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GEO-ENVIRONMENTAL & GEOTECHNICAL ASSESSMENT (GROUND INVESTIGATION) REPORT

546 SIPSON ROAD,
SIPSON,
HILLINGDON
UB7 0JB

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Report Title: **Geo-environmental & Geotechnical Assessment Ground Investigation Report for 546 Sipson Road, Sipson, Hillingdon UB7 0JB**

Report Status: **Final**

Job No: **P5040J2780/JRO**

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QUALITY CONTROL – REVISIONS

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EXECUTIVE SUMMARY

Site Details	**Site Address**	546 Sipson Road, Sipson, Hillingdon UB7 0JB
	National Grid	507481 177232
	Site Area	0.97Ha (approx.)
	Proposed Development	The proposed development is to comprise the demolition of the existing building and the erection of a new building ranging between 1 and 6 storeys, to provide a 302-bedroom hotel with a basement and ancillary facilities including; a restaurant, car parking, coach parking, hard and soft landscaping, and associated works.
Encountered Conditions	**Scope of Works**	The assessment incorporated a desk study to determine the site's setting to inform a preliminary risk assessment followed by an intrusive investigation to confirm the ground and groundwater conditions and support the development of a geotechnical and geo-environmental assessment.
	Ground Conditions	The ground conditions encountered broadly consistent with those anticipated from the desk study, and comprised Made Ground, to depths of up to 1.3m, underlain locally by Langley Silt, and by clay or sand and gravel of the Taplow Gravel Formation, to depths of up to 4.7m, underlain by the London Clay Formation to the base of the boreholes (maximum depth of 25.0m).
	Groundwater	No groundwater strikes were encountered during the drilling of the boreholes. During return monitoring, groundwater was encountered at depths of between 3.84m to 4.09m bgl within the Taplow Gravel Member.
Geo-environmental Assessment Summary and Recommendations		Following generic risk assessments, no exceedances of contaminants above the generic assessment criteria were recorded in any of the soil samples tested. No asbestos fibres were detected in the samples analysed in the laboratory. Elevated levels of nickel, copper and total cyanide were found to exceed environmental water quality standards, and concentrations of selenium were found to exceed drinking water quality standards within water samples tested. However, the site does not lie within a Source Protection Zone, and no significant onsite source of these contaminants has been identified. Therefore, a pollutant linkage is therefore not considered to exist, and there is not considered to be a significant risk of pollution to controlled waters. Gas monitoring has recorded concentrations of carbon dioxide in excess of 5% on several occasions and a site classification of CS2 is considered to be prudent. Where the proposed basement is not constructed under the building footprint a system comprising a gas-proof membrane with ventilated sub-floor void, and all penetrations sealed, should be installed at the site. As with any ground investigation, the presence of further hotspots between sampling points cannot be ruled out, and caution must be exercised during construction works. Should any contamination be encountered, a suitably qualified environmental consultant should be informed immediately, so that adequate measures may be recommended.
Geotechnical	**Foundations**	Given the anticipated loads of the proposed 6-storey building, it is considered that conventional foundations are not likely to be suitable due to the high structural loads. Piled foundations are therefore recommended and indicative pile carrying capacities are given in Table 12.1 and 12.2.
	Sulphates	Buried concrete for foundations should be designed to Class DS-2 (AC-1s), except where London Clay is likely to be disturbed and exposed to air. In such cases, a Design Class of DS-5, AC-4s should be adopted.

	Ground Floor Slabs	Given that piled foundations are recommended, a suspended floor slab is required.
	Excavations	Temporary excavations are unlikely to remain stable and some form of temporary support or battering back to a safe angle and dewatering are likely to be required. Subject to seasonal variations, surface water/groundwater encountered during site works could likely be dealt with by conventional pumping from a sump used to collate waters.
Recommended Further Work		The following works are recommended: • Carry out soil waste classification to aid estimation of costs for off-site soil disposal or determine possibility for re-use on site; • Submit chemical testing results to appropriate waste facility to confirm waste classification; • Due to the use of deep foundations and the underlying Principal Aquifer an EA Piling Risk Assessment may be required. • Production of a Materials Management Plan (MMP) prior to commencement of works to ensure legal compliance of on-site soil movement; • Seek approval of the Generic Quantitative Risk Assessment and Soil Gas Assessment from the Local Authority, NHBC and other relevant stakeholders; • Seek confirmation of the water supply pipe requirements by the appropriate service provider.
This Executive Summary is intended to provide a brief summary of the main findings and conclusions of the investigation. For detailed information, the reader is referred to the main report ref. P5040J2780.		

1 INTRODUCTION

1.1 Terms of Reference

1.1.1 MKH Real Estate Limited ("The Client") has commissioned Jomas Associates Ltd ('Jomas') to undertake an investigation of the geotechnical and geo-environmental factors pertaining to the proposed development at a site referred to as 546 Sipson Road, Sipson, Hillingdon UB7 0JB (herein referred to as 'the site'). The site's location is presented in Figure 1.

1.1.2 A Phase 1 Desk Study has been produced for the site and issued separately (detailed in Table 1.1 below), followed by an intrusive investigation (detailed in this report).

1.1.3 An intrusive investigation has been undertaken in accordance with Jomas' proposal dated 02nd May 2023.

1.2 Proposed Development

1.2.1 The proposed development will involve the demolition of the existing building and the erection of a new building ranging between 1 and 6 storeys, to provide a 302-bedroom hotel with a basement and ancillary facilities including; a restaurant, car parking, coach parking, hard and soft landscaping and associated works.

1.2.2 For the purpose of geo-environmental assessment and selection of generic assessment criteria, the development is considered "commercial".

1.2.3 Plans of the proposed development are provided as Figures 4 & 5.

1.2.4 For the purpose of geotechnical assessment, it is considered that the project could be classified as a Geotechnical Category (GC) 2 site in accordance with BS EN 1997.

1.3 Objectives

1.3.1 The objectives of Jomas' investigation are as follows:

- To undertake an intrusive investigation, to determine the ground and groundwater conditions as well as to assess the nature and extent of contaminants (if any) potentially present at the site;
- To establish the presence of significant pollutant linkages, in accordance with the procedures set out within Part IIA of the Environmental Protection Act 1990, associated statutory guidance and current best practice including the EA land contamination risk management (LCRM) guidance; and,
- To determine soil/rock properties to inform the preliminary geotechnical assessment for foundations, excavation stability, buried concrete and recommendations for further action (if required).

1.4 Scope of Works

1.4.1 The following tasks were undertaken to achieve the objectives listed above:

- Intrusive ground investigation to determine shallow ground conditions, and potential for contamination to be present at the site;

- Undertaking of laboratory chemical and geotechnical testing upon samples obtained;
- Return ground gas/groundwater monitoring;
- The compilation of this report, which collects and discusses the above data, and presents an assessment of the site conditions, conclusions and recommendations.

1.5 Supplied Documentation

1.5.1 A number of relevant reports prepared by or supplied to Jomas Associates prior to the commencement of this investigation are detailed in Table 1.1:

Table 1.1: Previous/Supplied Reports

Title	Author	Reference	Date
Desk Study/Preliminary Risk Assessment Report for 546 Sipson Road, Sipson, Hillingdon, UB7 0JB	Jomas Associates Ltd	P5040J2780/JRO	25th April 2023

1.6 Limitations

1.6.1 Jomas has prepared this report for the sole use of MKH Real Estate Limited, in accordance with the generally accepted consulting practices and for the intended purposes as stated in the agreement under which this work was completed. This report may not be relied upon by any other party without the explicit written agreement of Jomas. No other third party warranty, expressed or implied, is made as to the professional advice included in this report. This report must be used in its entirety.

1.6.2 The records search was limited to information available from public sources; this information is changing continually and frequently incomplete. Unless Jomas has actual knowledge to the contrary, information obtained from public sources or provided to Jomas by site personnel and other information sources, have been assumed to be correct. Jomas does not assume any liability for the misinterpretation of information or for items not visible, accessible or present on the subject property at the time of this study.

1.6.3 Whilst every effort has been made to ensure the accuracy of the data supplied, and any analysis derived from it, there may be conditions at the site that have not been disclosed by the investigation, and could not therefore be taken into account. As with any site, there may be differences in soil conditions between exploratory hole positions. Furthermore, it should be noted that groundwater conditions may vary due to seasonal and other effects and may at times be significantly different from those measured by the investigation. No liability can be accepted for any such variations in these conditions.

1.6.4 Any reports provided to Jomas have been reviewed in good faith. Jomas cannot be held liable for any errors or omissions in these reports, or for any incorrect interpretation contained within them.

1.6.5 This investigation and report has been carried out in accordance with the relevant standards and guidance in place at the time of the works. Future changes to these may require a re-assessment of the recommendations made within this report.

1.6.6 **This report is not an engineering design and the figures and calculations contained in the report should be used by the Structural Engineer, taking note that variations may apply,**

depending on variations in design loading, in techniques used, and in site conditions. Our recommendations should therefore not supersede the Engineer's design.

2 DESK STUDY SUMMARY

2.1 Site Information

2.1.1 The site location plan is appended to this report in Figure 1, Appendix 1.

Table 2.1: Site Information

Name of Site	Douglas Webb House
Address of Site	546 Sipson Road, Sipson, Hillingdon, UB7 0JB
Approx. National Grid Ref.	507481 177232
Site Area (Approx)	0.97ha
Site Occupation	Vacant commercial offices with associated parking and soft landscaping areas. The site is currently tenanted to a car parking company.
Local Authority	London Borough of Hillingdon
Proposed Site Use	Demolition of existing buildings for the construction of new buildings for commercial use.

2.2 Site Walkover

2.2.1 A site Walkover survey was undertaken by Jomas on the 06th April 2023.

Table 2.2: Site Description

Area	Item	Details
On-site:	**Current Uses:**	The site is occupied by vacant 3-storey interconnected brown brick buildings with associated courtyard areas. Access inside the buildings was limited, but plant rooms, office rooms, and kitchen areas were observed. The buildings are partially demolished in places, with windows smashed, some walls/roofs missing etc. Waste materials were noted on the ground across the whole site, and some light fly tipping was observed in the north of the site.
	Evidence of historic uses:	No evidence of historic uses beyond former commercial use.
	Surfaces:	Over half of the site is hard cover either by the buildings or by car parking areas and roadways. There are areas of soft landscaping predominantly in courtyard areas and along the south and east of site. The hard cover is a mixture of concrete, asphalt and block paving.

Area	Item	Details
	Vegetation:	Much of the vegetation around site is either shrubs/bushes or trees. This is most notable in the east of site and in the courtyard areas, where the vegetation is very overgrown. There are a large number of trees around site, with many located in the car park and surrounding the building. In addition, a row of coniferous trees is present along the western site boundary. None of the vegetation seen appeared to be exhibiting any evidence of distress.
	Topography/Slope Stability:	Overall, there is no significant changes in elevation across site.
	Drainage:	The site appears to be connected to normal drainage facilities. Drain covers are situated around the site. No obvious evidence of drainage issues.
	Services:	Various pipes and manholes were observed around the site relating to gas and electricity. However, the Jomas engineer was informed that the services are no longer connected.
	Controlled waters:	No controlled waters were noted on site.
	Tanks:	A fill point was observed in the south-west of site. No tanks were observed, however a bunded brick/concrete tank cradle with some minor dark brown staining was noted. The former tanks were likely to have been used for heating oil storage.
Neighbouring land:	**North:**	Sipson Road immediately adjacent to site, beyond which lies agricultural fields and residential houses.
	East:	The M4 motorway with associated cuttings is adjacent to the east, in addition to various hotels, residential houses, and a quarry approximately 100m from site.
	South:	Adjacent to the southern boundary is a large long stay car park, beyond which lies Heathrow Airport.
	West:	Residential houses.

2.2.2 Site photographs taken during the site walkover can be found as Figure 3, in Appendix 1.

2.3 Summary of Preliminary Risk Assessment (Desk Study)

2.3.1 As detailed in Table 1.1, a Phase 1 Desk Study report has been produced for the site and issued separately (Jomas Associates Ltd, April 2023). The findings of the Phase 1 Desk Study are presented in the following section. Reference should be made to the original reports and documents for further details. Comments made in the following section regarding possible ground conditions on the site and within the surrounding area are based purely on the desk study. Where appropriate, this information will be used in the later sections of this report as supplementary information to assist in the evaluation of the ground conditions and aid the identification of geotechnical and geochemical constraints and hazards that could impact on the scheme.

2.3.2 A review of earliest available (1866) historical maps indicates that the site was comprised of undeveloped land with an area of marshy ground in the south-east. By the map dated 1896, a large pond encroaches into the south-east of site, and a large area in the north of site is now comprised of woodland. By 1912, the pond encroaching onto the site appears to have been infilled. The map dated 1932 indicates that the site is in use as allotment gardens. No significant changes occur to the site until 1987, by which time it appears in its current configuration with a large building constructed across site, and the north of site comprising a large car park.

2.3.3 The land in the surrounding area of site has been predominantly used for agricultural uses. Notable residential developments are observed to have taken place from the 1930s, with the most significant developments occurring in a period of post war urbanisation in the 1950's and 1960's. This period coincides with the construction of Heathrow Airport, in which the area additionally undergoes significant developments in infrastructure e.g. roadways.

2.3.4 As part of previous planning application for the site a Preliminary Risk Assessment report was undertaken by RSK in May 2020. The report describes that the site was historically used as the Metropolitan Police's Section House and included: a basement used as a firing range; ground floor as a gymnasium; first floor for changing facilities; an eastern block containing 102 bedrooms, 12 of which were accessible bedrooms; a central and western block compromising a reception, kitchen, offices, canteen and storage rooms.

2.3.5 During the site walkover, the engineer reported the presence of a filling point in the south-west of site. No tanks were observed, however a bunded brick/concrete tank cradle with some minor dark brown staining was noted. The former tanks were likely to have been used for heating oil storage.

2.3.6 In the second half of the 19th century, various ponds are shown to be present around, and on, the site. This includes a large pond encroaching into the south-east of site, which is infilled by 1912, a small pond and culvert 25m east which is infilled by 1896, and a pond approximately 300m east of site which is infilled by 1896. In addition, a landfill is recorded 198m west of the site by the Groundsure report. The records available indicate that the landfill is licenced to receive any waste excluding inert waste. Given the permeable nature of the underlying superficial deposits, nature of infilling material and proximity, the ponds and landfill are considered to pose a potentially significant risk of ground gas.

2.3.7 Information provided by the British Geological Survey indicates that the site is directly underlain by superficial deposits of the Langley Silt Member and possibly the Taplow Gravel Member. These superficial deposits are underlain by solid deposits of the London Clay Formation. No artificial deposits are reported within the site.

2.3.8 Borehole records from approximately 19m south-east of the site, indicated 'Superficial ground' to a depth of around 6m bgl, overlying London Clay to a depth of around 60m bgl, overlying Clays with some gravel (inferred to represent the Lambeth Group) to a depth of around 84m, overlying Chalk to the base of the borehole at approximately 120m bgl.

2.3.9 The superficial deposits of the Langley Silt are identified as unproductive strata, whilst the underlying Taplow Gravel Member deposits are identified as a Principal aquifer with the underlying solid deposits identified as Unproductive.

2.3.10 A review of the Enviro+Geoinsight Report indicates that there are no source protection zones within 500m of the site.

2.3.11 There are 23No groundwater abstractions reported within 2km of the site; with the nearest recorded as active abstraction for 'general use' 103m south-east.

2.3.12 There are no surface water or potable water abstractions reported within 1km of the site.

2.3.13 There are 2No detailed river entries reported by Water Network, as an 'inland river not influenced by normal tidal action' 140m east and 223m east.

2.3.14 There are 3No surface water features reported within 250m of the site.

2.3.15 There are no Environment Agency Zone 2 or 3 floodplains reported within 50m of the site.

2.3.16 An intrusive investigation was recommended to confirm the preliminary geo-environmental risks identified and to provide geotechnical information for use in design. The investigation should assess the thickness of any Made Ground, and allow samples of Made Ground and natural soils to be taken for laboratory analysis.

2.3.17 Soil gas monitoring should be undertaken due to on-site infilled ponds and off-site waste landfilling. This should be undertaken in accordance with CIRIA C665.

2.3.18 The conceptual site model is reproduced in Table 2.3 overleaf.

Table 2.3: Preliminary Risk Assessment for the Site

Sources	Pathways (P)	Receptors	Consequence of Impact	Probability of Impact	Risk Estimation	Hazard Assessment
• Potential for Made Ground associated with previous development operations – on site (S1) • Potential contamination associated with former heating oil tanks in the SW – on site (S2) • Potential risk of ground gas associated with infilled ground – on and off site (S3) - Infilled pond in SE of site - Infilled ponds 25m E and 300m E - Active/recent landfill 198m W • Potential asbestos containing materials within existing buildings – on site (S4) • Current and previous industrial use – off site (S5) - Cuttings immediately adjacent to site - Industrial products 19m SW - Unspecified tank 188m E - Waste landfilling 198m W	• Ingestion and dermal contact with contaminated soil (P1) • Inhalation or contact with potentially contaminated dust and vapours (P2) • Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6)	• Construction workers (R1) • Maintenance workers (R2) • Neighbouring site users (R3) • Future site users (R4) • Building foundations and on site buried services (water mains, electricity and sewer) (R5)	Medium	Low likelihood	Moderate/Low	GI – Ground Investigation
			Severe for Asbestos	Likely	High for Asbestos	
	• Accumulation and migration of soil gases (P5)		Severe	Low likelihood	Moderate	
	• Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hardstanding or via service pipe/corridors and surface water runoff (P3) • Horizontal and vertical migration of contaminants within groundwater (P4)	• Neighbouring site users (R3) • Building foundations and on site buried services (water mains, electricity and sewer) (R5) • Controlled waters (R6) - Principal aquifer (Taplow Gravel Member – if present) - 23No groundwater abstractions reported within 2km; nearest recorded as active abstraction for 'general use' 103m SE - Inland river not influenced by normal tidal action 140m E and 223m E.	Medium	Low likelihood	Moderate/Low	

3 PREVIOUS GROUND INVESTIGATIONS

3.1.1 Jomas is not aware of any previous intrusive investigation works that have been undertaken on the site.

4 GROUND INVESTIGATION

4.1 Scope of Works

4.1.1 A ground investigation was undertaken on the 17th May 2023.

4.1.2 A summary of the fieldwork carried out at the site, with justifications for exploratory hole positions, is presented in Table 4.1 below.

Table 4.1: Scope of Intrusive Investigation

Investigation Type	Number of Exploratory Holes Achieved	Exploratory Hole Designation	Depth Achieved	Justification
Windowless Sample Boreholes	5	WS1-5	Up to 2.5mbgl	Obtain shallow samples for laboratory chemical and geotechnical testing. To allow in-situ geotechnical testing. WS3 targeting a historic fuelling station with above ground tanks on-site, and potential ground gas migration from a landfill off site. WS5 targeting historic infilled ponds on site and ground gas migration from off-site infilled ponds.
Cable Percussion Boreholes	2	BH1-2	Up to 25mbgl	Obtain deeper samples for laboratory geotechnical testing. To allow in-situ geotechnical testing. BH2 targeting historic infilled ponds on site and ground gas migration from off-site infilled ponds.
Monitoring Wells	3	WS3, BH1 & BH2	Up to 5mbgl	Gas and groundwater monitoring wells.

4.1.3 The ground investigation was undertaken in accordance with British Standard BS5930:2015+A1:2020 "Code of practice for ground investigations", British Standard BS10175:2011+A2:2017 "Investigation of potentially contaminated sites - code of practice", NHBC Standards, Chapter 4.1 and AGS Guidelines for Good Practice in Site Investigations.

4.1.4 Exploratory hole positions are shown on the exploratory hole location plan presented in Figure 2, Appendix 1. The exploratory hole records are included in Appendix 2.

4.1.5 Where monitoring well installations were not installed, the exploratory holes were backfilled with the arisings (in the reverse order in which they were drilled) and the ground surface was reinstated so that no depression was left.

4.2 In-situ Geotechnical Testing

4.2.1 In-situ geotechnical testing included Standard Penetration Tests. The determined 'N' values have been used to determine the relative density of granular materials and have been used with standard correlations to infer various other derived geotechnical parameters including the undrained shear strength of the cohesive strata. The results of the individual tests are on the appropriate exploratory hole logs in Appendix 2.

4.3 Laboratory Analysis

4.3.1 A programme of laboratory testing, scheduled by Jomas Associates Limited, was carried out on selected samples of Made Ground and natural strata.

Chemical Testing

4.3.2 Chemical testing of soils was undertaken by Terra Tek Ltd, which holds UKAS and MCERTS accreditations for a wide range of determinands.

4.3.3 The samples were analysed for a wide range of contaminants as shown in Table 4.2 below:

Table 4.2: Chemical Tests Scheduled

	No. of tests	
Test Suite	**Made Ground / Topsoil**	**Natural**
Basic Suite 3	6	0
Basic Suite 5	3	0
Total Organic Carbon	3	0
Jomas Modified BRE SD-1 Suite	0	8
The Hydrocarbon Suite	3	0
Asbestos Screen & ID	8	0

4.3.4 The determinands contained in the Basic Suite 3 are as detailed in Table 4.3 below. Basic Suite 5 contains the same determinands but without the hydrocarbon compounds to avoid overlapping with the extended hydrocarbon testing.

4.3.5 The Hydrocarbon Suite includes TPHCWG, PAH, phenols and VOCs including BTEX & MTBE.

Table 4.3: Basic Suite of Determinands

DETERMINAND	LIMIT OF DETECTION (mg/kg)	UKAS ACCREDITATION	TECHNIQUE
Arsenic	0.5	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Cadmium	0.1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Chromium	1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Chromium (Hexavalent)	0.3	N	APHA/AWWA, 19th edition: Method 3500Cr-D
Lead	1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Mercury	0.1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Nickel	1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Selenium	0.5	Y (ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Copper	1	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Zinc	0.5	Y (MCERTS/ISO 17025)	BS7755: Section 3.9: 1995/ISO 11466:1995
Boron (Water Soluble)	0.2	Y (ISO 17025)	MAFF Book 427: The Analysis of Agricultural Materials: Method 8
pH Value	0.1 units	Y (MCERTS/ISO 17025)	BS1377, Part 3, 1990: Soils for Civil Engineering Purposes.
Sulphate (Water Soluble)	0.01g/l	Y (MCERTS/ISO 17025)	In-house documented method
Total Cyanide	0.1	N	Colorimetry
Speciated/Total PAH	0.05/0.10	Y (MCERTS/ISO 17025)	GACHAMJA A.M. Chromatography and Analysis: 1992 9-11 (modified)
Phenols	0.7	N	Skalar Analysis of Soil
Total Petroleum Hydrocarbons (banded)	1	N	TNRCC Method 1005: 2001 (modified)

4.3.6 To support the selection of appropriate tier 1 screening values, 3No. samples were analysed for total organic carbon.

4.3.7 The laboratory test results are included in Appendix 3.

Geotechnical Laboratory Testing

4.3.8 In addition to the contamination assessment, soil samples were submitted to the UKAS Accredited laboratory of Terra Tek Ltd. for a series of geotechnical analyses.

4.3.9 This testing was designed to classify the samples and to obtain parameters (either directly or sufficient to allow relevant correlations to be used) relevant to the technical objectives of the investigation.

4.3.10 The following laboratory geotechnical testing was carried out:

Table 4.4: Laboratory Geotechnical Analysis

Methodology	Test Description	Number of tests
BS EN 17892	Moisture Content Determination	10
BS1377:1990	Liquid and Plastic Limit Determination (Atterberg Limits)	10
BS1377:1990	Determination of the undrained shear strength in triaxial compression with single stage loading and without measurement of pore pressure	8

4.3.11 In addition, 8No. soil samples were analysed for a modified BRE Special Digest 1 suite (acid and water soluble sulphate, total sulphur and pH) to assist with the ACEC classification for buried concrete.

4.3.12 The laboratory test results are included in Appendix 4.

5 GROUND CONDITIONS ENCOUNTERED

5.1 General

5.1.1 A factual record of the conditions encountered during the physical investigation of the site is presented in the following section.

5.2 Ground Conditions

5.2.1 The ground conditions encountered comprised a thickness of Made Ground locally overlying Langley Silt Member deposits overlying the Taplow Gravel Member and London Clay Formation. These are summarised in Table 5.1 below.

Table 5.1: Ground Conditions Encountered

Stratum and Description	Encountered from (mbgl)	Base of strata (mbgl)	Thickness range (m)
Concrete/asphalt/grass/wood chippings over dark brown/black silty sandy gravel/gravelly clay with occasional rootlets. Sand is fine to medium. Gravel consists of fine to coarse, angular to subrounded flint, brick, concrete, occasional plastic and glass, and rare tiles. (MADE GROUND) *Rare black staining observed in WS1, WS3, WS4 & WS5.*	0.00	0.20 – 1.30	0.20 – 1.30
Firm consistency** blackish dark brown mottled orange silty sandy gravelly CLAY with occasional rootlets and black staining. Sand is fine. Gravel consists of fine to medium, subangular to subrounded flint. (LANGLEY SILT MEMBER) *Only encountered within WS1, WS4 & WS5.* *Black staining observed in WS1 & WS4.*	0.40 – 0.70	0.80 – 1.50	0.40 – 0.80
Soft to firm consistency** brown mottled orange sandy gravelly CLAY. Sand is fine to medium. Gravel consists of fine to coarse, angular to subrounded flint. (LANGLEY SILT MEMBER / TAPLOW GRAVEL MEMBER – COHESIVE) *Only encountered within WS1, WS3, WS4 & WS5.*	0.80 – 1.50	>1.80 - >2.20	>0.50 – 1.20
Loose to very dense reddish brown/yellowish orange/orangish brown locally silty SAND and GRAVEL/sandy GRAVEL. Sand is fine to medium. Gravel consists of fine to coarse, angular to sub-rounded flint. (TAPLOW GRAVEL MEMBER – GRANULAR) *Only encountered within WS2, WS3, WS5, BH1 & BH2.*	0.20 – 2.00	>0.80 – 4.70	0.20 – 3.40
Firm becoming very stiff consistency** grey CLAY. (LONDON CLAY FORMATION) *Only encountered within BH1 & BH2.*	4.50 – 4.70	>20.00 – >25.00 [base not proven]	>15.50 – >20.30 [thickness not proven]

***Consistency estimated using semi-empirical correlations with SPT N-values, Plasticity Indices and published literature*

5.2.2 The Made Ground was distributed in a generally even thickness across site, with the exception of WS2 where natural soils were encountered directly underlying concrete.

5.3 Groundwater

5.3.1 Groundwater strikes were not recorded during the ground investigation.

5.3.2 A total of 4No. return groundwater monitoring results were carried out between 23rd May and 12th June 2023. Results are presented in Appendix 5 and summarised below.

Table 5.2: Groundwater Monitoring Summary

Exploratory Hole ID	Depth Encountered (mbgl)	Well Response Zone as installed (top / bottom) mbgl (mbgl)	Depth to Base of Well – as gauged (mbgl)	Strata targeted by response zone
BH1	-	1.0 – 5.0	-	Taplow Gravel Member/London Clay Formation
BH2	3.84 – 4.09	1.0 – 5.0	4.90 – 4.92	Taplow Gravel Member/London Clay Formation
WS3	Dry	1.0 – 5.0	1.80 – 1.81	Taplow Gravel Member

5.3.3 The gas and groundwater monitoring well within BH1 was destroyed after installation and could not be utilised during the subsequent monitoring events.

5.3.4 It should be noted that changes in groundwater levels can occur for a number of reasons including seasonal effects and variations in drainage. Such fluctuations may only be recorded by the measurement of the groundwater level within a standpipe or piezometer installed within appropriate response zones. Changes in groundwater level can have a direct effect on excavation stability and dewatering requirements, and cohesive soils can soften under rising or high groundwater levels.

5.4 Physical and Olfactory Evidence of Contamination

5.4.1 With the exception of a black staining within the Made Ground and shallow natural soils of some boreholes, no other visual or olfactory evidence of potential contamination was identified within the investigation positions.

5.5 Limitations

5.5.1 During the intrusive ground investigation, WS1 was terminated at a depth of 1.8m due to refusal of the sample barrel in hard natural ground.

5.5.2 WS2 was terminated at a depth of 0.8m due to refusal of the sample barrel in hard natural ground.

5.5.3 WS3 was terminated at a depth of 2.2m due to refusal of the sample barrel in hard natural ground.

5.5.4 WS4 was terminated at a depth of 2.0m due to refusal of the sample barrel in hard natural ground.

5.5.5 WS5 was terminated at a depth of 2.5m due to refusal of the sample barrel in hard natural ground.

5.5.6 The possible presence of unidentified natural and/or manmade obstructions elsewhere on site cannot be discounted.

6 RISK ASSESSMENT – ANALYTICAL FRAMEWORK

6.1 Context and Objectives

6.1.1 This section seeks to evaluate the level of chronic risk pertaining to human health and the environment which may result from both the existing use and proposed future use of the site. It makes use of the ground investigation findings, as described in the previous sections, to evaluate further the potential pollutant linkages identified in the desk study. A combination of qualitative and quantitative techniques is used, as described below.

6.1.2 The purpose of generic quantitative risk assessment is to compare concentrations of contaminants found on site against generic assessment criteria (GAC) to establish whether there are actual or potential unacceptable risks. It also determines whether further detailed assessment is required. The approaches detailed all broadly fit within a tiered assessment structure in line with the framework set out in the Department of Environment, Food and Rural Affairs (DEFRA), EA and Institute for Environment and Health Publication, Guidelines for Environmental Risk Assessment and Management.

6.2 Analytical Framework – Soils

6.2.1 There is no single methodology that covers all the various aspects of the assessment of potentially contaminated land and groundwater. Therefore, the analytical framework adopted for this investigation is made up of a number of procedures, which are outlined below. All of these are based on a Risk Assessment methodology centred on the identification and analysis of Source – Pathway – Receptor linkages.

6.2.2 The soil analytical test results have been compared to Suitable 4 Use Levels (S4UL) published by the Chartered Institute of Environmental Health in order to assess the potential long-term risks to human health posed by contaminants in the soils. S4UL'S have been derived for a range of land uses and Soil Organic Matter contents. They represent the minimal or tolerable risk, above which further assessment of the risks or remedial action may be required.

6.2.3 In the absence of a S4UL recommended concentration, other available general assessment criteria (GAC), including the Category 4 Screening Levels (C4SL) published by DEFRA have been used. Site-specific assessments are undertaken wherever possible and/or applicable. All assessments are carried out in accordance with the CLEA protocol.

6.2.4 The assessment criteria used for the screening of determinands within soils are identified within Table 6.1.

Table 6.1: Selected Assessment Criteria - Contaminants in Soils

Substance Group	Determinand(s)	Assessment Criteria Selected
Organic Substances		
Non-halogenated Hydrocarbons	Total Petroleum Hydrocarbons (TPHCWG banded)	S4UL
	Total Phenols	S4UL
Polycyclic Aromatic Hydrocarbons (PAH-16)	Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(123-cd)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene	S4UL
Volatile Organic Compounds (VOCs/sVOCs).	Toluene, Ethylbenzene, Benzene, Xylenes	S4UL
Inorganic Substances		
Heavy Metals and Metalloids	Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Selenium, Zinc	S4UL
	Copper, Zinc, Nickel	BS: 3882 (2015).
Cyanides	Free Cyanide	CLEA v1.06
Sulphates	Water Soluble Sulphate	BRE Special Digest 1:2005

6.2.5 It is understood that the site is to be converted to provide a 302-bedroom hotel with a basement and ancillary facilities including; a restaurant, car parking, coach parking, hard and soft landscaping and associated works. As a result, the site has been assessed with regards to a commercial end use scenario.

6.2.6 GAC have been selected with consideration to the Soil Organic Matter (SOM) content of the soil. From the soils analytical results, the average value for Total Organic Carbon for the Made Ground is 1.9%, which gives an equivalent SOM of 3.3%. Published GAC have been selected as those derived assuming a SOM of 1%.

6.3 BRE

6.3.1 The BRE Special Digest 1:2005, 'Concrete in Aggressive Ground' is used with soluble sulphate and pH results to assess the aggressive chemical environment of future underground concrete structures at the site.

6.4 Analytical Framework – Groundwater and Leachate

6.4.1 The requirement to protect groundwater from pollution is outlined in Groundwater Protection: Principles and Practice (GP3, EA, August 2013, v1.1).

6.4.2 Where undertaken, the groundwater quality analysis comprises a Level 1 assessment in accordance with the EA Remedial Targets Methodology Document (EA, 2006).

6.4.3 The criteria used by Jomas' in the Level 1 assessment of groundwater and leachate quality are shown in Table 6.2.

Table 6.2: Selected Assessment Criteria - Contaminants in Water

Substance Group	Determinand(s)	Assessment Criteria Selected
Metals	Arsenic, Boron, Cadmium, Chromium, Copper, Cyanide, Lead, Mercury, Nickel,	EQS/DWS
	Zinc	EQS
	Selenium	DWS
PAHs	Sum of Four – benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, indeno(123-c,d)pyrene	DWS
PAH	Anthracene, Naphthalene	EQS
PAHs	Benzo(a)pyrene	EQS/ DWS
PAHs	Remainder	LEC
Total Petroleum Hydrocarbons	Aliphatic C5-C6, Aliphatic >C6-C8, Aliphatic >C8-C10. Aliphatic >C10-C12, Aliphatic >C12-C16, Aliphatic >C16-C21, Aromatic C5-C7, Aromatic >C7-C8, Aromatic >C8-C10, Aromatic >C10-C12, Aromatic >C12-C16, Aromatic >C16-C21, Aromatic> C21-C35	WHO
Benzene	Benzene	EQS/ DWS
Toluene	Toluene	EQS/ WHO
Ethylbenzene	Ethylbenzene	WHO
Xylene	Xylene	EQS/WHO

Environmental Quality Standards EQS

Environmental Quality Standards (EQS) have been released by the EA for dangerous substances, as identified by the EC Dangerous Substances Directive. EQS can vary for each substance, for the hardness of the water and can be different for fresh, estuarine or coastal waters.

WHO Health

These screening criteria have been taken from the World Health Organisation Guidelines for Drinking Water Quality (2017). The health value is a guideline value representing the concentration of a contaminant that does not result in any significant risk to the receptor over a lifetime of exposure.

Further criteria have been obtained from 'Petroleum Products in Drinking-water' - Background document for development of WHO Guidelines for Drinking-water Quality (2005).

UK Drinking Water Standards (DWS)
These comprise screening criteria provided by the Drinking Water Inspectorate (DWI) in the Water Supply (Water Quality) Regulations 2018.

7 GENERIC QUANTITATIVE RISK ASSESSMENT – SOIL DATA

7.1 Screening of Soil Chemical Analysis Results – Human Health Risk Assessment

7.1.1 Laboratory analysis for soils is summarised in Table 7.1 to Table 7.4. Raw laboratory data is included in Appendix 3.

7.1.2 Results have been screened against generic assessment criteria for a "commercial" end use, assuming 1% soil organic matter.

Table 7.1: Soil Laboratory Test Results - Metals, Metalloids, Phenol, Cyanide

Determinand	Unit	No. samples tested	Screening Criteria		Min	Max	No. Exceeding
Arsenic	mg/kg	9	S4UL	640	13.2	23.7	0
Cadmium	mg/kg	9	S4UL	190	0.34	2.43	0
Chromium	mg/kg	9	S4UL	8600	17	33	0
Lead	mg/kg	9	C4SL	2330	13	1020	0
Mercury	mg/kg	9	S4UL	320	<0.10	1.50	0
Nickel	mg/kg	9	S4UL	980	17	30	0
Copper	mg/kg	9	S4UL	68000	13	93	0
Zinc	mg/kg	9	S4UL	730000	35.8	285	0
Total Cyanide [A]	mg/kg	9	CLEA v 1.06	33	<0.10	0.42	0
Selenium	mg/kg	9	S4UL	12000	<0.50	0.81	0
Boron Water Soluble	mg/kg	9	S4UL	240000	0.7	2.4	0
Phenols	mg/kg	9	S4UL	440	<0.7	<0.7	0

Notes: [A] Generic assessment criteria derived for free inorganic cyanide.

Table 7.2: Soil Laboratory Test Results - Polycyclic Aromatic Hydrocarbons (PAHs)

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Naphthalene	mg/kg	9	S4UL	190	<0.05	<0.05	0
Acenaphthylene	mg/kg	9	S4UL	83000	<0.05	0.34	0
Acenaphthene	mg/kg	9	S4UL	84000	<0.05	<0.05	0
Fluorene	mg/kg	9	S4UL	63000	<0.05	<0.05	0
Phenanthrene	mg/kg	9	S4UL	22000	<0.10	2.59	0
Anthracene	mg/kg	9	S4UL	520000	<0.10	1.80	0
Fluoranthene	mg/kg	9	S4UL	23000	<0.10	8.73	0
Pyrene	mg/kg	9	S4UL	54000	<0.10	7.46	0
Benzo(a)anthracene	mg/kg	9	S4UL	170	<0.05	4.55	0

Determinand	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
Chrysene	mg/kg	9	S4UL	350	<0.10	4.18	0
Benzo(b)fluoranthene	mg/kg	9	S4UL	44	<0.10	3.98	0
Benzo(k)fluoranthene	mg/kg	9	S4UL	1200	<0.10	2.47	0
Benzo(a)pyrene	mg/kg	9	S4UL	35	<0.05	3.27	0
Indeno(123-cd)pyrene	mg/kg	9	S4UL	500	<0.10	1.65	0
Dibenzo(ah)anthracene	mg/kg	9	S4UL	3.5	<0.10	0.45	0
Benzo(ghi)perylene	mg/kg	9	S4UL	3900	<0.05	1.92	0
Total PAH	mg/kg	9	-	-	<1.3	41.1	-

Table 7.3: Soil Laboratory Test Results - Total Petroleum Hydrocarbons (TPH)

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
C_6-C_{10}	mg/kg	6	S4UL	2000	<1	<1	0
>C_{10}-C_{12}	mg/kg	6	S4UL	9700	<1	<1	0
>C_{12}-C_{16}	mg/kg	6	S4UL	36000	<1	2	0
>C_{16}-C_{21}	mg/kg	6	S4UL	28000	<1	8	0
>C_{21}-C_{35}	mg/kg	6	S4UL	28000	<1	<1	0
Total TPH	mg/kg	6	-	-	<5	<13	-

Note: *The lower value of guidelines for Aromatic/Aliphatics has been selected

Table 7.4: Soil Laboratory Analysis Results - Total Petroleum Hydrocarbons (TPHCWG)

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
>C_5-C_6 Aliphatic	mg/kg	3	S4UL	3200	<10	<10	0
>C_6-C_8 Aliphatic	mg/kg	3	S4UL	7800	<10	<10	0
>C_8-C_{10} Aliphatic	mg/kg	3	S4UL	2000	<1.0	<1.0	0
>C_{10}-C_{12} Aliphatic	mg/kg	3	S4UL	9700	<1.0	<1.0	0
>C_{12}-C_{16} Aliphatic	mg/kg	3	S4UL	59000	<1.0	<1.0	0
>C_{16}-C_{35} Aliphatic	mg/kg	3	S4UL	1600000	<8.0	<16	0
>C_6-C_7 Aromatic	mg/kg	3	S4UL	26000	<10	<10	0
>C_7-C_8 Aromatic	mg/kg	3	S4UL	56000	<10	<10	0
>C_8-C_{10} Aromatic	mg/kg	3	S4UL	3500	<10	<10	0
>C_{10}-C_{12} Aromatic	mg/kg	3	S4UL	16000	<1.0	<1.0	0
>C_{12}-C_{16} Aromatic	mg/kg	3	S4UL	36000	<1.0	<1.0	0
>C_{16}-C_{21} Aromatic	mg/kg	3	S4UL	28000	<1.0	<1.0	0

TPH Band	Unit	No. Samples Tested	Screening Criteria		Min	Max	No. Exceeding
>C_{21}-C_{40} Aromatic	mg/kg	3	S4UL	28000	<2.0	<2.0	0
Total TPH (Ali/Aro)	mg/kg	3	-	-	<66	<74	-

7.2 Asbestos in Soil

7.2.1 8No samples of the Made Ground were screened in the laboratory for the presence of asbestos. The results of the analysis are summarised below in Table 7.5 below.

Table 7.5: Asbestos Analysis - Summary

Sample	Screening Result	Quantification result (%)	Comments
WS1 – 0.50mbgl	None Detected	N/A	N/A
WS2 – 0.40mbgl	None Detected	N/A	N/A
WS3 – 0.50mbgl	None Detected	N/A	N/A
WS4 – 0.50mbgl	None Detected	N/A	N/A
WS5 – 0.20mbgl	None Detected	N/A	N/A
BH1 – 0.20mbgl	None Detected	N/A	N/A
BH1 – 1.00mbgl	None Detected	N/A	N/A
BH2 – 1.00mbgl	None Detected	N/A	N/A

7.2.2 No asbestos containing materials (ACM) or fibres were reported in samples analysed in the laboratory.

7.3 Volatile Organic Compounds

7.3.1 In addition to the suites outlined previously, 3No samples were tested for the presence of volatile organic compounds (VOCs) including BTEX compounds (benzene, toluene, ethylbenzene, xylene).

7.3.2 No VOCs were reported above the laboratory detection limit within any of the samples tested.

7.4 Summary of Human Health Generic Quantitative Risk Assessment

7.4.1 In summary, no exceedances of contaminants above the GAC were recorded in any of the soil samples tested.

7.5 Screening of Soil Chemical Analysis Results – Potential Risks to Plant Growth

7.5.1 Zinc, copper and nickel are phytotoxins and could therefore inhibit plant growth in soft landscaped areas. Concentrations measured in soil for these determinands have been compared with the pH dependent values given in BS:3882 (2015). This does not constitute a full BS:3882 topsoil test.

7.5.2 Table 7.6 shows the soil analytical results compared with the relevant screening values, adopting a pH value of greater than 7, as indicated by the results of the laboratory analysis.

Table 7.6: Soil Laboratory Analysis Results - Phytotoxic Determinands

Determinand	Threshold level (mg/kg)	Min (mg/kg)	Max (mg/kg)	No. Exceeding
Nickel	110	17	30	0
Copper	200	13	93	0
Zinc	300	35.8	285	0

7.5.3 None of the samples exceeded the threshold levels and a significant risk to plant growth has not been identified.

7.6 Screening for Water Pipes Materials

7.6.1 The results of the analysis have been assessed for potential impact upon water supply pipes. Table 7.7 below summarises the findings of the assessment:

Table 7.7: Screening Guide for Water Pipes

Determinand	No. of tests	Threshold for Polyethylene Pipes* (mg/kg)	Value for site data (mg/kg)		No of Exceedances
			Min	Max	
Total VOCs	3	0.5	<0.29	<0.29	0
BTEX	3	0.1	<0.03	<0.03	0
MTBE	3	0.1	<0.005	<0.005	0
EC_5-EC_{10}	6	1	<1	<1	0
EC_{10}-EC_{16}	6	10	<2	<3	0
EC_{16}-EC_{40}	6	500	<2	<9	0
Naphthalene	9	5	<0.05	<0.05	0
Phenols	9	2	<0.7	<0.7	0

** UK Water Industry Research (2010) Source Guidance for Selection of Water Supply Pipes to be Used in Brownfield Sites. Report No. 10/WM/03/21.*

7.6.3 The above suggests that upgraded pipe work is unlikely to be required.

7.6.4 The water supply pipe requirements for this site should be discussed at an early stage with the relevant utility provider.

7.7 Assessment of Soil Analytical Data with Respect to Controlled Waters

7.7.1 At the Preliminary Risk Assessment (Desk Study) stage, risks to controlled waters were low/moderate.

7.7.2 The following controlled waters receptors were identified:

- Principal aquifer within the Taplow Gravel Formation

- 23No groundwater abstractions reported within 2km; nearest recorded as active abstraction for 'general use' 103m south-east
- Surface waters (inland river not influenced by normal tidal action) located 140m east and 223m east

7.7.3 Pathways for migration of leachable/mobile contamination were considered to be potentially present within the directly underlying Taplow Gravel Formation.

7.7.4 The ground conditions encountered are considered to confirm the expected geological succession and confirm the pathways for migration of leachable / mobile contamination.

7.7.5 However, with reference to Section 5.4, no olfactory evidence of potentially mobile contamination was encountered, and therefore a pollutant linkage to controlled waters is not considered to exist.

7.8 Waste Characterisation

7.8.1 The classification of materials for waste disposal purposes was outside the scope of this report. Should quantities of material require off-site disposal, waste classification will be required to determine whether soils may be treated as hazardous or non-hazardous.

7.8.2 Note that Waste Acceptance Criteria (WAC) analysis may then be required by the landfill operator to determine whether materials can be disposed of at either an inert, stable non-reactive hazardous or hazardous landfill.

8 GENERIC QUANTITATIVE RISK ASSESSMENT – GROUNDWATER DATA

8.1 Groundwater sampling

8.1.1 Groundwater sample obtained from the monitoring wells installed within exploratory location BH2 were submitted for chemical analysis.

8.1.2 The samples were obtained by means of low flow methodology. Groundwater sampling records are presented in Appendix 7.

8.2 Assessment of groundwater analytical data with respect to controlled waters

8.2.1 The results of the laboratory testing are summarised in Table 8.1 to Table 8.3 below and compared to GAC for controlled waters receptors. Analytical laboratory certificates are presented in Appendix 3.

Table 8.1: Groundwater Laboratory Analysis Results – Metals, Metalloids, Phenol, Cyanide

Determinand	Unit	No. samples tested	Screening Criteria		Value	No of Exceedances
Arsenic	µg/l	1	10	DWS	0.9	0
	µg/l		50	EQS	0.9	0
Cadmium	µg/l	1	5	DWS	0.08	0
	µg/l		<0.08-0.25^{+}	EQS	0.08	0
Chromium	µg/l	1	50	DWS	<0.4	0
	µg/l		4.7	EQS	<0.4	0
Lead	µg/l	1	10	DWS	<0.01	0
	µg/l		1.2*	EQS	<0.01	0
Nickel	µg/l	1	20	DWS	6.3	0
	µg/l		4*	EQS	6.3	1No (BH2)
Copper	µg/l	1	1.0	EQS	5.75	1No (BH2)
			2000	DWS	5.75	0
Zinc	µg/l	1	10.9*	EQS	1.8	0
Mercury	µg/l	1	1.0	DWS	<0.05	0
	µg/l	1	0.07	EQS	<0.05	0
Selenium	µg/l	1	10	DWS	33.0	1No (BH2)
Boron	µg/l	1	1000	DWS	260	0
	µg/l		2000	EQS	260	0
Cyanide (Total)	µg/l	1	50	DWS	16.3	0
	µg/l		1	EQS	16.3	1No (BH2)
Phenols (Total)	µg/l	1	7.7	EQS	<0.5	0

* bioavailable concentration
$^{+}$Assessment criteria dependent on water hardness
**bioavailable concentration + ambient background concentration dissolved for Thames Groundwater (2 µg/L)

Table 8.2: Groundwater Analysis Results - Polycyclic Aromatic Hydrocarbons (PAHs)

Determinand	Unit	No. samples tested	Screening Criteria		Value	No. of Exceedances
Naphthalene	µg/l	1	2.0	EQS	<0.01	0
Acenaphthylene	µg/l	1	-	-	<0.01	-
Acenaphthene	µg/l	1	-	-	<0.01	-
Fluorene	µg/l	1	-	-	<0.01	-
Phenanthrene	µg/l	1	-	-	<0.01	-
Anthracene	µg/l	1	0.1	EQS	<0.01	0
Fluoranthene	µg/l	1	0.0063	EQS	<0.01	0
Pyrene	µg/l	1	-	-	<0.01	-
Benzo(a)anthracene	µg/l	1	-	-	<0.01	-
Chrysene	µg/l	1	-	-	<0.01	-
Benzo(b)fluoranthene	µg/l	1	0.017	EQS	<0.01	0
Benzo(k)fluoranthene	µg/l	1	0.017	EQS	<0.01	0
Benzo(a)pyrene	µg/l	1	0.01	DWS	<0.01	0
	µg/l	1	0.00017	EQS	<0.01	0
Dibenzo(ah)anthracene	µg/l	1	-	-	<0.01	0
Benzo(ghi)perylene	µg/l	1	0.0082	EQS	<0.01	0
Sum of four Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(ghi)perylene Indeno(123-cd)pyrene	µg/l	1	0.1	DWS	<0.04	0

Table 8.3: Groundwater Analysis Results - TPHCWG & BTEX - Controlled Waters

Determinand	Unit	No. Samples tested	Screening Criteria		Value	No. of Exceedances
Benzene	µg/l	1	1.0	DWS	<1.0	0
	µg/l	1	10	EQS	<1.0	0
Toluene	µg/l	1	74	EQS	<1.0	0
Ethylbenzene	µg/l	1	300	WHO	<1.0	0
Xylenes (total)	µg/l	1	500	WHO	<3.0	0
	µg/l	1	30	EQS	<3.0	0
MTBE	µg/l	1	15	WHO	<1.0	0
>C_5-C_6 Aliphatic	µg/l	1	15000	WHO	<10.0	0
>C_6-C_8 Aliphatic	µg/l	1	15000	WHO	<10.0	0
>C_8-C_{10} Aliphatic	µg/l	1	300	WHO	<10.0	0
>C_{10}-C_{12} Aliphatic	µg/l	1	300	WHO	<10.0	0
>C_{12}-C_{16} Aliphatic	µg/l	1	300	WHO	<10.0	0
>C_{16}-C_{21} Aliphatic	µg/l	1	-	-	10	-
>C_{21}-C_{35} Aliphatic	µg/l	1	-	-	56	-
>C_5-C_7 Aromatic	µg/l	1	10	WHO	<10.0	0
>C_7-C_8 Aromatic	µg/l	1	700	WHO	<10.0	0
>C_8-C_{10} Aromatic	µg/l	1	300	WHO	<10.0	0
>C_{10}-C_{12} Aromatic	µg/l	1	90	WHO	<10.0	0
>C_{12}-C_{16} Aromatic	µg/l	1	90	WHO	<10.0	0
>C_{16}-C_{21} Aromatic	µg/l	1	90	WHO	<10.0	0
>C_{21}-C_{35} Aromatic	µg/l	1	90	WHO	52	0

8.2.2 In addition to the suite outlined above, the one water sample were also analysed for a suite of volatile organic compounds (VOCs). None of the compounds analysed for were reported above the laboratory method detection limit.

8.2.3 Similarly, for the BTEX (Benzene, Toluene, Ethylbenzene and Xylene) compounds, none of the results were reported above the laboratory method of detection.

8.2.4 Concentrations of nickel, copper, and total cyanide were found to exceed environmental water quality standard.

8.2.5 Concentrations of selenium were found to exceed drinking water standards quality standard.

8.2.6 No concentrations were reported to exceed World Health Organisation guide values for ingestion of water.

8.2.7 The recorded the depth to London Clay Formation (4.7mbgl), whereas the M4 motorway is in approximately 5m of cut to the east of the site. Therefore, it is concluded that the shallow groundwater within the Taplow Gravel Member underlying the site is not in continuity with the river located approximately 140m east of the site.

8.2.8 The groundwater beneath the site is not considered to be in hydraulic continuity with the nearest groundwater abstraction located from 103m south-east of the site. This 130m deep abstraction well is considered to abstract groundwater from the deep chalk aquifer underlying the London Clay Formation. In addition, the site does not lie within any Source Protection Zones.

8.2.9 It should be noted that the EQS values of nickel are based on the bioavailable concentrations of these metals, rather than the total dissolved concentrations reported by the laboratory. The bioavailable concentrations of the metals would be expected to be lower than the total concentration reported. Given this, the relatively slight exceedances of nickel are not considered to pose significant risk to controlled water receptors.

8.2.10 Concentrations of copper were found to exceed the EQS of 1.0 µg/L in BH2 (5.75 µg/L). Concentrations of total cyanide were found to exceed the EQS of 1.0 µg/L in BH2 (16.3 µg/L). Concentrations of selenium were found to exceed the DWS of 10.0 µg/L in BH2 (33.0 µg/L). With reference to Table 7.1, no exceedances of copper, total cyanide, or selenium were recorded within the soil samples analysed at the laboratory and, on this basis, it is considered that no significant onsite source of these contaminants has been identified on site.

8.2.11 Based on the lack of pathway to discrete receptors and lack of potential sources of contaminants on site, no pollutant linkage to controlled waters is considered to exist.

8.3 Assessment of Groundwater Analytical Data with Respect to Vapour Intrusion Pathways

8.3.1 As outlined above, polyaromatic hydrocarbons (PAH), total petroleum hydrocarbons (TPHCWG) and volatile organic compounds (VOCs) were below laboratory limit of detect within the groundwater sample analysed. On this basis the risk posed to human health receptors by vapour inhalation from a groundwater source is considered to be negligible.

8.3.2 From the above assessment, it is concluded that a pollutant linkage to end users of the proposed development and adjacent site users from vapour inhalation from a groundwater source does not exist.

8.3.3 Further consideration of vapour risks is provided within Section 9, alongside the ground gas assessment.

9 SOIL GAS RISK ASSESSMENT

9.1 Soil Gas Results

9.1.1 Four return monitoring visits have been undertaken between 23 May 2023 and 12 June 2023, to monitor wells installed within boreholes at the site for soil gas concentrations and groundwater levels.

9.1.2 The results of the monitoring undertaken are summarised in Table 9.1 below, with the monitoring records presented in Appendix 6.

Table 9.1: Summary of Gas Monitoring Data

Hole No.	Number of monitoring events	CH_4 (%)	CO_2 (%)	O_2 (%)	VOCs (ppm)	Steady Flow Rate (l/hr)	Peak Flow Rate (l/hr)	Depth to water (mbgl)	Well Response Zone as installed (top/bottom) (mbgl)	Strata targeted by response zone
BH1	Monitoring well destroyed prior to first monitoring visit.								1.0 – 5.0	Taplow Gravel Member/ London Clay Formation
BH2	4	0.1 – 0.2	0.3 – 5.0	11.1 – 13.3	0.0 – 9.0	0.0 - +0.1	0.0 - +0.1	3.84 – 4.09	1.0 – 5.0	Taplow Gravel Member/ London Clay Formation
WS3	4	0.1 – 0.2	2.4 – 7.6	13.0 – 17.9	0.0 – 5.0	0.0 - +0.1	-0.1 - +0.1	Dry	1.0 – 5.0	Taplow Gravel Member

9.2 Screening of Results

9.2.1 As shown in Table 9.1, methane was detected between levels of 0.1 to 0.2% v/v during monitoring. The concentrations of carbon dioxide ranged from 0.3 to 7.6% v/v. The maximum concentration of Volatile Organic Compounds measured was 9.0 ppm. The maximum gas flow rate recorded was +0.1l/hr.

9.2.2 In the assessment of risks posed by hazardous ground gases and selection of appropriate mitigation measures, BS8485 (2015) + A1 (2019) identifies four types of development, termed Type A to Type D.

9.2.3 Type B buildings are defined as

> *"private or commercial property with central building management control of any alterations to the building or its uses but limited or no central building management control of the maintenance of the building, including the gas protection measures. Multiple occupancy. Small to medium size rooms with passive ventilation of rooms and other internal spaces throughout ground floor and basement areas. May be conventional building or civil engineering construction. Examples include managed apartments, multiple occupancy offices, some retail premises and parts of some public buildings (such as schools, hospitals, leisure centres) and parts of hotels."*

9.2.4 Type B has been adopted as the relevant category for the proposed development.

9.2.5 The soil gas assessment method is based on that proposed by Wilson & Card (1999), which was a development of a method proposed in CIRIA publication R149 (CIRIA, 1995). The method uses both gas concentrations and borehole flow rates to define a characteristic situation based on the limiting borehole gas volume flow for methane and carbon dioxide. In both these methods, the limiting borehole gas volume flow is renamed as the Gas Screening Value (GSV).

9.2.6 The Gas Screening Value (litres of gas per hour) is calculated by using the following equation.

GSV = (Concentration/100) X Flow rate

Where concentration is measured in percent (%)
and flow rate is measured in litres per hour (l/hr)

9.2.7 In accordance with CIRIA C665, worst case conditions are used in the calculation of GSVs for the site. These have been summarised below in Table 9.2.

9.2.8 The Characteristic Situation is then determined from Table 8.5 of CIRIA C665.

Table 9.2: Summary of Gas Monitoring Data and Gas Screening Value

Gas	Concentration (v/v %)	Peak Flow Rate (l/hr)	GSV (l/hr)	Characteristic Situation (after CIRIA C665)
CO_2	7.6	0.1	**0.0076**	**1**
CH_4	0.2	0.1	**0.0002**	**1**

9.2.1 Based on the calculated GSVs, the site is classified as Characteristic Situation 1 (CS1). However, CO_2 concentrations of >5% v/v were recorded in the monitoring wells, so following CIRIA C665 guidance increasing the classification to CS2 should be considered. Based on the conceptual site model and gas monitoring results CS2 is considered appropriate for the site.

9.2.2 The methodology set out in BS8485 (2015) + A1 (2019) has been used for determining the required gas protection measures. On CS2 sites the gas protection measures must provide a minimum of 3.5 points for a Type B development.

9.2.3 A basement carpark is proposed for the development, which will cover almost the entire building footprint with the exception of some of the ground floor restaurant area on the western side. Furthermore, it is assumed that the proposed basement car park will be formed in accordance with Building Regulations (2000), Approved Document F. Due to the basement car park being well ventilated this will provide a score of '4' in accordance with BS8485.

9.2.4 Where, the basement is not proposed under the building footprint the CS2 sites the gas protection measures must provide a minimum of 3.5 points for a Type C development.

9.2.5 This can be achieved in a number of ways, within BS8485 it is recommended that a range of protection measures are utilised with a minimum of two separate methods chosen from the three groupings (Structural, Ventilation and Barrier).

9.2.6 However, it is felt the following provides options for the most suitable solution for the proposed development:

Table 9.3: Recommended Gas Protection Measures

Protection Measures	BS 8485 Score
<u>Structural</u> Cast in situ monolithic reinforced ground bearing raft or reinforced cast in situ suspended floor slab with minimal penetrations	**1.5**
<u>Ventilation</u> Pressure relief pathway	**0.5**
Or Passive sub floor dispersal layer of:	
• Very good performance:	**2.5**
• Good performance:	**1.5**
<u>Barrier</u> Gas resistant membrane meeting all of the following criteria: • sufficiently impervious to the gases with a methane gas transmission rate <40.0 ml/day/m2/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; • sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab); • sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); • capable, after installation, of providing a complete barrier to the entry of the relevant gas; and • verified in accordance with CIRIA C735	**2**
MINIMUM REQUIRED TOTAL	**3.5**

9.2.7 To achieve a score of 1.5 the suspended slab should be well reinforced to control cracking and have minimal penetrations of the slab. Any necessary penetrations should be cast into the slab.

9.2.8 The media used to provide the dispersal layer can vary, but commonly are formed using either clear void; a polystyrene void former blanket; a geocomposite void former blanket; a no-fines gravel layer with gas drains or a no-fines gravel layer. In designing the ventilation layer, the ventilation effectiveness of different media needs to be taken into consideration. The effectiveness of the ventilation layer depends on a number of different factors including the transmissivity of the medium, the width of the building, the side ventilation spacing and type and the thickness of the layer.

9.2.9 During construction where personnel are required to enter excavations of greater than 1.2m the air quality (carbon dioxide, methane and oxygen as a minimum) should be regularly checked prior and during person entry. Appropriate precautions, including but not limited to, venting, PPE and gas alarms should be undertaken

9.2.10 Any permanent excavations such as manholes, inspection chambers or other void spaces formed beneath the sites ground surface are potential ground gas traps and precautions, as per above, are considered the minimum necessary prior to person entry.

9.2.11 BS 8576:2013 has been used to derived threshold levels for carbon monoxide and volatile organic compounds.

9.2.12 Given the recorded levels it is not considered that additional protection measures need to be incorporated to protect end users from the recorded carbon monoxide concentrations.

10 GEO-ENVIRONMENTAL ASSESSMENT SUMMARY AND RECOMMENDATIONS

10.1 Land Quality Impact Summary

10.1.1 Following the ground investigation, the following is noted:

- It is understood that the proposed development will comprise demolition of the existing building and the erection of a new building ranging between 1 and 6 storeys, to provide a 302-bedroom hotel with a basement and ancillary facilities including; a restaurant, car parking, coach parking, hard and soft landscaping and associated works.

- Following generic risk assessments, no elevated concentrations of contaminants were detected in soils in excess of generic assessment criteria for the protection of human health within a commercial end-use scenario.

- No asbestos containing materials or fibres were detected in the Made Ground samples analysed in the laboratory.

- A significant risk to plant growth has not been identified.

- The risk to end users associated with vapour risk inhalation from soils is considered negligible.

- The risk to controlled waters from soils is considered negligible.

- Gas monitoring has recorded concentrations of carbon dioxide in excess of 5% on several occasions and a site classification of CS2 is considered to be prudent. Where the proposed basement is not constructed under the building footprint a system comprising a gas-proof membrane with ventilated sub-floor void, and all penetrations sealed, should be installed at the site.

- Upgraded potable water supply pipe materials are unlikely to be required. The water supply pipe requirements for this site should be discussed at an early stage with the relevant utility provider.

- Following the land contamination assessment, no further assessment or risk mitigation is required, and the site can be considered suitable for the proposed use.

- As with any ground investigation, the presence of further hotspots between sampling points cannot be ruled out. Should any contamination be encountered, a suitably qualified environmental consultant should be informed immediately, so that adequate measures may be recommended.

10.1.2 The above conclusions are made subject to approval by the statutory regulatory bodies.

10.2 Review of Pollutant Linkages Following Ground Investigation

10.2.1 The site CSM has been revised and updated from that suggested in the desk study in view of the ground investigation data, including soil laboratory analysis results. Table 10.1 highlights whether pollutant linkages identified in the original CSM are still relevant following the risk assessment, or whether pollutant linkages, not previously identified, exist.

Table 10.1: Plausible Pollutants Linkages Summary (Pre-Remediation)

<table>
<tr><th>Potential Source
(from desk study)</th><th>Pathway</th><th>Receptor</th><th>Relevant Pollutant Linkage?</th><th>Comment</th></tr>
<tr><td rowspan="3">• Potential for Made Ground associated with previous development operations – on site (S1)
• Potential contamination associated with former heating oil tanks in the SW – on site (S2)
• Potential risk of ground gas associated with infilled ground – on and off site (S3)
- Infilled pond in SE of site
- Infilled ponds 25m E and 300m E
- Active/recent landfill 198m W
• Potential asbestos containing materials within existing buildings – on site (S4)
• Current and previous industrial use – off site (S5)
- Cuttings immediately adjacent to site
- Industrial products 19m SW
- Unspecified tank 188m E
- Waste landfilling 198m W</td><td>• Ingestion and dermal contact with contaminated soil (P1)
• Inhalation or contact with potentially contaminated dust and vapours (P2)
• Permeation of water pipes and attack on concrete foundations by aggressive soil conditions (P6)</td><td rowspan="2">• Construction workers (R1)
• Maintenance workers (R2)
• Neighbouring site users (R3)
• Future site users (R4)
• Building foundations and on site buried services (water mains, electricity and sewer) (R5)</td><td>N</td><td>The findings of this report should be included in the construction health and safety file, with adequate measures put in place for the protection of construction and maintenance workers.
Contact should be made with relevant utility providers to confirm if upgraded materials are required.
The concrete classification to protect buried concrete is discussed in Section 12.4</td></tr>
<tr><td>• Accumulation and migration of soil gases (P5)</td><td>Y</td><td>Where the proposed basement is not constructed under the building footprint gas protection measures are required in accordance with CS2 classification.</td></tr>
<tr><td>• Leaching through permeable soils, migration within the vadose zone (i.e., unsaturated soil above the water table) and/or lateral migration within surface water, as a result of cracked hardstanding or via service pipe/corridors and surface water runoff (P3)
• Horizontal and vertical migration of contaminants within groundwater (P4)</td><td>• Neighbouring site users (R3)
• Building foundations and on site buried services (water mains, electricity and sewer) (R5)
• Controlled waters (R6)
- Principal aquifer (Taplow Gravel Member)</td><td>N</td><td>A significant risk of impact to controlled waters has not been identified.
The concrete classification to protect buried concrete is discussed in Section 12.4</td></tr>
</table>

Potential Source (from desk study)	Pathway	Receptor	Relevant Pollutant Linkage?	Comment
		- 23No groundwater abstractions reported within 2km; nearest recorded as active abstraction for 'general use' 103m SE - Inland river not influenced by normal tidal action 140m E and 223m E.		

11 DERIVATION OF GEOTECHNICAL PARAMETERS

11.1 Introduction

11.1.1 A summary of ground conditions obtained from the ground investigation and the derived geotechnical parameters is provided below.

11.2 Plasticity of Cohesive Materials

11.2.1 Atterberg Limit determination was undertaken on 4 samples of Taplow Gravel Member and 6 samples of London Clay Formation, at depths ranging from 1.50m to 23.00mbgl.

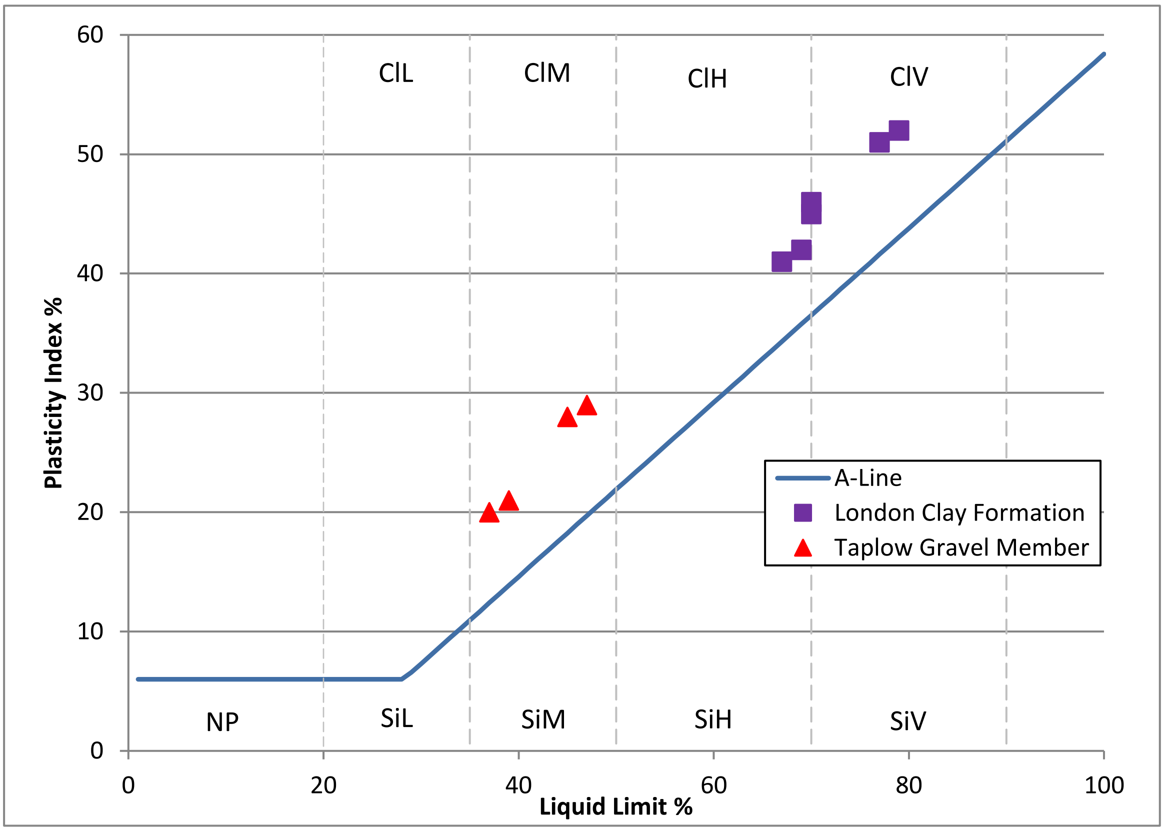
11.2.2 Plasticity Index values ranged from 20% to 29% in the Taplow Gravel Member and were indicative of intermediate plasticity, as illustrated in Figure 11.1 below.

11.2.3 Plasticity Index values ranged from 41% to 52% in the London Clay Formation and were indicative of high to very high plasticity, as illustrated in Figure 11.1 below.

11.2.4 Modified Plasticity Index values ranged from 6.1% to 19.3% in the Taplow Gravel Member, indicating soils with non-shrinkable to low volume change potential.

11.2.5 Modified Plasticity Index values ranged from 39.1% to 52.0% in the London Clay Formation, indicating soils with medium to high volume change potential.

Figure 11.1: Plasticity Chart



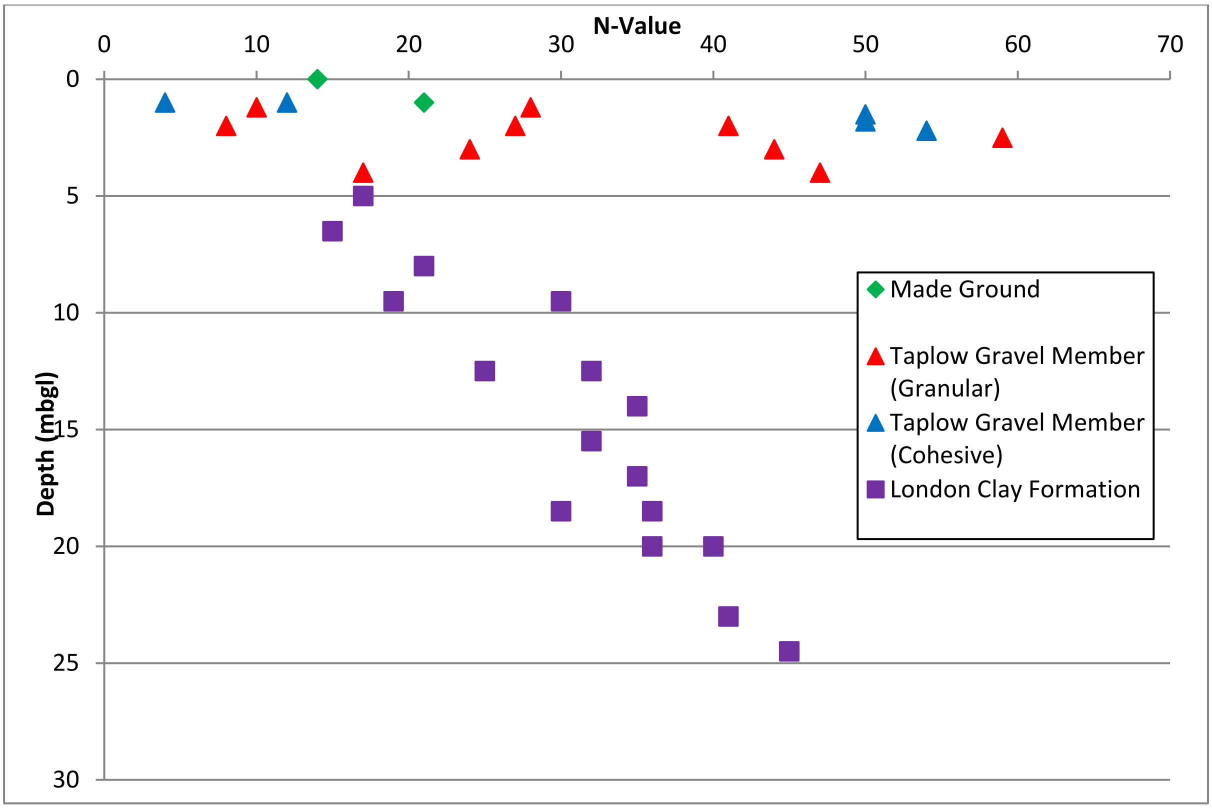
11.3 Standard Penetration Tests

11.3.1 Standard Penetration Tests were undertaken at regular intervals throughout the windowless sample boreholes and cable percussive borehole. The results of the SPTs are plotted against depth in Figure 11.2 below.

11.3.2 The strata have been grouped into “Made Ground”, “Taplow Gravel - Cohesive”, “Taplow Gravel – Granular)” and “London Clay Formation”.

11.3.3 N_{equi} results have been calculated for both strata where the SPT crossed strata boundaries or where the full 300mm of penetration could not be achieved for 50 or more blows. Where only minimal penetration was achieved, the test was recorded as a ‘refusal’ and an N_{equi} result was not calculated.

Figure 11.2: SPT 'N' Value v Depth



11.3.4 The results show a degree of scatter in the shallow Made Ground and Taplow Gravel Member strata. The London Clay Formation results show a clear trend of increasing N-value number with depth.

11.4 Undrained Shear Strength

11.4.1 As discussed above, the N values recorded in the clay vary with depth, this infers that the undrained shear strength of the clay similarly varies. Figure 11.3 below shows the undrained shear strength inferred by the correlation suggested by Stroud (1974);

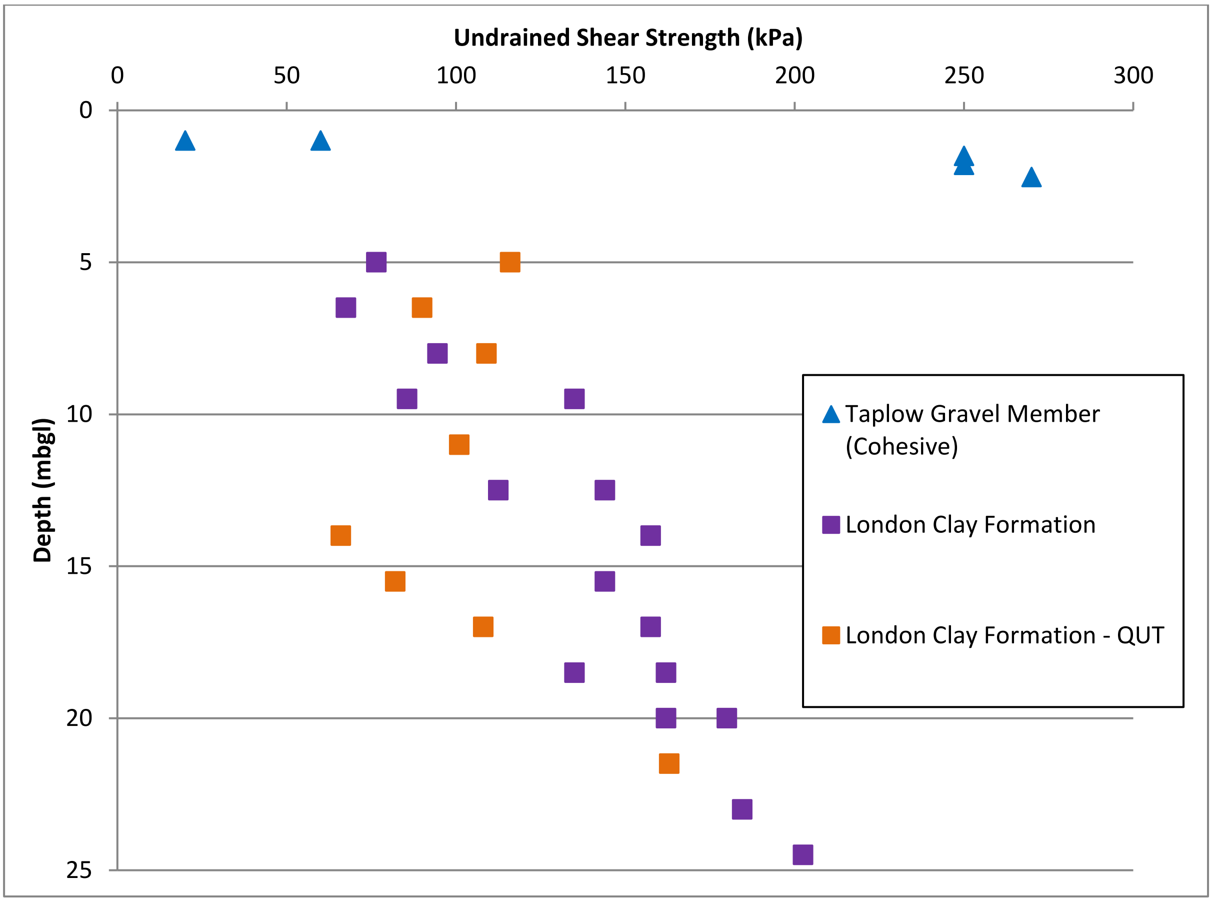
$c_u = f_1 \times N$ can be applied,

in which
c_u= mass shear strength (kN)
f_1 = constant
N= SPT Value achieved during boring operations

11.4.2 In the above equation f_1 is dependent on the plasticity of the material that the SPT is being carried out in. As the plasticity indices were shown to be greater than 25% a value for f_1 of 4.5 has been adopted after Tomlinson (2001).

11.4.3 The graph below shows the shear strength profile of the encountered cohesive materials at the site, based on the SPT to shear strength correlation described above, as well as the results of undrained triaxial tests on undisturbed samples taken from the borehole.

Figure 11.3: Undrained Shear Strength v Depth



11.4.4 Although the results are quite variable, there is a clear trend of increasing shear strength with depth within the London Clay Formation, with both measured QUT results and correlated SPT results being broadly comparable. most of the strata. The Taplow Gravel Member deposits show a greater degree of variation.

11.4.5 In addition, three of the SPT 'N' results in the Cohesive Taplow Gravel Member were very high (equal to or in excess of 50). It would appear likely that these high results were due to the presence of obstructions over the length of the test, rather than a representation of the true strength of the clay. However, this could not be proved as the boreholes could not be progressed beyond this point. Due to the boreholes being able to progress at this point, it could not be proved if the high re

11.5 Coefficient of Compressibility

11.5.1 Stroud and Butler (1974) developed a relationship between the coefficient of compressibility (m_v) and SPT 'N' value.

$m_v = 1/ f_2 \times N$ can be applied,

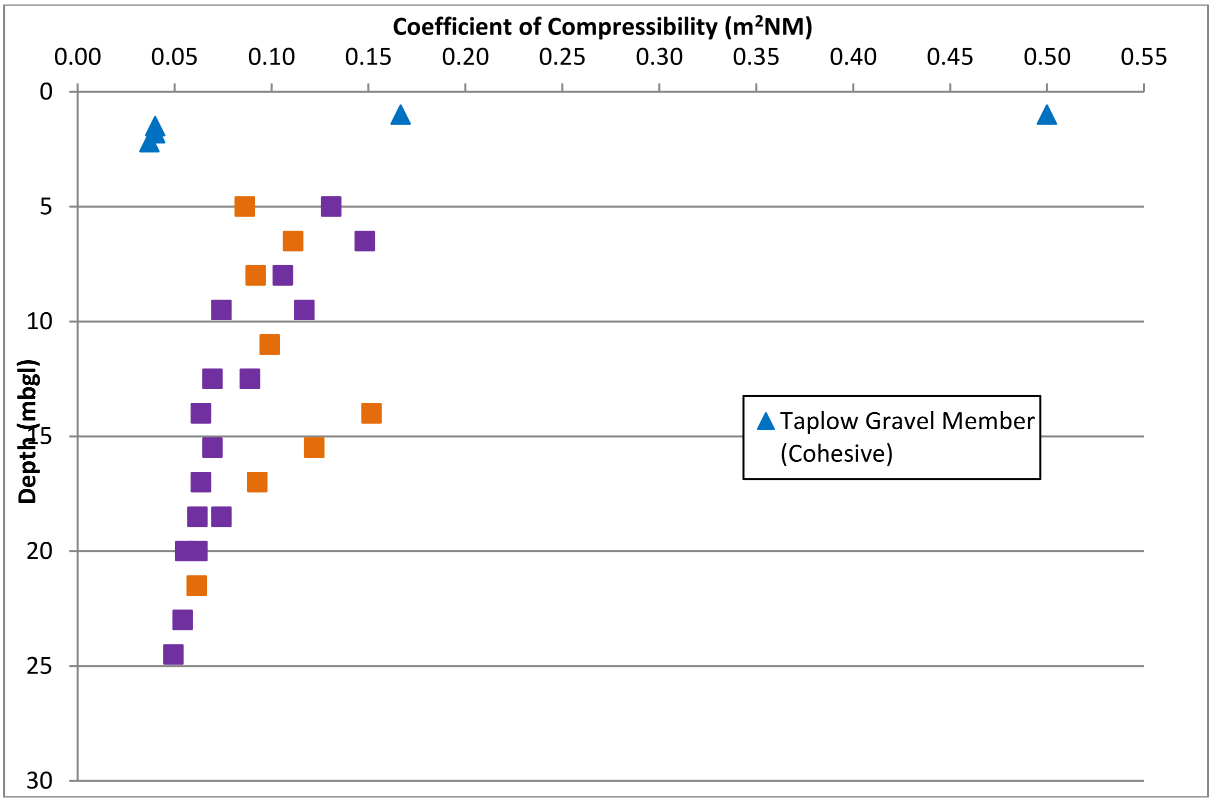
in which

m_v = coefficient of compressibility (m^2/MN)
f_2 = constant dependent on the plasticity index
N = SPT Value achieved during boring operations

11.5.2 Using the plasticity indices obtained and the graphs provided in Tomlinson (2001) a value of f_2 of 0.45 has been taken and used with the SPT 'N' values to infer coefficient of compressibility (m_v).

11.5.3 Where the undrained shear strength of the clays was measured using the quick undrained triaxial methodology, the m_v value was calculated by rearranging the equations for f_1 and f_2 and substituting in the measured undrained shear strength.

Figure 11.4: Coefficient of Volume Compressibility (m_v) v Depth



11.5.4 As would be expected, the results reduce with depth as the clay increases in strength and the over burden increases, reducing the potential for compressibility.

11.5.5 As would be expected, the results from of the London Clay Formation are generally of "very low to low compressibility" with some near surface clays of "medium compressibility".

11.5.6 This is considered to be due to weathering and softening of the upper horizon of the London Clay Formation, as well as the lack of overburden pressure at shallow depth allowing the clays to relax and so compress slightly when loaded.

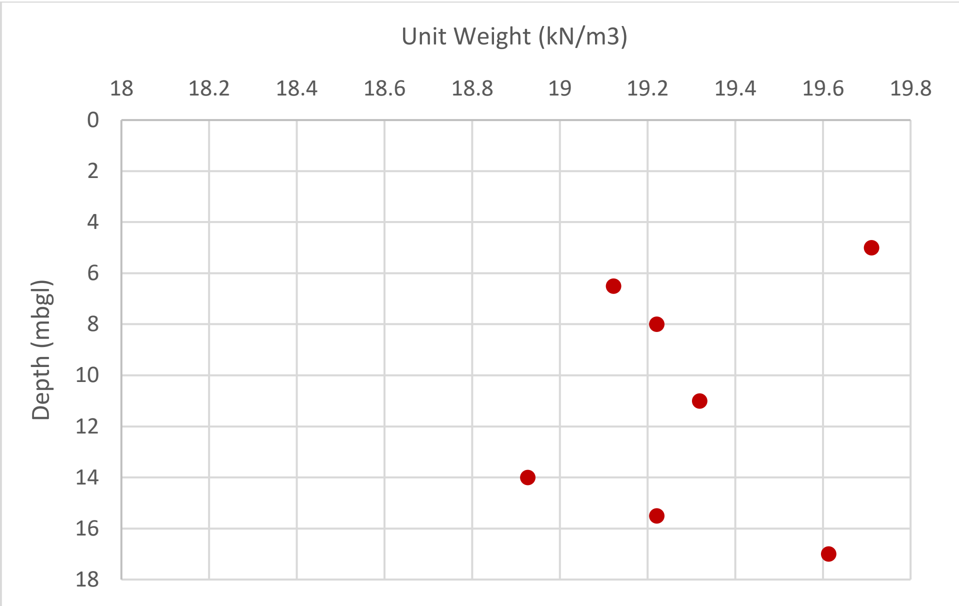
11.6 Density

11.6.1 In order to calculate the undrained shear strength using the quick undrained triaxial methodology the bulk density of the materials has to be calculated. These values are provided on the quick undrained triaxial testing certificates provided in Appendix 4. These can be converted to a Unit Weight in kN/m^3.

11.6.2 A characteristic Unit Weight of 19kN/m^3 has been adopted for the London Clay Formation, with the data plotted on Figure 11.5.

Unit Weight values for other strata have been derived based on correlations and suggested values given in BS8004:2015. These are summarised in Table 11.1 below.

Figure 11.5: Unit Weight v Depth – London Clay



11.6.3 In the absence of geotechnical laboratory test results, the correlations and suggested values for both cohesive and granular materials given in BS8004:2015 have been used. The derived bulk densities are summarised below in Table 11.1.

Table 11.1: Derived Bulk Densities

Strata	Unit Weight (kN/m^3)
Made Ground	17
Langley Silt Member	18
Taplow Gravel Member (Granular)	19
Taplow Gravel Member (Cohesive)	18
London Clay Formation	19

11.7 Effective Angle of Shearing Resistance / Angle of Friction

11.7.1 In cohesive soils, the effective angle of shearing resistance can be derived from the plasticity index of the soil, using the following equation presented in BS8004:2015.

$$\emptyset' = 42 - (12.5xLOG10(PI))$$

Where PI = Plasticity Index.

11.7.2 Values have been calculated for all available Plasticity Index results and are presented in Table 11.2.

Table 11.2 Derived Angles of Shearing Resistance

Sample	Stratum	Derived Angle of Shearing Resistance (°)
WS1 @ 1.5m	Taplow Gravel Member	23.7
WS3 @ 2.0m	Taplow Gravel Member	25.7
WS4 @ 1.7m	Taplow Gravel Member	23.9
WS5 @ 1.5m	Taplow Gravel Member	25.5
BH1 @ 5.5m	London Clay Formation	21.7
BH1 @ 10.0m	London Clay Formation	21.3
BH1 @ 17.5m	London Clay Formation	21.2
BH2 @ 7.0m	London Clay Formation	21.8
BH2 @ 20.0m	London Clay Formation	20.7
BH2 @ 23.0m	London Clay Formation	20.5

11.7.3 In granular materials, the effective angle of friction can be derived from the correlation between angle of friction and SPT N-values postulated by Peck *et al* (1967) and reproduced in Tomlinson (2001).

11.8 Stiffness Moduli

11.8.1 In cohesive materials, the undrained stiffness modulus (Young's Modulus) can be derived using the correlation with SPT N-Values, presented in CIRIA Report R143.

$$\underline{Eu = 1.2 * N}$$

11.8.2 The drained Young's Modulus for cohesive material (with the exception of London Clay) can also be derived from the SPT-N values, as follows:

$$\underline{E' = 0.9N}$$

11.8.3 In London Clay, the correlation is slightly different:

$\underline{E' = 0.7N}$

11.8.4 In granular materials, the drained Young's Modulus can be derived using the following correlation:

$E' = N$

11.9 Summary of Derived General Properties

11.9.1 Based on the analysis of the ground investigation data and past experience with similar deposits, the following derived general parameters are given in Table 11.3.

Table 11.3 Derived Geotechnical Parameters

Property*	Taplow Gravel Member (Granular)	Taplow Gravel Member (Cohesive)	London Clay Formation
Unit Weight[1)]	19.0	18.0	19.0
Drained Friction, ϕ' (◦)	29 - 42[3)]	24 – 26[2)]	21 – 22[2)]
Drained Cohesion, c' (kPa)	-	0	0
SPT 'N' Value	8 – 47	4 – 54	15 – 45
Undrained Young's Modulus, E_u (MPa)[4)]	-	4.8 – 64.8	18.0 – 54.0
Drained Young's Modulus E' (MPa)	8 – 47[5)]	3.6 – 48.6[6)]	10.5 – 31.5[6)]
Undrained Shear Strength, c_u (kPa)[7)]	-	20 – 270	67.5 – 202.5
Undrained Shear Strength, c_u (kPa)[8)]	-	-	66 – 163
Plasticity Index (%)	-	20 – 29	41 – 52
Modified Plasticity Index (%)	-	6.1 – 19.3	39.1 – 52.0
Volume Change Potential [NHBC]	-	Non-shrinkable to Low	Medium to High
Modulus of Volume Compressibility, m_v (m^2/MN)[9)]	-	0.037 – 0.500	0.049 – 0.148

[1)] Derived from Figures 1 and 2 of BS8004:2015

[2)] Calculated from: ϕ' = (42°- 12.5log10I_p) for 5% ≤ I_p ≤ 100% Where, I_p is the soil's plasticity index (BS8004:2015).

[3)] Calculated from Correlation between SPT 'N' values and ϕ' (Peck *et al* 1967)

[4)] Calculated from: E_u = 1.2 N MPa, based on the guidance given in CIRIA Report 143.

[5)] Calculated from: E' = 1.0 N MPa, based on the guidance given in CIRIA Report 143.

[6)] Calculated from E' = 0.9 N MPa, based on the guidance given in CIRIA Report 143 (COHESIVE SOILS) or 'Calculated from E' = 0.7MPa, based on the guidance given in CIRIA Report 143 (LONDON CLAY).

[7)] The undrained shear strength (c_u) of the cohesive soils was correlated to the SPT "N" values using Stroud (1974), where c_u=f_1N and f_1 is factor related to the Plasticity Index (PI) of the clay (a value of f_1 equal to 5.0 for PI ≤ 25% and a value of f_1 value equal to 4.5 for PI>25).

[8)]These values have been determined from the unconsolidated undrained triaxial compression testing in accordance with BS1377: Part 7: 1990, Clause 8.

Property*	Taplow Gravel Member (Granular)	Taplow Gravel Member (Cohesive)	London Clay Formation

[9)] Calculated from: $m_v = 1/f_2$ N m²/MN, f_2 is a coefficient proposed by Stroud and Butler (1975) and varies with Plasticity Index (PI) as presented in Figure 27 of CIRIA Report 27 or $10/c_u$.

12 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

12.1 General

12.1.1 Subsequent to intrusive investigation of the site and receipt of the laboratory test results, the following geotechnical assessments have been made.

12.2 Proposed Foundations

General

12.2.1 All topsoil is to be stripped from beneath proposed structures ahead of development.

12.2.2 The Made Ground and underlying Langley Silt Member (where present) is not considered to provide suitable bearing strata due to its low and variable bearing properties, and the unacceptable risk of total and differential settlement.

12.2.3 All foundations should be deepened beneath these deposits and any soft/loose soils encountered in order to found within underlying competent strata.

Piled Foundations

12.2.4 Given the anticipated loads of the proposed 6-storey building, it is considered that conventional foundations are not likely to be suitable due to the high structural loads. Piled foundations are therefore recommended.

12.2.5 Preliminary load capacities calculated for varying diameter of CFA piles taken into the London Clay Formation are given in Table 12.1 and 12.2. The design should be used for preliminary purposes only as the actual working load is dependent on the type of pile and method of installation.

Table 12.1: Indicative Pile Capacities – within basement (kN)

Pile toe depth (mbgl)	Pile diameter (mm)		
	450	600	800
	Indicative Allowable Pile Capacity (kN)		
12	228	328	482
14	283	405	591
16	344	490	710
18	411	593	840
20	484	684	981
22	*563*	*793*	*1132*

Table 12.2: Indicative Pile Capacities – outside basement (kN)

Pile toe depth (mbgl)	Pile diameter (mm)		
	450	600	800

	Indicative Allowable Pile Capacity (kN)		
12	260	371	539
14	315	448	648
16	376	533	767
18	443	626	897
20	516	728	1038
22	*595*	*836*	*1189*

12.2.6 To comply with BS EN 1997 and the guidance given by the Federation of Piling Specialists the ground must be proven to a minimum of 5m below the proposed toe of the piles. Consequently, values below 20mbgl have been given indicatively in grey italics.

12.2.7 The construction of a piled foundation is a specialist job and the advice of a reputable local contractor familiar with the type of ground and groundwater conditions encountered on this site should be sought prior to finalising the design.

12.2.8 These working loads have been calculated on the basis of the ground and groundwater conditions encountered in the boreholes and assume the following:

- The contribution to the working load of the upper 3.0m has been ignored due to the presence of a proposed basement. In Table 11.2m the contribution to the working load of the upper 1.5m has been ignored due to the potential presence of Made Ground / Langley Silt
- Partial factors were applied on the sum of the end bearing and skin friction working loads as defined by BS EN 1997 using Design Approach 1 Combination 2.
- No allowance has been made for additional forces acting on the pile shaft, such as negative skin friction, or loading due to desiccation or heave forces.
- Groundwater level was adopted as 3.8mbgl.

12.2.9 The preliminary working loads given are applicable to single vertically loaded piles. Where groups of piles are to be constructed, the working load of each individual pile should be reduced appropriately and a calculation made to check for the factor of safety against block failure.

12.2.10 A temporary working platform is likely to be required. In addition, some form of temporary drainage may also be required to prevent the working platform becoming waterlogged or deteriorating during use. A working platform should be designed in accordance with BRE BR470, or similar design standard.

12.3 Retaining Walls

12.3.1 It is anticipated that retaining structure(s) will be required.

12.3.2 Based on the analysis of the available site investigation data and past experience with similar deposits the parameters in Table 12.33 are considered appropriate for the potential retaining structure(s).

Table 12.3: Geotechnical Parameters for Retaining Wall Design

	Taplow Gravel Member (Granular)	Taplow Gravel Member (Cohesive)	London Clay Formation
Critical state angle of shearing resistance (ϕ')°	32	24	21
Effective Cohesion kN/m^2	0	0	0
Saturated Bulk Weight (γ_{sat}) kN/m^3	19.0	18.0	19.0

12.3.3 In addition, the specialist contractor should ensure the stability of the cut-face during the temporary works.

12.3.4 As an alternative to cantilever retaining walls, fully embedded retaining walls comprising a contiguous/secant piled basement box could be formed. The piles would need to act as retaining walls as well as carry the structural loadings. The piles should be designed to withstand the earth pressures, and still meet the required structural requirements regarding issues such as deflection, deformation and bending.

12.3.5 To provide sufficient support for the excavation, it is recommended that un-propped piles are formed to at least three times the depth of excavation.

12.3.6 If these piles can be suitably propped, then this depth may be reduced. Suitable propping could be provided by the basement floor and the ground floor if they are suitably tied into the piles and suitably reinforced. This may require specialist construction techniques.

12.4 Aggressive Ground Conditions

12.4.1 Sulphate attack on building foundations occurs where sulphate solutions react with the various products of hydration in Ordinary Portland Cement (OPC) or converted High-Alumina Cement (HAC). The reaction is expansive, and therefore disruptive, not only due to the formation of minute cracks, but also due to loss of cohesion in the matrix.

12.4.2 In accordance with BRE Special Digest 1, the characteristic values of sulphate used to determine the concrete classification are determined using the methodology summarised in Table 12.2 below.

Table 12.2: Concrete in the Ground Characteristic Value Determination

No Samples in the dataset	Method for determining the sulphate characteristic value
1 - 4	Highest value
5 - 9	Mean of the top 2No highest results
10 or greater	Mean of the top 20% highest results

12.4.3 Table 12.3 summarises the analysis of the aggressive nature of the ground for each of the strata encountered within the ground investigation.

Table 12.3: Concrete in the Ground Class

Stratum	No Samples	pH range	Characteristic WS Sulphate (mg/l)	Characteristic Total Potential Sulphate (%)1)	Design Sulphate Class	ACEC Class
Made Ground	8	7.8 – 8.3	125	N/A	DS-1	AC-1
Langley Silt Member	2	7.3 – 7.9	50	N/A	DS-1	AC-1
Taplow Gravel Member	2	7.9 – 8.6	30	N/A	DS-1	AC-1
London Clay Formation	5	7.7 – 8.8	370	4.20	DS-2	AC-1s

1) Applies to soils containing more than 0.3% of Oxidisable Sulphides, calculated in accordance with BRE SD-1

12.4.4 Analysis of the results indicates that the London Clay contains significant concentrations of Oxidisable Sulphides (e.g. Pyrite), which can be oxidised to form additional Sulphate on disturbance and exposure to air as outlined in BRE SD-1:2005. The Total Potential Sulphate must therefore also be considered in the designation of a Design Class, in cases where the London Clay is to be disturbed and exposed to air. In such cases, a Design Class of DS-5 should be adopted, with an ACEC Classification of AC-4s.

12.4.5 The concrete structures, including foundations, will need to be designed in accordance with BS EN 1992-1-1:2004+A1:2014. It is recommended that the advice of this publication be taken for the design and specification of all sub-surface concrete.

12.5 Ground Floor Slabs

12.5.1 As piled foundations are recommended, a suspended floor slab is recommended.

12.6 Excavations

12.6.1 Temporary excavations within the Made Ground and granular soils are unlikely to remain stable and some form of temporary support or battering back to a safe angle is likely to be required.

12.6.2 Temporary excavations within the cohesive soils are likely to remain relatively stable in the short term though some spalling may be anticipated.

12.6.3 Ground works should always be designed in such a manner to avoid entry into excavations by construction or maintenance personnel. However, in the event that such works cannot be avoided or designed out, they should only be undertaken in accordance with a safe system of work, following an appropriate risk assessment and in accordance with any legislative requirements, e.g. Confined Spaces Regulations.

12.7 Groundwater Control

12.7.1 Groundwater strikes were not recorded during the ground investigation.

12.7.2 During return monitoring groundwater was reported at depths of between 3.84m and 4.09mbgl within only BH2. This may be representative of a water table within the Taplow Gravel.

12.7.3 Subject to seasonal variations, any groundwater encountered during site works could be readily dealt with by conventional pumping from a sump used to collate waters.

12.7.4 Surface water or rainfall ingress is likely to freely drain through the granular materials. If this does not occur, then they too could be dealt with by traditional sump and pump.

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APPENDICES

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APPENDIX 3 – CHEMICAL LABORATORY TEST RESULTS

APPENDIX 4 – GEOTECHNICAL LABORATORY TEST RESULTS

APPENDIX 5 – SOIL GAS MONITORING RESULTS

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