thickness

Probe ID	Location	Slab Thickness (mm) Distance from Basement Wall (m)					
		0.50	1.00	1.50	2.00	2.50	3.00
T1	Eastern basement wall (centre)	500	500	500	500	500	500
T2	Eastern basement wall (north)	>1000	>1000	>1000	>1000	>1000	>1000
T3	Northern basement wall (east)	500	500	500	500	500	500
T4	Northern basement wall (west)	500	500	500	900	900	>1000
T5	Western basement wall (north)	920	920	920	700	700	700
T8	Southern basement wall (centre)	500	500	500	500	500	500
T9	Eastern basement wall (south)	500	500	500	>1000	>1000	>1000

The thickness of the existing basement slab appears to be highly variable. The slab thickness remained consistent for three of the profiles undertaken (profiles T1, T3 and T8) with distance from the basement wall. The thickness of the slab increased with distance for profiles T4 and T9 and decreased for profile T5. Core and probe locations where the thickness of the slab was not proven may be representative of deepened footings or pile caps. Probe positions are indicated on Figure 2.

8.5 Foundation Solutions

8.5.1 Piled Foundations

Whilst it is considered that a basement raft foundations would be feasible at the site, information from the structural engineer indicates that it is proposed to support the proposed development on piled foundations. Bored or continuous flight auger (CFA) piles, terminating in the deeper layers of the London Clay Formation or Lambeth Group are likely to be suitable from a geotechnical perspective.

Preliminary anticipated CFA or bored pile bearing capacities are detailed in the table, below:

Table 15 - Anticipated Preliminary CFA or Bored Pile Capacities (kN)

Pile Length (m)	Pile Diameter (m)						
	300mm	450mm	600mm	750mm	900mm	1200mm	1500mm
15	365	575	805	1060	1330	1930	2610
20	545	850	1180	1535	1910	2735	3646
25	865	1350	1865	2410	2995	4255	5650
30	1180	1820	2500	3210	3950	5545	7275
35	1505	2315	3155	4035	4945	6880	8960

Partial safety factors have been applied to the calculated pile capacities above in accordance with Design Approach 1: Combination 2, as detailed within Tables A.6, A.7 and A.8 of Annex A in BS EN 1997-1. A model factor of 1.4 has also been applied to soil strength properties. This was found to be the most conservative design approach.

Loads are based on single piles only and do not take into account the action of groups of piles. This should be considered at the detailed design stage. In addition, depending on the proposed finished floor level and variation in the groundwater table beneath the site, there may be uplift pressures on the basement due to the continuous water table in the Hackney Gravel Member, which was measured from approximately 0.80m below existing basement level during return monitoring visits to site. It is considered likely that these uplift pressures will be low and that piled foundations will have sufficient tension capacity in order to resist these. However, further groundwater level monitoring is recommended prior to the constructions stage. Maximum uplift pressures are likely to be encountered during construction when the basement is watertight but the superstructure has not yet been constructed.

The pile capacity estimates presented above are preliminary and are based on a conservative soil profile derived from exploratory holes undertaken on site. The adopted pile profile is summarised as follows:

Table 16 - Adopted Soil Profile

Stratum	Depth (m bbl)	Bulk Density (kN/m^3)	Shear Strength (kN/m^2)	N_c	Soil/Pile Friction Angle (°)	N_q
Hackney Gravel Member	GL to 4.00 (15.40m to 11.40m AOD)	16	-	-	32	30
London Clay Formation	4.00 to 20.00 (11.40m to -4.60m AOD)	20	75 at 4.00m bgl, increasing linearly to 145 at 20.00m bbl	9	-	-
Lambeth Group	20.00 (-4.60m AOD) to a maximum proven depth of 35.00 (-19.60m AOD)	20	200 at 20.00m bgl, increasing linearly to 225 at 35.00m bbl	9	-	-

A piling contractor should be consulted with regard to detailed pile design, since the type of pile adopted will affect capacity. An appropriate piling platform should be designed and constructed in accordance with BRE Digest 470 (Working platforms for tracked plant).

8.6 Retaining Wall

Design parameters for basement retaining walls for the proposed development are summarised in the table below:

Table 17 – Soil Profile beneath Proposed Retaining Walls

Stratum	Depth (m beneath basement)	Bulk Density (kN/m^3)	Total Stress		Effective Stress	
			Cu(kN/m^2)	Φ(º)	C' (kN/m^2)	Φ'(º)
Hackney Gravel Member	GL to 4.00 (15.40m to 11.40m AOD)	16**	0*	33**	0**	33**
London Clay Formation	4.00 to 20.00 (11.40m to -4.60m AOD)	20**	75 at 4.00m bgl, increasing linearly to 145 at 20.00m bbl**	0*	0*	27*
Lambeth Group	20.00 (-4.60m AOD) to a maximum proven depth of 35.00 (-19.60m AOD)	20*	200 at 20.00m bgl, increasing linearly to 225 at 35.00m bbl**	0*	0*	28*

* Conservative assumption.

** Moderately conservative value, based on *in situ* and/or laboratory testing.

It should be noted that the actual coefficient of earth pressure used for design should reflect the form of construction employed and any temporary works required. Given the presence of groundwater in the Hackney Gravel Member, a watertight basement wall solution will be required, such as a secant piled or a diaphragm wall.

8.7 Basement Floor Slab

It is understood that a single storey basement is proposed beneath the new development. In this case, it is likely that ground conditions immediately underlying the floor slab of this structure will comprise Hackney Gravel Member. Ground bearing floor slabs are therefore likely to be suitable for the proposed development, if a basement raft foundation is not adopted. Should Made Ground or cohesive material be encountered at slab formation level, this should be removed and replaced with granular fill, compacted to an end product specification. The basement floor slab should be designed to withstand the potential uplift pressures discussed in Section 8.5.1 above.

8.8 Chemical Attack on Buried Concrete

Samples of Made Ground, Hackney Gravel Member, London Clay Formation and Lambeth Group were tested for pH and for sulphate content. The results are presented below:

Table 18 - Results of pH and sulphate testing

Sample Location and Depth (m bbl)	Sample Type	pH	Water Soluble (2:1 extract) sulphate (mg/l)	Design Sulphate Class	ACEC Class
BH1 at 1.60 (13.80m AOD)	Hackney Gravel Member	8.8	<10	DS1	AC1
BH1 at 3.80 (11.60m AOD)	London Clay Formation	8.0	52	DS1	AC1
BH1 at 4.50 (10.90m AOD)	London Clay Formation	8.2	240	DS1	AC1
BH1 at 9.50 (5.90m AOD)	London Clay Formation	8.6	290	DS1	AC1
BH1 at 23.50 (-8.10m AOD)	Lambeth Group	9.1	30	DS1	AC1
BH1 at 26.50 (-11.10m AOD)	Lambeth Group	9.3	36	DS1	AC1
BH2 at 1.00 (14.40m AOD)	Hackney Gravel Member	8.6	12	DS1	AC1
BH2 at 2.50 (12.90m AOD)	Hackney Gravel Member	8.8	10	DS1	AC1
BH2 at 3.20 (12.20m AOD)	Hackney Gravel Member	8.5	17	DS1	AC1
BH2 at 5.50 (9.90m AOD)	London Clay Formation	8.0	210	DS1	AC1
BH2 at 14.50 (0.90m AOD)	London Clay Formation	8.5	280	DS1	AC1
BH2 at 30.00 (-14.60m AOD)	Lambeth Group	9.3	32	DS1	AC1
T10 at 1.00m bgl (17.40m AOD)	Made Ground	11.2	1300	DS2	AC2

The data was used to assess appropriate concrete classification for buried concrete in accordance with BRE Special Digest 1, based on the following assumptions:

- Brownfield ground conditions;
- Mobile groundwater conditions;
- For a dataset of one to four samples, the characteristic value for soluble sulphate has been taken as the highest of the results, while the characteristic value for pH is taken as the lowest of pH results. The characteristic values for the Made Ground are therefore taken as 1,300mg/l for soluble sulphate and 11.2 for pH value. The characteristic values for the Hackney Gravel Member are taken as 17mg/l for soluble sulphate and 8.5 for pH value. The characteristic values for the Lambeth Group are taken as 36mg/l for soluble sulphate and 9.1 for pH value; and
- For a dataset of five to nine samples, the characteristic value for soluble sulphate has been taken as the average of the two highest results, while the characteristic value for pH is taken as the average of the two lowest pH results. The characteristic values for the London Clay Formation are therefore taken as 285mg/l for soluble sulphate and 8.0 for pH value.

Based on the above, it is considered that a Design Sulphate Class of DS-2 and an Aggressive Chemical Environment for Concrete (ACEC) Classification of AC2 would be appropriate for buried concrete structures in contact with the Made Ground. A Design Sulphate Class of DS-1 and an ACEC Classification of AC1 would be appropriate for buried concrete structures in contact with the Hackney Gravel Member, London Clay Formation and Lambeth Group only.

8.9 Temporary Works and Excavations

The site has a significant development history. Buried obstructions, including relic concrete foundations should therefore be anticipated and programmed for. Heavy construction plant may be required to remove some larger obstructions or to cut down existing piled foundations.

Groundwater was recorded at depths ranging from 0.80m to 2.23m bbl (14.50m to 15.29m AOD) within wells screened within the Hackney Gravel Member. A secant piled or diaphragm wall will exclude water from outside the proposed basement excavation. However, groundwater control measures may be required whilst excavating through the Hackney Gravel Member. This should be undertaken by localised groundwater pumping.

If perched groundwater is encountered during excavation, degradation of the formation may occur. The formation should therefore be adequately protected from seepages and protected from adverse weather conditions. If the formation layer becomes wet resulting in softening or loosening of the surface materials, then excavation may have to be taken deeper in order to find a suitable bearing layer. In addition, the potential for ñboilingò of granular materials beneath any temporary soil retention should be considered along with the effect of groundwater uplift pressures on the integrity of any basement formation level prior to casing any floor slabs. Instability of excavations in granular material should be expected, especially during periods of adverse weather. Suitable shoring measures may be required for any excavations greater than 1.20m. All temporary excavations should be undertaken in accordance with CIRIA Report 97 ï Trenching Practice. It would be prudent form all formation soils to be inspected by a suitable qualified geotechnical engineer prior to casting any concrete.

9 MATERIAL RE-USE AND WASTE CHARACTERISATION

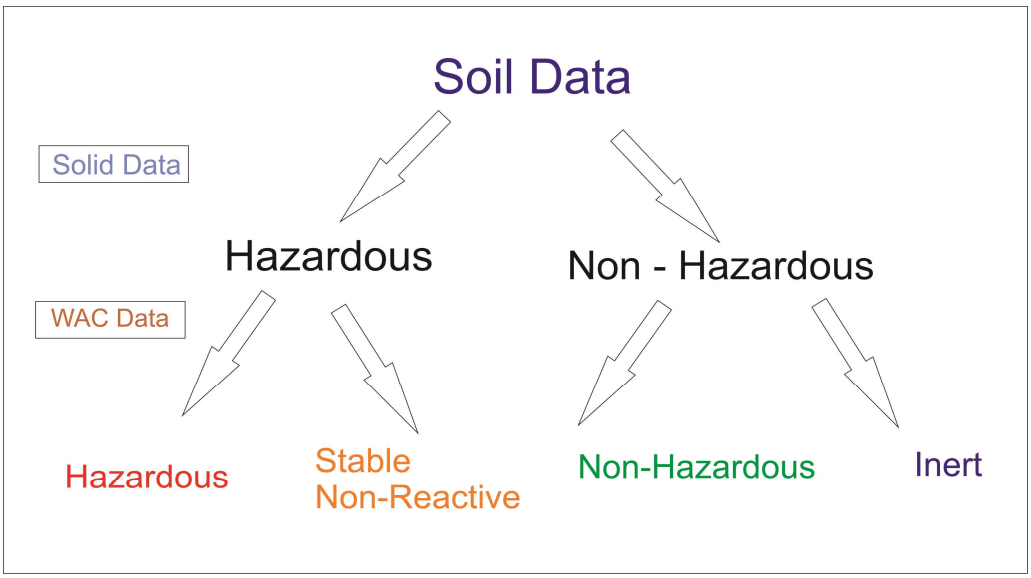
9.1 Assessment Criteria

Following redevelopment, no significant change in site levels is proposed. It is likely that soil arisings generated through piling or any other excavation associated with the development will require removal from site, since there is limited potential for on-site re-use of this material. Should no suitable off site re-use options be available, disposal to landfill may need to be considered. However, if contaminated material is to be disposed of, use of soil treatment facilities should also be considered.

If disposal to landfill is required, the excavated material would be considered as waste and should be classified in line with the Hazardous Waste Directive - HWD, Council Directive 91/689/EC. This legislation divides waste into two categories, hazardous and non-hazardous. These two categories can then be subdivided into a number of classes relating to the type of landfill/cell to which the material can be sent; these are illustrated below.

In order to provide an indication of the likely waste characterisation of soils excavated from the site, should disposal be required, a waste characterisation exercise has been carried out. This is summarised in Sections 9.2 to 9.5 below. Any material sent to landfill should be accompanied by the appropriate duty of care documentation and the chemical data should be forwarded to the accepting landfill for approval prior to removal of the soil from site.

Waste Characterisation Categories



9.2 Soil Sampling and Testing

Solid Suite of Analysis

Two samples of Made Ground, three samples of Hackney Gravel Member and two samples of the London Clay Formation were submitted to a UKAS/MCERTS accredited laboratory as part of the intrusive works. All soil samples were analysed for the following solid suite of analysis:

pH, arsenic, asbestos, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, sulphide, sulphate, cyanide, phenols, PAH, BTEX, MTBE and TPH CWG.

WAC Testing

Two samples of Made Ground, two samples of Hackney Gravel Member and two samples of London Clay Formation were also submitted for the solid WAC suite of analysis.

The solid WAC suite of analysis included testing for the following determinands:

Total organic carbon (TOC), loss on ignition (LOI), BTEX, sum of PCBs, mineral oil and total PAH, acid neutralisation capacity and pH.

WAC single stage leachate analysis was also carried out on the above samples. The analysis included testing for the following determinands:

Arsenic, barium, cadmium, chromium, copper, mercury, molybdenum, nickel, lead, antimony, selenium, zinc, chloride, fluoride, sulphate, total dissolved solids (TDS), phenol index and dissolved organic carbon.

All soil analysis and WAC results are provided in Appendix F.

9.3 Solid Soil Data

Results of the solid suite of analysis were analysed using HazWasteOnline, Software which allows users to classify waste as defined in the EWC (European Waste Catalogue 2002) based on the regulatory framework for the Classification Labelling and Packaging of Substances and mixtures Regulation, (EC) No 172/2008 and the latest Environment Agency guidance (Technical Guidance WM3).

The solid soil data indicates that, of the two samples of Made Ground analysed, one would be characterised as non-hazardous waste and one would be characterised as hazardous waste. The sample collected from borehole BH3 at 1.00m bgl exceeded the corrosive hazardous waste threshold due to a high pH.

All three samples of Hackney Gravel Member and the two samples of London Clay would be suitable for disposal as non-hazardous waste.

Asbestos was not detected in any of the three samples submitted for screening.

9.4 WAC Data

9.4.1 Solid Data

An exceedance of the inert solid WAC thresholds for TPH was recorded in the sample of Made Ground suitable for disposal as non-hazardous waste. No exceedances were recorded of the Stable Non-Reactive Hazardous Waste (SNRHW) thresholds in the sample of Made Ground suitable for disposal as hazardous waste.

No exceedances of the Inert solid WAC thresholds were recorded for either of the two samples of Hackney Gravel Member nor the two samples of London Clay Formation.

9.4.2 Leachate Data

There were no exceedances of the SNRHW WAC threshold criteria in the sample of Made Ground classified as hazardous waste. There were no exceedances of the corresponding inert WAC thresholds in the remaining sample of Made Ground, the two samples of Hackney Gravel Member or the two samples of London Clay Formation classified as non-hazardous waste.

9.5 Summary of Results

The results of the waste characterisation exercise are provided in Appendix F and summarised in the table below.

Table 16 – Summary of Waste Characterisation Exercise

Position	Depth (m bgl)	Strata	Solid Suite of Analysis	Exceedance of Corresponding Inert, SNRHW and Hazardous waste WAC Limit Value?	WAC Analysis Results
T10	1.00	Made Ground	**Non-Hazardous**	Yes (TPH)	**Non-Hazardous**
BH3	1.00	Made Ground	**Hazardous** (pH)	No	**SNRHW**
BH1	1.60	Hackney Gravel Member	**Non-Hazardous**	No	**Inert**
BH2	1.00	Hackney Gravel Member	**Non-Hazardous**	No	**Inert**
BH2	3.20	Hackney Gravel Member	**Non-Hazardous**	N/A	N/A

Position	Depth (m bgl)	Strata	Solid Suite of Analysis	Exceedance of Corresponding Inert, SNRHW and Hazardous waste WAC Limit Value?	WAC Analysis Results
BH1	3.80	London Clay Formation	**Non-Hazardous**	No	**Inert**
BH3	5.90	London Clay Formation	**Non-Hazardous**	No	**Inert**

N/A ï Additional WAC analysis not carried out on sample

The results of the waste characterisation exercise can be summarised as follows:

- Of the two samples of Made Ground analysed for the solid suite of analysis one was characterised as hazardous waste and one was characterised as non-hazardous waste. WAC testing was undertaken on the non-hazardous samples which would be suitable for disposal as non-hazardous waste. WAC testing was undertaken on the hazardous sample which would be suitable for disposal to a SNRHW waste landfill;
- All three samples of Hackney Gravel Member analysed for the solid suite of analysis were characterised as non-hazardous waste. WAC testing was undertaken on two samples of these samples which would be suitable for disposal as inert waste.
- Two samples of London Clay Formation were analysed for the solid suite of analysis and both were characterised as non-hazardous waste. WAC testing was undertaken both of these samples which would both be suitable for disposal to an inert waste landfill.

To summarise, the results of the waste characterisation exercise showed that of the two samples of Made Ground submitted for WAC testing one would be suitable for disposal to a SNRHW landfill and one would be suitable for disposal to a non-hazardous waste landfill. The two samples of Hackney Gravel Member and two samples of London Clay Formation submitted for WAC testing would all be suitable for disposal to an inert waste landfill.

Any material sent to landfill should be accompanied by the appropriate duty of care documentation and the chemical data should be forwarded to the accepting landfill for approval prior to removal of the soil from site.

10 CONCLUSIONS AND RECOMMENDATIONS

Environmental

Based on the available information, the potential risk to human health receptors from concentrations of contaminants of concern detected within soils and groundwater sampled from beneath the site is considered to be **LOW.**

TPH compounds were detected at concentrations in excess of the UK DWS screening value within groundwater sampled from monitoring well BH3. Contaminants of concern were not recorded within groundwater analysed from other monitoring wells on site at concentrations in excess of adopted AC. The site does not lie within a groundwater SPZ and there are no groundwater licensed potable groundwater abstractions within a 1km radius of the site. The UK DWS screening criteria are therefore considered to be conservative in this case. Based on the available information, the potential risk to controlled waters receptors from concentrations of contaminants of concern detected within groundwater sampled from beneath the site is considered to be **LOW.**

Based on the ground gas monitoring undertaken on site as part of the current investigation CIRIA CS1 is applicable to the site, whereby ground gas protection measures are not required. Therefore, the risk posed by ground gas to human health receptors and infrastructure is considered to be **LOW**.

Results of the waste characterisation exercise showed that of the two samples of Made Ground submitted for WAC testing one would be suitable for disposal to a SNRHW landfill and one would be suitable for disposal to a non-hazardous waste landfill. The two samples of Hackney Gravel Member and two samples of London Clay Formation submitted for WAC testing would all be suitable for disposal to an inert waste landfill.

Geotechnical

Whilst it is considered that a basement raft foundations would be feasible at the site, information from the structural engineer indicates that it is proposed to support the proposed development on piled foundations. Bored or CFA piles, terminating in the deeper layers of the London Clay Formation or Lambeth Group are likely to be suitable from a geotechnical perspective.

It is understood that a single storey basement is proposed beneath the new development. In this case, it is likely that ground conditions immediately underlying the floor slab of this structure will comprise Hackney Gravel Member. Ground bearing floor slabs are therefore likely to be suitable for the proposed development. Should Made Ground or cohesive material be encountered at slab formation level, this should be removed and replaced with granular fill, compacted to an end product specification.

Testing has indicated that a Design Sulphate Class of DS-2 and an ACEC Classification of AC2 would be appropriate for buried concrete structures in contact with the Made Ground. A Design Sulphate Class of DS-1 and an ACEC Classification of AC1 would be appropriate for buried concrete structures in contact with the Hackney Gravel Member, London Clay Formation and Lambeth Group only.

FIGURES

Figure 1: Site Location Plan

Map Date: Current

Scale: Not to scale

RPS
35 New Bridge Street
London
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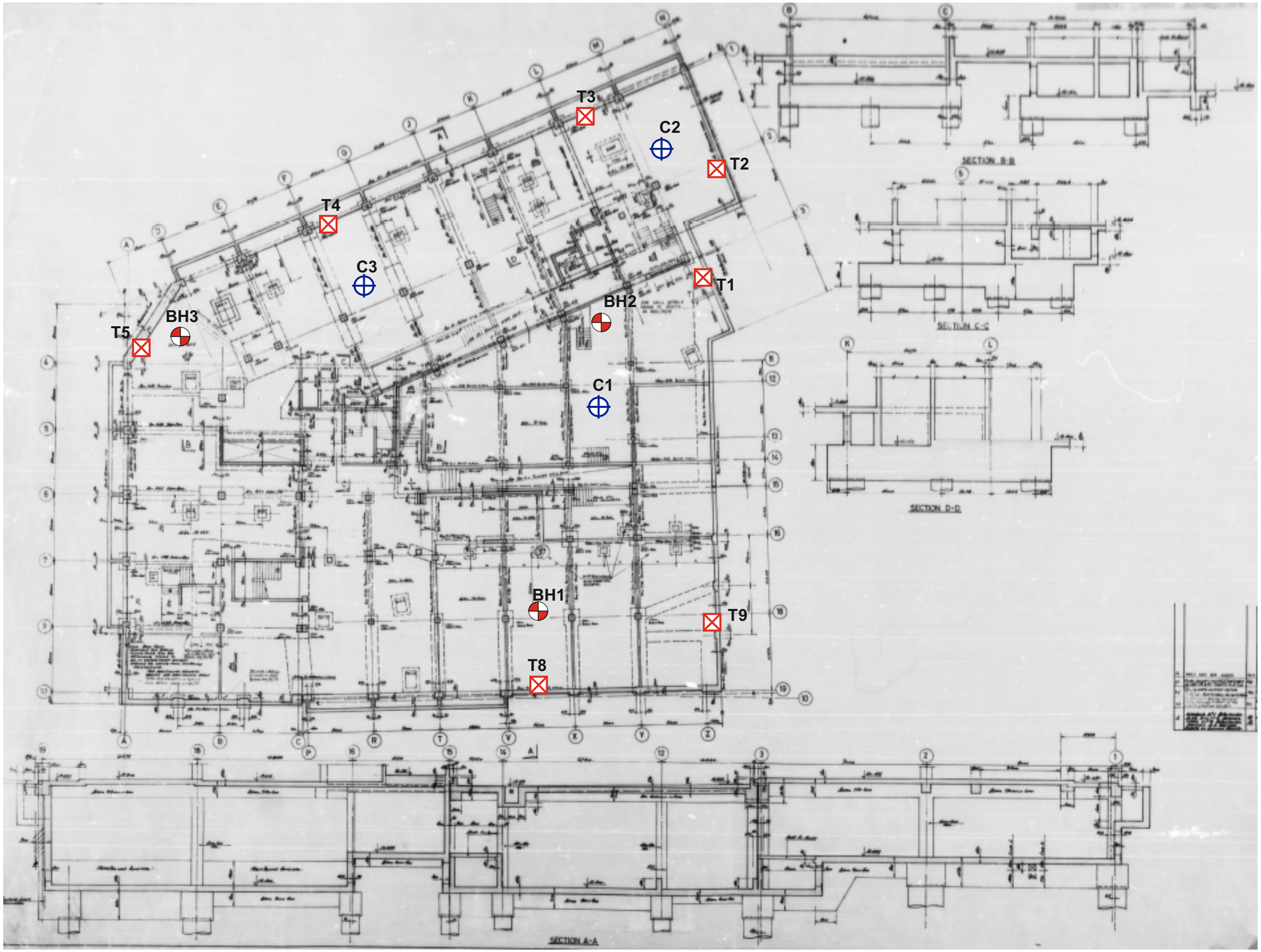

N

Legend

- Exploratory Borehole
- Concrete Core
- TRL Probe

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Client: CLARKE NICHOLLS MARCEL

Project: 150 HOLBORN

Title: EXPLORATORY HOLE LOCATION PLAN

Job Ref: HLEI39025

Scale: NTS

Date: May 2016

Figure Number: 2

Rev: 0

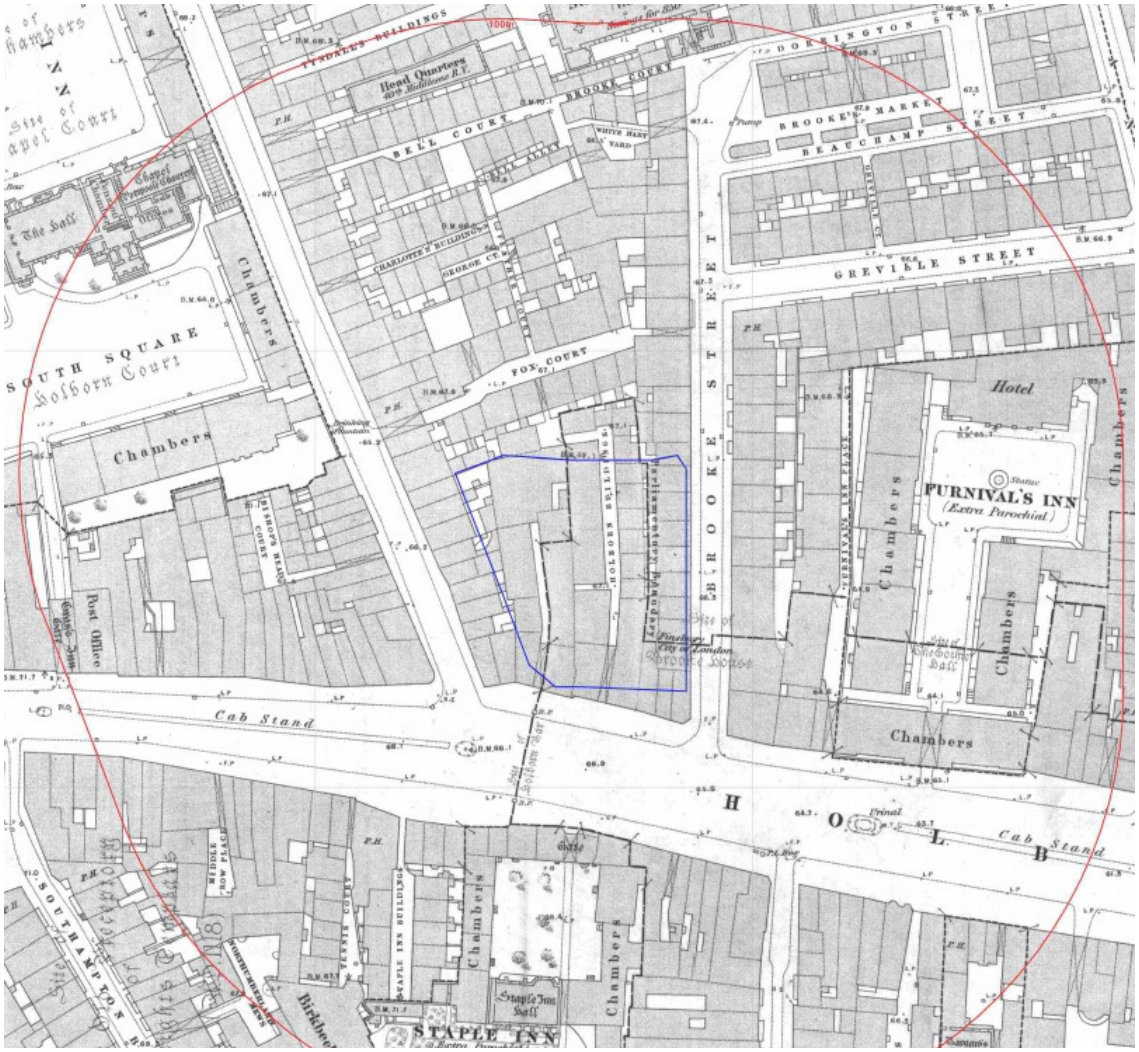

Figure 3: Historical Map Extract

Map Date: 1875

Scale: Not to scale

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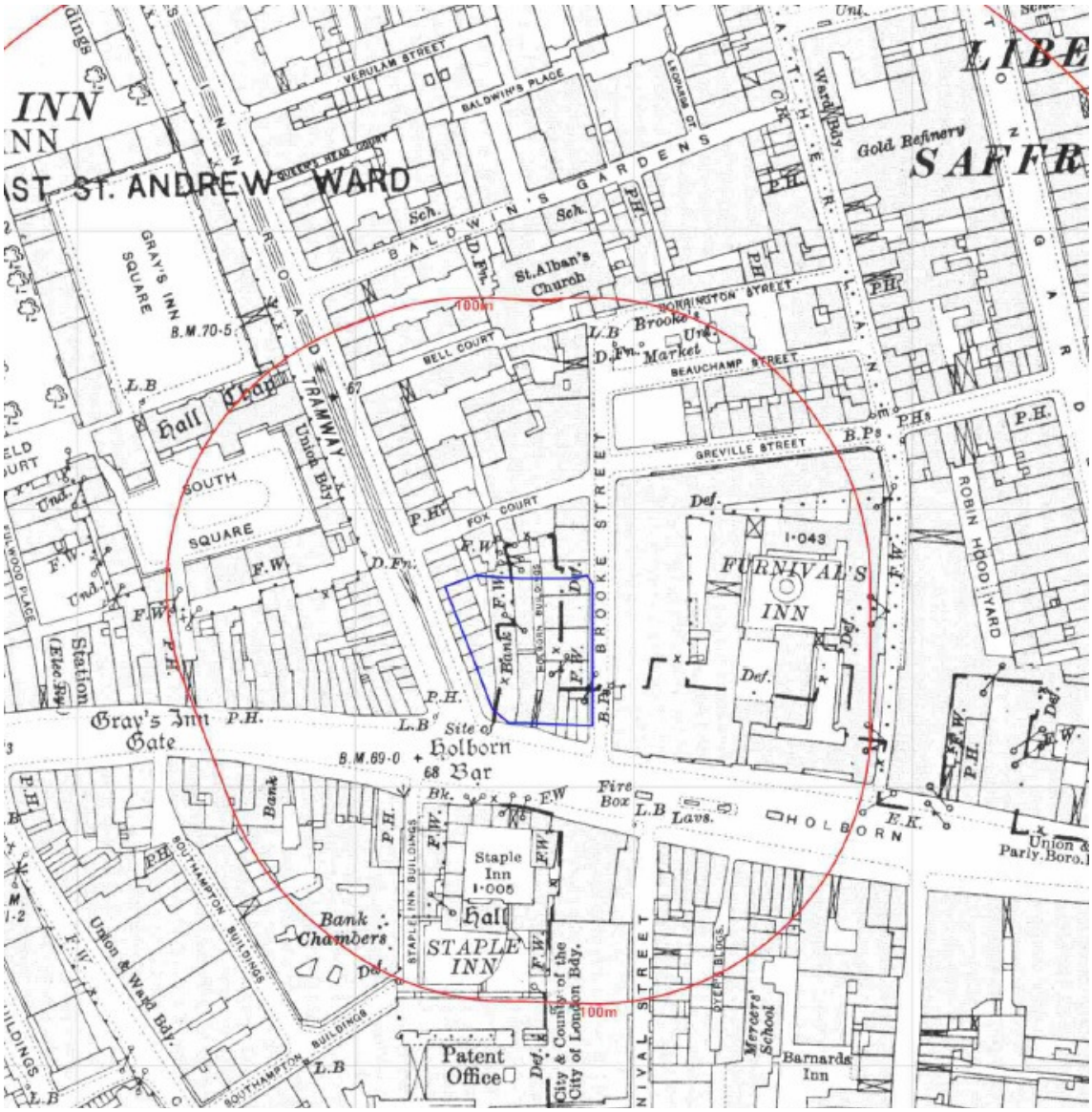

Figure 4: Historical Map Extract

Map Date: 1916

Scale: Not to scale

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