Ref: 16/25450-1
August 2016

52 HOLMES ROAD,

LONDON, NW5 3AB

REPORT ON A PHASE 2 GROUND INVESTIGATION

Prepared for

G.D.C. Partnership

Working on behalf of

Maison Henry Bertrand (England) ltd

Document Control

Project: 52 Holmes Road, London, NW5 3AB
Document Type: Report on a Ground Investigation
Document reference: SAS 16/25450-1
Document Status: FINAL
Revision: 0
Changes: -
Date: August 2016
Author: Aubrey Davidson BSc MSc DIC. Senior Environmental Engineer 
Author: T Murray BSc (Hons) MSc FGS Geotechnical Engineer 
Checked: Jim Warren MRSC. Managing Director 

CONTENTS

1.0 EXECUTIVE SUMMARY

Site Location	52 Holmes Road, London, NW5 3AB
Client	Maison Henry Bertrand (England) Limited
Proposed Development	At the time of reporting of July 2016, it is proposed to demolish the existing property and construct a new 6 storey (plus basement) mixed use property, comprising 9 self-contained units and industrial employment space within the basement and ground floor.
Environmental Setting	The site is underlain by the London Clay formation. The Bedrock geology underlying the site is classified as Unproductive Strata There is no surface water within 250m of the site.
Geotechnical Investigation	
Ground Conditions Encountered	The boreholes and trial pits revealed ground conditions that were generally consistent with the geological records and known history of the area and comprised Made Ground up to 1.00m in thickness underlain by the London Clay Formation.
Groundwater	Groundwater was encountered at a depth of 5.10m and 4.72m below ground level in Boreholes 1 and 2 respectively after a period of approximately four to five weeks.
Engineering Observations and Recommendations	Based on the ground and groundwater conditions encountered in the boreholes, it should be possible to support the proposed new development on conventional strip or basement raft foundations taken down below the Made Ground and any weak superficial soils and placed in the natural stiff gravelly clay deposits which occur at a depth of approximately 0.60m below ground level. Foundations should be placed at a minimum depth of 1.00m below final ground level in order to avoid the zone affected by seasonal moisture content changes.
Environmental Investigation	
Soil Contamination	The findings of the Phase 2 site investigation have demonstrated that in the context of a proposed mixed residential and commercial use of the site, the contaminants of concern with respect to end-user protection were Asbestos encountered across the whole site plus localised Cyanide, Lead and PAH.

Risk Assessment

Potential Contaminants / Source	Pathway	Receptor	Site specific settings	Risk Classification: Based on Phase II Investigation	Action Required
Asbestos & Cyanide, Lead and PAH	Inhalation, ingestion and dermal contact.	Human health Site users	Mixed residential and commercial use	Low/Medium	Further action required – Remediation required

	Asbestos & Cyanide, Lead and PAH	Inhalation, ingestion and dermal contact	Human Health Workers	Workers and the general public should follow regulation on health and safety during development (HSE, 1991)	Low	All site works must be carried out according to Health and Safety Executive (HSE) procedures.
	No Sources	Through high permeability strata, fissures and shafts, and by inhalation by humans	Human Health Inhalation of Gases	Nature and depth of any made ground is unknown.	Low	No Further Action
	Cyanide, Lead and PAH	Leaching (direct precipitation, overland flow and through flow)	None	Unproductive Aquifer underlying the site	Low	No Further Action
	Cyanide, Lead and PAH	Negligible groundwater flow	None	Unproductive Aquifer underlying the site	Low	No Further Action
	Cyanide, Lead and PAH	Chemical attack, gas accumulation in buildings	Building structures/services	Made ground underlying the site	Low	WATER UK HBF guide recommendations for potable water pipes..
	Cyanide, Lead and PAH	Uptake (root and stomata), ingestion, inhalation and dermal absorption by animal)	Ecological features (i.e. Flora and Fauna)	No significant Ecological system within 250m of the site.	Low	No Further Action
Recommendations	A full Remediation Strategy may be required at site. A Validation Report will be required after remedial actions are completed in order to validate the remediation undertaken.					

2.0 INTRODUCTION

2.1 Outline and Limitations of Report

At the request of G.D.C Partnership, working on of Maison Henry Bertrand (England) Limited, a ground investigation was carried out in connection with a proposed development at the above site.

The information was required for the design and construction of foundations and infrastructure for the proposed development, which includes demolition of the existing property and construction of a new 6 storey (plus basement) mixed use property, comprising 9 self-contained units and industrial employment space within the basement and ground floor. Information was also required in order to assess whether any remediation was required for the protection of the end-user from the presence of potential contamination within the soils encountered.

The recommendations and comments given in this report are based on the ground conditions encountered in the exploratory holes made during the investigation and the results of the tests made in the field and the laboratory. It must be noted that there may be special conditions prevailing at the site remote from the exploratory hole locations which have not been disclosed by the investigation and which have not been taken into account in the report. No liability can be accepted for any such conditions.

2.2 Report objectives

This report comprises a Phase 2 - Intrusive Investigation Report to assess potential contamination within the soils and waters encountered and assess potential risks to the end-user of the site from the presence of such contamination.

Planning permission granted by councils for development of Brownfield land often have conditions attached which require the following site investigation to be undertaken and submitted to the local authority for approval:

1. Phase 1 - Preliminary Risk Assessment
2. Phase 2 - Intrusive Investigation
3. Phase 3 - Remediation Strategy
4. Phase 4 - Validation Report

A Phase 1 - Preliminary Risk Assessment has previously been undertaken at the site.

3.0 SITE DETAILS

(National Grid Reference: TQ 288 850)

3.1 Site Location

52 Holmes Road is a commercial property, located on the northern side of Holmes Road, Kentish Town at approximate postcode NW5 3AB. The commercial property has two levels of accommodation; ground and first floor. The commercial property comprises a hardstanding area at the front of the property, which is used for parking. The site covers an approximate area of 0.04 Hectares with the general area being under the authority of the London Borough of Camden.

The site is located on the northern side of Holmes Road with a commercial property to the east, a charity to the west and roadways to the north and south.

3.2 Published Geology

The 1:50000 Geological Survey of Great Britain (England and Wales) covering the area (Sheet 256, 'North London', Solid and Drift Edition) indicates the site to be underlain the London Clay Formation at depth.

3.3 Previous Investigations

A report on a Phase 1 Preliminary Risk Assessment was undertaken at the site by Site Analytical Services Limited (SAS Report Ref: 16/25450 dated August 2016).

3.4 Proposed development

Demolition of existing building and replacement with a new build mixed use development of 6 storeys (plus basement) comprising of 9 self-contained units (8x2 bed and 1x3 bed) on floors 1-5 and 377sq.m of industrial employment space (B1c) on the basement and ground floors.

3.5 References of planning applications

The main planning application for the site Ref: 2016/1986/P was registered on the London Borough of Camden portal in April 2016.

4.0 SCOPE OF WORK

4.1 Site Works

The exploratory investigation included for an inspection of the site and near surface soils in order to:-

- Determine the presence, extent and significance of potential contaminants in the sub-surface strata associated with current and former activities at the site.
- Assess the significance of potential impacts on sensitive receptors at or adjacent to the site.
- Assess the potential environmental liabilities and consequences associated with the site.
- Identify requirements for further works, including the design of any additional investigative/monitoring works and remedial measures if deemed necessary.

The proposed scope of works was agreed by the client prior to the commencement of the investigations. To achieve this, the following works were undertaken:-

- The drilling of one rotary percussive borehole to a depth of 20.00m below ground level (Borehole 1).
- The drilling of two continuous flight auger boreholes to a depth of 10.00m below ground level (Boreholes 2 and 3). In the event, Borehole 3 was attempted three times, but has to be terminated at approximately 0.70m depth due to concrete obstructions.
- The installation of a groundwater monitoring standpipe to a depth of 5.00m depth in Boreholes 1 and 2, together with one return monitoring visit.
- The excavation by hand of three trial pits, to 1.50m maximum depth to expose existing foundations on-site.
- Sampling and in-situ testing as appropriate to the ground conditions encountered in the boreholes and trial pits.
- Laboratory testing to determine the engineering properties of the soils encountered in the exploratory holes.
- Interpretative reporting on foundation options for the proposed building and infrastructure.
- A study into the possibility of the presence of toxic substances in the soil, together with limited comment on any remediation required.

4.2 Ground Conditions

The locations of the exploratory holes are shown on the site sketch plan, Figure 1.

The boreholes and trial pits revealed ground conditions that were generally consistent with the geological records and known history of the area and comprised Made Ground up to 1.00m in thickness underlain by the London Clay Formation.

These ground conditions are summarised in the following Table A. For detailed information on the ground conditions encountered in the boreholes and trial pits, reference should be made to the exploratory hole records presented in Appendix A.

Strata	Depth to top of strata (mbgl)	Depth to base of strata (mbgl)	Description
Made Ground	0.00	0.60 to 1.00	Surface layer of reinforced concrete over slightly gravelly sand containing brick and concrete rubble.
London Clay Formation	0.60 to 1.00	20.00	Firm then stiff becoming very stiff fissured dark grey blue silty sandy clay containing parting of silty fine sand and occasional gypsum crystals.

Table A. Summary of Ground Conditions in Exploratory Holes

4.3 Groundwater

Groundwater was not encountered in any of the boreholes or trial pits during site works and the material remained essentially dry throughout.

It must be noted that the speed of excavation is such that there may well be insufficient time for further light seepages of groundwater to enter the boreholes and trial pits and hence be detected, particularly within more cohesive soils.

Groundwater was encountered at a depth of 5.10m and 4.72m below ground level in Boreholes 1 and 2 respectively after a period of approximately four to five weeks.

Isolated pockets of groundwater may also be present perched within any less permeable material found at shallower depth on other parts of the site especially within any Made Ground.

It should be noted that the comments on groundwater conditions are based on observations made at the time of the investigation (June to August 2016) and that changes in the groundwater level could occur due to seasonal effects and also changes in drainage conditions.

5.0 IN-SITU AND LABORATORY TESTS

5.1 Standard Penetration Tests

The results of the Standard Penetration Tests carried out in the natural soils are shown on the exploratory hole records in Appendix A. SPT 'N' values range between 7 and 55.

The results of the tests are shown on the appropriate borehole records and summary sheets presented in Appendix A.

5.2 Undrained Triaxial Compression Test Results

Quick Undrained Triaxial Compression tests were made on six selected undisturbed 100mm diameter samples taken from Borehole 1, with a hand vane test performed on one sample that was unsuitable for the quick undrained triaxial test. The results show the samples to be of medium and then high to very high strength in accordance with BS 5930 (2015).

The results of the tests are presented on Table 1, contained in Appendix B.

5.3 In-situ Vane Tests

In the essentially cohesive natural soils encountered at the site, in-situ shear vane tests were made at regular depth increments in order to assess the undrained shear strength of the materials. The results indicate that the natural soils are of a generally high strength in accordance with BS 5930 (2015).

The results of the in-situ tests are shown on the appropriate exploratory hole records contained in Appendix A.

5.4 Classification Tests

Atterberg Limit tests were conducted on four selected samples taken from the cohesive portion of the natural soils in Boreholes 1 and 2 and showed the samples tested to fall into Class CH according to the British Soil Classification System.

These are fine grained silty clay soils of high plasticity and as such generally have a low permeability and a medium to high susceptibility to shrinkage and swelling movements with changes in moisture content, as defined by the NHBC Standards, Chapter 4.2. The results indicated Plasticity Index values of between 36% to 42%, with three samples being either at or above the 40% boundary between soils assessed as being of medium swelling and shrinkage potential and those assessed as being of high swelling and shrinkage potential.

The test results are given in tabular format presented on Table 2, contained in Appendix B.

5.5 Sulphate and pH Analyses

The results of the sulphate and pH analyses made on five natural soil samples selected to give a range of depth are presented Table 3, whilst further analyses on soil samples are given within the contamination test results, both contained in Appendix B. The results presented within Table 3 show the soil samples to have water soluble sulphate contents of up to 2.63g/litre associated with near neutral to slightly acidic pH values. The samples selected for contamination analysis indicate the soils to have soluble sulphate contents of up to 2.0g/litre associated with alkaline pH values.

6.0 CONTAMINATION TESTING

6.1 Site conceptual model

In accordance with current UK guidance on contaminated land risk assessment (CLR7, CLR11 and BS10175), the following Conceptual Site Model has been generated to summarise the primary sources, receptors and migration and exposure pathways present on the site and to aid in the decision making process.

For an environmental risk to exist there has to be a source of contamination, receptor or receptors at risk from the contamination and one or more pathway which links the two. Such contaminant – pathway – receptor relationships are termed pollutant linkages.

The subject site has been assessed within the source – pathway – receptor methodology as described above in the framework of a conceptual site model. A conceptual site model can be defined as a testable representation of environmental processes on a site and its vicinity. Its purpose is to identify potential contaminants, pathways and receptors with a view to, initially identifying potential and eventually, quantifying significant pollutant linkages. It should highlight any limitation and uncertainties present in the risk assessment and be able to communicate the results of the risk assessment to all stakeholders.

A Phase I Desk Study has been undertaken at the site and environmental information has also been researched from the Environmental Agency website, Google maps and other on line sources. The site conceptual model is presented below.

Potential Contaminants / Source	Pathway	Receptor	Site specific settings	Action Required
Made Ground / Unknown History	Inhalation, ingestion and dermal contact.	Human health Site users	Mixed Residential and Commercial use	Further action required – Further Investigation
Made Ground / Unknown History	Inhalation, ingestion and dermal contact	Human Health Workers	Workers and the general public should follow regulation on health and safety during development (HSE, 1991)	Further action required – Further Investigation

Made Ground / Unknown History	Through high permeability strata, fissures and shafts, and by Inhalation by humans	Human Health Inhalation of Gases	Nature and depth of any made ground is unknown.	Further action required – Further Investigation
Made Ground / Unknown History	Leaching (direct precipitation, overland flow and through flow)	None	Unproductive Aquifer underlying the site	No further action required
Made Ground / Unknown History	Negligible groundwater flow	None	Unproductive Aquifer underlying the site	No further action required
Made Ground / Unknown history	Chemical attack, gas accumulation in buildings	Building structures/services	Made ground underlying the site	Further action required – Further Investigation
Made Ground / Unknown History	Uptake (root and stomata), ingestion, inhalation and dermal absorption by animal)	Ecological features (i.e. Flora and Fauna)	No significant Ecological system within 250m of the site.	No further action required

Table B: Phase 1 Conceptual Site Model

6.2 Made Ground encountered

The investigation revealed the presence of Made Ground across the site to depths of between up to 1.00m bgl. The Made Ground in BH3A to 3C and TP1-3 inclusive was encountered to the full depth of investigation at 0.55m – 0.70m.

The Made Ground consisted of a surface layer of chipboard then concrete typically overlying sand with concrete and brick rubble and flint gravel.

Depth of Made Ground	
Trial Hole	**Depth (bgl)**
BH1	1.00m
BH2	0.60m
BH3A	Full Depth – 0.70m
BH3B	Full Depth – 0.70m
BH3C	Full Depth – 0.62m
TP1	Full Depth – 0.65m
TP2	Full Depth – 0.55m
TP3	Full Depth – 0.70m

Table C: Depth of Made Ground

6.3 Sampling Strategy

The strategy for selecting the locations of the exploratory positions was based on the conceptual source, pathway and receptor model and potentially contaminating activities identified by the Conceptual Site Model.

A non-targeted sampling strategy is appropriate when there is:
- No adequate information available regarding the likely locations of contamination;
- No sensitive areas where there is a need for a high degree of confidence.

A targeted sampling strategy is appropriate when there is:
- Adequate information available regarding the likely locations of contamination;
- Sensitive areas where there is a need for a high degree of confidence.

No adequate information was available regarding likely locations, so a non-targeted sampling pattern was adopted at the site, designed to provide coverage across the site as a whole. Non-targeted sampling depths were chosen to reflect the receptors of concern including future users of the site, visitors to the site, construction workers on-site, service and maintenance workers, site neighbours and wider public, construction materials, groundwater and surface water and typically comprised a near surface samples within the Made Ground. Samples were analysed from this depth range below ground level as it is felt that these soils will be representative of those of highest end-user exposure through the dermal contact, dust inhalation and soil ingestion pathways.

A total of six sampling locations have been excavated at the site providing a density equivalent to a circa 15m grid.

Site Area/Activity	**Exploratory Hole Location(s)**	**Surface**
General site coverage where Made Ground of unknown origin is expected. Non-targeted sampling	BH1, BH2, BH3C TP1, TP2, TP3	Made Ground

Table D: Site Conceptual Model

6.4 Determination of Contaminants of Concern

Samples for a full contamination analysis were obtained from 0.25m in BH1, BH3A and TP2, from 0.40m in TP3 and from 0.50m in BH2, made at the locations indicated on the site sketch plan (Figure 1).

The samples were submitted for a broad screen of total potential contaminants, including those potential contaminants of concern on-site and included pH, Sulphate, Sulphide, Cyanide, Phenols, Metals & Semi-Metals: Cd, Cr, Pb, Hg, Ni, Se, Cu, Zn, V, B, As, Asbestos Screening and Quantification, Organics: USEPA 16 speciated Polycyclic Aromatic Hydrocarbons, Aromatic /Aliphatic Carbon Banded Petroleum Hydrocarbons, BTEX and MTBE Compounds and Soil Organic Matter (SOM).

The samples selected for contamination assessment were sub-contracted to i2 Analytical Limited (a UKAS and MCERTS accredited laboratory) and their report is contained in Appendix B.

6.5 Qualitative Risk Assessment

The hazard caused by the presence of a substance or element is not absolute but depends on the proposed end use of the site.

It is understood that the site is to be developed for mixed commercial and residential use without areas of private garden. As such the S4UL screening levels for residential use without home-grown produce and Category 4 Screening Level for residential use have been used in the following soil assessment.

Site data has been assessed against current generic assessment criteria (GAC) / guideline values in accordance with current industry practice and statutory guidance; chemical toxicology (TOX), Soil Guideline Value (SGV) reports developed using the new Contaminated Land Exposure Assessment (CLEAv1.06) framework, CLR 11 (Environment Agency, 2009) and SP1010: Development of Category 4 screening levels for assessment of land affected by contamination (DEFRA, 2014).

However, it must be remembered that GAC are not binding standards but can be useful in forming judgements regarding the level of risk i.e. unacceptable or acceptable. Exceedance of GAC does not automatically result in the requirement for remedial / risk management work but would warrant further assessment.

6.6 Suitable 4 Use Levels, Category 4 Screening Levels, Soil Guideline Values, CLR Documents & Chartered Institute of Environmental Health Values

Under Part 2A of the Environmental Protection Act 1990, land is determined as contaminated if it is deemed to be causing significant harm, or where there is a Significant Possibility of Significant Harm to human health.

From January 2009 revised Soil Guidance Values for certain contaminants were issued in the Contaminated Land Reports (CLR) by the Environment Agency in conjunction with Department of the Environment, Food, Agriculture and Rural Affairs. These values and the CLEA methodology used to derive them have superseded CLEA and TOX reports for soil contaminants.

The CLR Documents are a series of contaminated land guidance documents developed by various past and present government agencies involved with protection of the environment.

These documents aim to provide a set of generic Soil Guideline Values and a site specific modelling programme based upon tolerable predicted uptakes from experimental data for a variety of common industrial toxic contaminants. In instances of carcinogenic and mutanagenic substances the guideline values are set on the basis of "As Low As Reasonably Practicable" (ALARP), as theoretically mutation can occur on exposure to a single particle of the contaminant.

Revised Statutory Guidance to support Part 2A of the Environmental Protection Act 1990 was published in April 2012, which introduced a new four-category system for classifying land under Part 2A for cases of a Significant Possibility of Significant Harm to human health, where Category 1 includes land where the level of risk is clearly unacceptable and Category 4 includes land where the level of risk posed is acceptably low.

'Category 4 Screening Levels' (C4SLs) have been introduced in March 2014 to provide a simple test for deciding when land is suitable for use and definitely not contaminated land. The Category 4 Screening Levels consist of estimates of contaminant concentrations in soil that are considered to present an 'acceptable' level of risk, within the context of Part 2A.

In response, in November 2014, The Chartered Institute of Environmental Health Generic Assessment Criteria for Human Health Risk Assessment adopt the Environment Agency's CLEA UK (Beta) Model and Category 4 Screening Levels and as such have derived guideline values that are compatible with current English legislation, policy and technical guidance in the form of LQM/CIEH S4ULS's (Suitable 4 Use Levels).

The methodology for deriving both the previous Soil Guideline Values and the new Suitable 4 Use Levels is based on the Environment Agency's Contaminated Land Exposure Assessment (CLEA) methodology.

At the time of writing this report Suitable 4 Use Levels are in place for some heavy metals, BTEX Substances, Petroleum Hydrocarbons and Polycyclic Aromatic Hydrocarbons as well as a number of selected organic compounds.

Generic Assessment Criteria for Human Health Risk Assessment (S4UL's) have been produced by LQM / Chartered Institute of Environmental Health for a residential use without home grown produce. These are Arsenic 40mg/kg, Beryllium 1.7mg/kg, Boron 11000mg/kg, Cadmium 85mg/kg, Trivalent Chromium (Chromium III) 910mg/kg, Hexavalent Chromium (Chromium VI) 6mg/kg, Copper 7100mg/kg, Mercury (Elemental) 1.2mg/kg, Mercury (Inorganic) 56mg/kg, Methylmercury 11mg/kg, Nickel 180mg/kg, Selenium 430mg/kg, Vanadium 1200mg/kg, Zinc 40000mg/kg, Benzene (2.5% SOM) 0.7mg/kg, Toluene (2.5% SOM) 1900mg/kg, Ethylbenzene (2.5% SOM) 190mg/kg, Xylenes (2.5% SOM) from 180mg/kg and Phenols (2.5% SOM) 1300mg/kg.

As no generic UK derived guidance is currently available for acceptable concentrations of Total Lead, the Category 4 Screening Level for residential use without home-grown produce of 310mg/kg has been used to identify where potential risks may exist.

The Environment Agency has released the CLEA software and its handbook to help assessors estimate risks. The Chartered Institute of Environmental Health Generic Assessment Criteria for Human Health Risk Assessment (S4UL's) adopt the Environment Agency's CLEA UK (Beta) Model and as such have derived guideline values that are compatible out current English legislation, policy and technical guidance.

Assessment criteria (S4UL's) for selected individual Polycyclic Aromatic Hydrocarbons have been produced by Chartered Institute of Environmental Health; however no values have been attached to Total Polycyclic Aromatic Hydrocarbons. Sixteen individual Polycyclic Aromatic Hydrocarbons with attached screening values include Benzo(a)anthracene 11-15mg/kg, Benzo(a)pyrene 3.2mg/kg, Dibenzo(a,h)anthracene 0.31- 0.32mg/kg and Naphthalene 2.3-13mg/kg for a residential scenario without home grown produce.

The concentrations of Total Petroleum Hydrocarbons have been assessed against assessment criteria (S4UL's) for individual Aromatic and Aliphatic carbon band ranges produced by Chartered Institute of Environmental Health for a residential scenario without home grown produce.

As no generic UK derived guidance is currently available for acceptable concentrations of Total Cyanide a screening value of 20mg/kg (Thiocyanate) has been used as a preliminary screening tool to identify where potential risks may exist.

As described in Using Soil Guideline Values – Environment Agency 2009, chemical data from the analysis of samples generated during the intrusive investigation have been used to create a data set for the site. The entire data set, as opposed to individual results has been analysed on the assumption that the samples from the site investigation are to some degree representative of the contaminant concentration throughout the area or volume of soil investigated. The most appropriate method for assessing a given dataset is dependent upon a range of specific factors together with the quantity and quality of the data generated.

In accordance with the recommendations provided within Guidance on comparing soil contamination data with a critical concentration – CIEH/CL:AIRE, 2008, we have selected the one sample t-test at a 95% confidence level as the most appropriate statistical tool for generating site representative soil concentration values and have assumed that the data is normally distributed. We have assumed that this statistical test is required to draw conclusions about the condition of the land under scrutiny as part of a planning scenario as opposed to the Part 2A scenario. Under a planning scenario, comparison is made between a value larger than the sample mean, in this case the Upper Confidence Limit and the critical concentration.

In instances where the Upper Confidence Limit exceeded the given critical value, then the Grubbs Test has been used to identify upper outliers to assess whether the highest value belongs to the general population of the dataset or is representative of an outlier.

6.7 Discussion

6.7.1 Human health risk assessment (On-site users, Workforce and Neighbouring residents)

Concentrations of the zootoxic heavy metals Total Arsenic, Total Boron, Total Cadmium, Hexavalent Chromium, Trivalent Chromium, Total Mercury, Total Selenium, Total Copper, Total Nickel and Total Zinc in the samples analysed did not exceed the S4UL Generic Guideline Values for a residential scenario without home-grown produce. As such there is not considered to be any potentially significant level of end-user risk associated with the concentrations of these contaminants encountered.

The concentration of Total Lead encountered in the BH2 location was in excess of the Category 4 Screening Level for residential use without home-grown produce of 310mg/kg at 450mg/kg. It was therefore decided to undertake statistical analysis of the data set, using the arithmetic mean and standard deviation for Lead. An outlier test identified the particularly elevated concentration of Lead in BH2 as not representative of the rest of the sample population and indicative of a locally affected area or "hot-spot" of contamination and the soil should be treated accordingly.

The concentration of Total Cyanide in TP2 at 0.25m was above the screening value of 20mg/kg at 62mg/kg. There is no current Guideline Value for residential end use, however a potential risk may exist depending on the final site development.

The concentrations of Total Phenol were below the S4UL Generic Guideline Value for a residential scenario without plant uptake.

Elevated concentrations of Polycyclic Aromatic Hydrocarbons including Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene were encountered in the sample from 0.25m depth in Trial Pit 2 in excess of the respective S4UL Generic Guideline Values for a residential scenario without home-grown produce at 1% SOM content. As such the potential risks to the end users of the site cannot be discounted at this stage.

The concentrations of Petroleum Hydrocarbons encountered within individual Aromatic and Aliphatic carbon band ranges in the samples analysed did not exceed the S4UL Generic Guideline Values for a residential scenario without home-grown produce. As such there is not considered to be any potentially significant level of end-user risk associated with the concentrations of these contaminants encountered.

The concentrations of Benzene Toluene, Ethylbenzene and Xylenes encountered did not exceed the S4UL Screening Levels for residential use without home grown produce. As such there is not considered to be any potentially significant level of end-user risk associated with the concentrations of these contaminants encountered.

There was no MTBE detected within the samples analysed.

6.7.2 Asbestos Containing Materials

The Made Ground at each exploratory location was screened for the presence of asbestos containing material. In all cases asbestos containing material was identified during the laboratory analysis. The material found comprised of loose fibres, or lagging or hard cement material. Samples from BH1, BH3A, TP2 and TP3 contained between 0.002% and 0.005% Chrysotile asbestos. The sample from BH2 contained 0.016% asbestos, which was a mixture of Chrysotile, Amosite and Crocidolite asbestos.

The risks associated with the asbestos containing material would be deemed low should they remain in-situ beneath the building floor slab. Any activities that would result in the asbestos containing material being disturbed, such as construction work, would be considered as a potential high risk and should be taken into consideration for future development be proposed for the site.

6.7.3 Landscape Planting / Ecological features

The concentrations of the phytotoxic substances Total Copper, Total Zinc and Total Nickel encountered in the samples obtained were generally below the landscape planting generic assessment levels.

6.7.4 Buildings and Construction Materials

Concrete Cast In-Situ

The range of concentrations of water soluble sulphate within the Made Ground at the site were within BRE (2005) Design Class DS-3 for concrete cast in-situ. This should be taken into account should any concrete structures be installed within the soils represented by these samples.

Potable Water Supply Pipes

If at any point in the future it be intended to install new water supply pipes within the Made Ground then consideration to the pipe materials used and/or the trench construction in accordance with UKWIR (2010). Based upon the analysis undertaken, the concentrations of TPH returned by samples of Made Ground may preclude the use of standard PE pipe materials at the site.

6.7.5 Shallow and deep groundwater/ Surface Water risk

The 1:50000 Geological Survey of Great Britain (England and Wales) covering the area (Sheet 256, 'North London', Solid and Drift Edition) indicates the site to be underlain the London Clay Formation at depth.

The site is not located within a source protection zone.

It is unlikely that the proposed development, including the installation of foundations or piles, would impact the quality of the water environment.

6.7.6 Soil Disposal

All samples were analysed using the 'Catwastesoil' assessment tool, which concluded that the samples taken from the site were not hazardous in nature.

The concentrations of asbestos within the samples analysed indicate that the material is non-hazardous, however on the basis that asbestos was identified in all samples analysed it should be assumed that pockets of greater concentration might be encountered that could result in a Hazardous classification.

6.7 Revised site conceptual model and Conclusions

The findings of the Phase 2 site investigation have demonstrated that in the context of a proposed mixed residential and commercial use of the site, the contaminants of concern with respect to end-user protection were Asbestos and Lead, Cyanide and of Polycyclic Aromatic Hydrocarbons including Benzo(b)fluoranthene, Benzo(a)pyrene and Dibenz(a,h)anthracene.

A Phase 2 Site Investigation has identified the following Source/Pathway/receptor linkages present on-site or potentially present.

Potential Contaminants / Source	Pathway	Receptor	Site specific settings	Risk Classification: Based on Phase II Investigation	Action Required
Asbestos & Cyanide, Lead, PAH	Inhalation, ingestion and dermal contact.	Human health Site users	Mixed residential and commercial use	Low	Further action required – Remediation required
Asbestos & Cyanide, Lead, PAH	Inhalation, ingestion and dermal contact	Human Health Workers	Workers and the general public should follow regulation on health and safety during development (HSE, 1991)	Low	All site works must be carried out according to Health and Safety Executive (HSE) procedures.
No Source	Through high permeability strata, fissures and shafts, and by inhalation by humans	Human Health Inhalation of Gases	Small amount of made ground on site.	No Risk	No Further Action
Cyanide, Lead, PAH	Leaching (direct precipitation, overland flow and through flow)	None	Unproductive Aquifer underlying the site	No Risk	No Further Action
Cyanide, Lead, PAH	Negligible groundwater flow	None	Unproductive Aquifer underlying the site	No Risk	No Further Action
Sulphates /TPH	Chemical attack, gas accumulation in buildings	Building structures/services	Made ground underlying the site	Low	WATER UK HBF guide recommendations for potable water pipes.

Cyanide, Lead, PAH	Uptake (root and stomata), ingestion, inhalation and dermal absorption by animal)	Ecological features (i.e. Flora and Fauna)	No significant Ecological system within 250m of the site.	No Risk	No Further Action

Table E: Phase 2 Conceptual Site Model

6.8 Viable Risks requiring action

- There is a risk to end-users of the site from the concentration of Asbestos encountered on-site. Remediation should be undertaken on-site to negate these risks.

- There is a risk to end-users of the site from hotspots of Total Cyanide, Lead and PAH encountered on-site. Remediation should be undertaken on-site to negate these risks.

- There is a risk to the workforce on-site from the concentrations of Asbestos, Cyanide, Lead and PAH encountered on-site. Appropriate PPE and following health and safety regulations would negate this risk.

6.9 Remedial options proposed

A number of potential remedial options are presented to sever the pollutant linkages present and include:

Option 1: Excavation of Impacted Soil

On the basis that the proposed development is the construction of a basement, then excavation and removal of the impact soils is the most likely solution to be adopted. Once excavation has been completed validation would be required to prove all impacted soil has been removed. Validation would involve taking a representative number of samples from the sides and base of any excavation and then sent off for appropriate chemical analysis. The stockpiled soils must be placed on an impermeable liner with raised edges. During periods of rainfall, the stockpile must be covered over to minimise leaching and run-off into the underlying soils. Covering of the stockpile may be required to prevent dust impacting receptors off-site. Damping down of the stockpile is advised to further reduce the risk associated with dust generation.

The remedial works must be inspected and independently validated by a suitable person. On completion of the development, a Validation and Closure Report must be supplied to both the Local Authority detailing the remediation works undertaken on the site. Any voids resulting from the removal of impacted soil that are not part of the basement excavation must be backfilled with a suitable certified clean granular soil.

The developer/groundworker must be made aware of the potential for sources not identified in the Phase 2 site investigation to be found within the site both during demolition and the excavation of trenches for services and foundations.

Option 2: Hard Landscape Entire Site

Maintaining a hard cover across the entire site could eliminate exposure to contaminated soils through:

I. Direct soil and dust ingestion,
II. Dermal contact
III. Inhalation of dust (indoor and outdoor).

It is understood that no soft landscaping is present on site and none is proposed.

The risk management framework set out in the Model Procedures for the Management of Land Contamination, CLR 11, is applicable to the redevelopment of sites that may be affected by contamination.

The risk management process set out in the Model Procedures has three main components:

- Risk assessment
- Options appraisal
- Implementation

This initial risk assessment has identified a number of relevant pollutant linkages, as demonstrated in the updated conceptual model.

A Phase 3 Remediation Strategy is required to assess remedial options and propose a viable strategy on-site.

The remediation strategy will need to review methods of reducing or controlling the identified unacceptable risks. This could be done by removing or treating the sources of contamination, removing or modifying the pathways or removing or modifying the behaviour of the receptors, to ensure there is no significant risk of significant harm to either human health or controlled waters from the identified contamination, in relation to the proposed end use.

An important part of the risk management process is identifying and informing all stakeholders with an interest in the outcome of the risk management project. To this end, if the regulators have not yet been contacted with regard to the redevelopment of this site, it is recommended that they be supplied with a copy of both the Preliminary Investigation reports and this Phase 2 Ground Investigation report in order to enable liaison to be undertaken with them.

Following liaison with the relevant regulatory bodies, a Phase 3 Remediation Strategy could be formulated, which should incorporate an options appraisal and summarise in detail the chosen remedial approach, along with the verification proposals. The remediation strategy should then be approved by the relevant regulatory authorities prior to implementation.

Where remediation is required, a Phase 4 Verification Report will need to be formulated following implementation of the remediation strategy, which should provide a complete record of all remedial activities conducted on site and include all the data obtained to support the remedial objectives and demonstrate that the remediation has been effective. Any unexpected conditions encountered during the remedial works should also be detailed within the verification report.

6.10 Discovery Strategy

The discovery strategy sets out the actions that must be taken if contamination is encountered during the course of a development.

A significant observation includes any observation of contamination. Examples of the types of observations that would be considered significant are set out in the following table.

Evidence	Description
Visual	• Fuel or oil like substances mixed in with or smeared on the soil or floating on perched, groundwater or surface waters. • Waste materials (refuse, barrels, industrial wastes, ash, tar, etc.) buried at specific location or across the site. • Marked variation in colour. For example red, orange, yellow, green, light or dark blue, etc. may indicate contamination from a variety of contaminants. • Soils including large amounts of ash and clinker where such contamination of soils wasn't expected.
Odours	• Fuel, oil and chemical type odours • Unusual odours such as sweet odours or fishy odours
Wellbeing	• Light headedness and/or nausea when in excavations, at the working face of an excavation, when visual or olfactory evidence of contamination exists, etc. • Burning of nasal passages, throat, lungs or skin • Blistering or reddening of skin due to contact with soil

Table F: Potential indicators of contamination

Note: The examples provided in this table are not exhaustive.

The following table sets out the actions that must be taken if significant or suspected land, water or air contamination is observed by site staff, contractors or visitors.

Person observing contamination	To be reported to:	Action to be taken
Site visitor	Must report observations to the site manager	None
Contractor	Must report observations to the site manager	Stop work and where possible and safe make area safe and secure area before reporting to site manager
On-site manager	Must report observations to their direct manager, the appointed Environmental Consultant, the Planning Authority and Contaminated Land Officer at the London Borough of Camden	Stop work and where possible and safe make area safe and secure area before reporting to others
Environmental Consultant	Must report observations to the site manager, the Planning Authority and Contaminated Land Officer at the London Borough of Camden	Advise that work stops and where possible that the area is made safe before reporting to others

Table G: Actions after observation

The following table identifies other organisations that may need to be contacted in an emergency or where pollution of controlled waters or nuisance is occurring.

Occurrence	Description	Contact
Risk to the public	If at any point residents, the public or others may be at risk as a result of contamination found during the course of investigation, remediation or development works	• Contact the emergency services if there is a risk to life • Contaminated Land Officer/Planning Authority • Health & Safety Executive
Nuisance to residents / the public	If a nuisance has been or is likely to be caused to nearby residents, the public and others – for example odours, dust, noise, vibration, etc.	• Pollution Control Team at the Local Council (and other Councils where necessary)
Pollution of controlled waters	If any surface, culverted or groundwater has been polluted – for example slurry, contaminated soil/water or a chemical spillage entering a river or canal.	• Environment Agency • Planning Authority and Contaminated Land Officer at the Local Council
Pollution of adjoining land	If land outside the boundary of the development site is polluted from site activities – for example slurry, contaminated soil/water or a chemical spillage	• The owner of the land • Planning Authority and Contaminated Land Officer at the Local Council

Table H: Actions after observation

Any materials brought onto the site (soils and / or clay) should be validated either at source or once laid at site. Given the nature of the ground conditions, appropriate health and safety practices should be adhered to in order to protect site workers. Any waste material leaving site for off-site disposal (soil and / or water) should be handled in accordance with the current Waste Management and Duty of Care Regulations.

The above conclusions have been drawn on the results of the tests carried out on the soil samples analysed and address remediation issues for the protection of the end-user only. It is recommended that any remedial measures suggested in this report should be subject to formal approval by local Environmental Health and/or Planning Departments and approval should be obtained prior to any works being undertaken. The comments made in this report do not address any third party liability.

7.0 FOUNDATION DESIGN

7.1 General

At the time of reporting of August 2016, it is proposed to demolish the existing property and construct a new 6 storey (plus basement) mixed use property, comprising 9 self-contained units and industrial employment space within the basement and ground floor. Details of the structures, layouts etc. have been provided, although details of the loadings were not available at the time of preparation of this report.

7.2 Site Preparation Works

The main contractor should be informed of the site conditions and risk assessments should be undertaken to comply with the Construction Design Management (CDM) regulations. Site personnel are to be made aware of the site conditions. It is recommended that extensive searches of existing man-made services are undertaken over the site prior to final design works.

7.3 Conventional Spread Foundations

A result of the inherent variability of uncontrolled fill, (Made Ground) is that 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.

Based on the ground and groundwater conditions encountered in the boreholes, it should be possible to support the proposed new development on conventional strip or basement raft foundations taken down below the Made Ground and any weak superficial soils and placed in the natural stiff gravelly clay deposits which occur at a depth of approximately 0.60m below ground level. Foundations should be placed at a minimum depth of 1.00m below final ground level in order to avoid the zone affected by seasonal moisture content changes.

Using theory from Terzaghi (1943), strip foundations placed within natural soils may be designed to allowable net bearing pressures of approximately 100kN/m^2 at 3.00m depth and 165kN/m^2 at 5.00m depth in order to allow for a factor of safety of 2.5 against general shear failure. The actual allowable bearing pressure applicable will depend on the form of foundation, its geometry and depth in accordance with classical analytical methods, details of which can be obtained from "Foundation Design and Construction", Seventh Edition, 2001 by M J Tomlinson (see references) or similar texts.

Any soft or loose pockets encountered within otherwise competent formations should be removed and replaced with well compacted granular fill.

In addition, foundations may need to be taken deeper should they be within the zones of influence of both existing or recently felled trees and any proposed tree planting. The depth of foundation required to avoid the zone likely to be affected by the root systems of trees is shown in the recommendations given in NHBC Standards, Chapter 4.2, April 2010, "Building near Trees" and it is considered that this document is relevant in this situation.

7.4 Piled Foundations

In the event that the use of conventional spread foundations proves either impracticable or uneconomical due to the size and depth of foundation required, then a piled foundation will be required. In these ground conditions, it is considered that some form of bored and in-situ cast concrete piled foundation with reinforced concrete ground beams should prove satisfactory.

The construction of a piled foundation is a specialist activity and the advice of a reputable contractor, familiar with the type of soil and groundwater conditions encountered at this site should be sought prior to finalising the foundation design. The actual pile working load will depend on the particular type of pile chosen and method of installation adopted.

To achieve the full bearing value a pile should penetrate the bearing stratum by at least five times the pile diameter.

Where piles are to be constructed in groups the bearing value of each individual pile should be reduced by a factor of about 0.8 and a calculation made to check the factor of safety against block failure.

Driven piles could also be used and would develop much higher working loads approximately 2.5 to 3 times higher than bored piles of a similar diameter at the same depth. However, the close proximity of adjacent buildings will in all probability preclude their use due to noise and vibration.

7.5 Retaining Walls

7.5.1 General

Several methods of retaining wall construction could be considered. These may include retaining structures cast in an underpinning sequence, or the use of temporary or sacrificial works to facilitate the retaining structure's construction. The excavation of the basement must not compromise the integrity of adjacent structures.

The full design of temporary and permanent retaining structures is beyond the scope of this report. However, the following design parameters for each element of soil recorded in the relevant exploratory holes are provided in Table I below to assist the design of these structures.

Stratum	Depth to top (m)	Bulk Density (Mg/m3) (γ)	Effective Angle of Internal Friction (Φ)
London Clay Formation	0.60	2.00	22

Table I: Retaining Wall Design Parameters

The designer should use these parameters to derive the active and passive earth pressure coefficients ka and kp. The determination of appropriate earth pressure coefficients, together with factors such as the pattern of the earth pressure distribution, will depend upon the type/geometry of the wall and overall design factors.

7.6 Excavations

Shallow excavations for foundations and services are likely to require nominal side support in the short term and groundwater is unlikely to be encountered in significant quantities once any accumulated surface water has been removed. Deeper and longer excavations below approximately 1.50m below existing ground level will require close side support and some seepages of groundwater could be encountered.

No particular difficulties are envisaged in removing such water by conventional internal pumping methods from open sumps.

Normal safety precautions should be taken if excavations are to be entered.

7.7 Chemical Attack on Buried Concrete

The results presented in Appendix B show the soil samples tested to have water soluble sulphate contents of up to 2.63/litre associated with near neutral to slightly acidic pH values. The samples of Made Ground tested indicated water soluble sulphate contents of up to 2.0g/litre associated with alkaline pH values.

In these conditions, it is considered that deterioration of buried concrete due to sulphate or acid attack is likely to occur. The final design of buried concrete according to Tables C1 and C2 of BRE Special Digest 1:2005 should be in accordance with Class DS-3 conditions.

7.8 List of Appendices

Figure 1 – Site Sketch Plan

Appendix A – Borehole / Trial Pit Logs

Appendix B – Laboratory Test Data

8.0 REFERENCES

1. Beckett M.J. and Sims D.L. (1984). "The Development of Contaminated Land", Symposium on Hazardous Waste Disposal and the Re-use of Contaminated Land. Society of Chemical Industry.

2. British Standards Institution, 2001. Investigation of Potentially Contaminated Sites - Code of Practice, BS 10175, BSI, London

3. British Standards Institution, 1986. Code of practice for foundations, BS 8004, BSI, London.

4. British Standards Institution, 1990. Methods for test for soils for civil engineering purposes, BS1377, BSI, London

5. British Standards Institution, 1994. Code of practice for earth retaining structures, BS8002, BSI, London

6. British Standards Institution, 20. Code of Practice for Site Investigations, BS5930:1999+A2: 2010, BSI, London

7. British Standards Institute: BS 10175 'Code of practice for the investigation of potentially contaminated sites', BSI 2011.

8. British Standards Institution, 2004. Geotechnical Design, BS EN 1997-1 BSI, London

9. Building Research Establishment Special Digest 1, 2005, "Concrete in Aggressive Ground – Third Edition."

10. Building Research Establishment, Report 414, 'Protective Measures for Housing on Gas Contaminated Land', 2004.

11. Building Research Establishment Digest 465, 'Cover Systems for Land Regeneration – Thickness Cover Systems for Contaminated Land', 2004.

12. CatWasteSoil, www.catwastesoil.com

13. CIEH/CL:AIRE, 2008. Guidance on comparing soil contamination data with a critical concentration. London: Chartered Institute of Environmental Health.

14. CIRIA Reports 149 to 152, 'Methane and Associated Hazards to Construction', 1995.

15. CIRIA C665, 'Assessing Risks Posed by Hazardous Ground Gases in Buildings', 2007.

16. DEFRA, 2006b. Environmental Protection Act 1990: Part 2A. Contaminated Land. Defra Circular 01/2006. London: Department for Environment, Food and Rural Affairs.

17. DEFRA, 2008a. Improvements to contaminated land guidance. Outcome of the "Way Forward" exercise on soil guideline values. Defra: Department for Environment, Food and Rural Affairs.

18. DEFRA, 2008b. Guidance on the legal definition of contaminated land. London: Department for Environment, Food and Rural Affairs.

19. DEFRA, 2015. Development of Category 4 Screening Levels for assessment of land affected by contamination - SP1010

20. Driscoll, R (1983) "The influence of vegetation on the shrinking and swelling of clay soils in Great Britain", Geo-technique 33, 93-107

21. Environment Agency, 2000a. Secondary model procedure for the development of appropriate soil sampling strategies for land contamination. R&D Technical Report P5-066/TR. Bristol: Environment Agency.

22. Environment Agency, 2000b. Technical aspects of site investigation, Volumes 1 and 2. R&D Technical Report P5-065/TR. Bristol: Environment Agency.

23. Environment Agency, 2002, CLR 8, 'Potential contaminants for the assessment of contaminated land'. DEFRA/EA.

24. Environment Agency, 2004 CLR 11, 'Model Procedures for the Management of Contaminated Land', DEFRA and Environment Agency,

25. Environment Agency, 2005. Sampling and testing of wastes to meet landfill Waste Acceptance Criteria. Bristol: Environment Agency

26. Environment Agency, 2009a. Updated technical background to the CLEA model. Science Report SC050021/SR3. Bristol: Environment Agency.

27. Environment Agency, 2009b. Human health toxicological assessment of contaminants in soil. Science Report Final SC050021/SR2. Bristol: Environment.

28. Environment Agency, 2009c. CLEA software version 1.06. Bristol: Environment Agency.

29. Environment Agency, 2009d. CLEA software (version 1.06) handbook. Science Report SC050021/SR4. Bristol: Environment Agency.

30. Environment Agency 2015. Waste Classification: Guidance on the classification and assessment of waste (1st edition 2015)

31. Environment Agency, 2009e. CLR 4, 'Sampling strategies for contaminated land'. Report by The Centre for Research into the Built Environment, the Nottingham Trent University, DoE, 1994.

32. Eurocode 1: Actions on structures – BS EN 1991-1-1:2002: General actions – Densities, self weight and imposed loads, BSI, London

33. Nathanail, C.P.; McCaffrey,C.; Gillett, A.G.; Ogden, R.C. & Nathanail, J.F., 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, Nottingham.

34. NHBC Standards, Chapter 4.1, "Land Quality - managing ground conditions", September 1999.

35. NHBC Standards, Chapter 4.2, "Building near Trees", April 2010.

36. Tomlinson, M J, 2001. "Foundation Design and Construction", Seventh Edition, Prentice Hall (ISBN 0-13-031180-4).

37. Water Supply (Water Quality) Regulations 2000, Statutory Instrument 2000 No. 3184, Crown Copyright 2000.

38. UK Water Industry Research Limited, 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites', report reference Number 10/WM/03/21, 2010.

39. Water Regulations Advisory Scheme, Information and Guidance Note, October 2002, 'The Selection of Materials for Water Supply Pipes to be Laid in Contaminated Land'.

Site Analytical Services Ltd.				REF: 16/25450
LOCATION:	52 Holmes Road, London, NW5 3AB			FIG: 1
TITLE:	Site Sketch Plan	DATE:	August 2016	SCALE: NTS