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KILN PLACE GROUND INVESTIGATION REPORT

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GROUND INVESTIGATION REPORT

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1. INTRODUCTION

Ramboll UK Limited (Ramboll) have been appointed by EC Harris to provide a geotechnical assessment for the proposed re-development of Kiln Place.

This is a Ground Investigation Report, as defined by "Eurocode 7: Geotechnical design –Part 2: Ground investigation and testing". This report defines the recommended characteristic values of geotechnical parameters based on the findings of a ground investigation, in line with the principles in Part 2 of EN 14688, "Geotechnical investigation and testing – Identification and classification of soil".

Design recommendations and the assumptions and methods of calculations used in their derivation will be reported separately in a Geotechnical Design Report, following the guidance in BS EN 1997-1:2004 "Eurocode 7: Geotechnical design – Part 1: General Rules".

1.1 Scope and Objectives of Report

The scope of this report includes the determination of the geotechnical aspects of the proposed works and to establish the basis for foundation design and analysis. The report is based on information derived from interpretation of the Harrison Geotechnical Engineering 2014 ground investigation results.

The report has been written to satisfy the following objectives:

- To summarise the findings of the ground investigation.
- Interpretation of the ground conditions.
- To provide ground models and characteristic values of geotechnical parameters for design based on the available factual information.

1.2 Report Limitations

The information presented within this report is based on the data and information within the following report:

- Ground Investigation Factual Report (Ref. GL18084 GI, Harrison Geotechnical Engineering, May, 2014).

This report has been prepared for the exclusive use of Ramboll UK Ltd and EC Harris for the purpose of assisting them in evaluating the site in the context of the proposed development. This report should not be used in whole or in part by any third parties without the express permission of Ramboll in writing.

Ramboll has endeavoured to assess all information provided to them, but make no guarantees or warranties for the completeness or accuracy of information relied upon.

The geotechnical risk register given in section 6 of this report relates to details of the proposed development at the time of writing this report. Any substantial changes to the proposed design may require a reassessment of the risks identified.

The ground investigations have been undertaken utilising a number of exploratory holes located at positions determined from the site history, current site layout, proposed location of development works, the likely ground conditions and the current standards at the time the work was undertaken. Since the ground conditions are only known in detail at each exploratory hole location, the ground conditions between holes have been interpolated. Therefore, the actual nature of the ground may differ from our interpretation. In addition, groundwater levels will vary seasonally and with changes in weather conditions.

2. EXISTING INFORMATION

2.1 Location

The site is located in Gospel Oak, Camden, London. The site is centred at National Grid reference TQ 28331 85485 (post code NW5 4AJ) and covers an area of approximately 15,300 square metres (1.53 ha).

The site is currently occupied by residential dwellings, car parking and green, open communal areas which include a play area. Surrounding land comprises mixed uses, including residential dwellings, industrial land and railway. The site is accessed via Lamble Street.

The site is bound to the south by railway, to the west by Grafton Road, to the north by Lamble Street and to the east by Meru Close.

2.2 Description of Project

It is proposed to construct two and three storey residential dwellings with both stand-alone blocks and by the infilling of space created between existing buildings. Private gardens are proposed for one row of dwellings in the north of the site. Landscaping is likely to remain unchanged from what is currently on site. Plans of the proposed development options are shown in Appendix A.

2.3 Topography

Generally the topography across the site gently increases in level from the north (40.5 metres above ordnance datum (mAOD)) to the south (43.83 mAOD), peaking in the centre of the site (44.37 mAOD).

2.4 Geology

The British Geological Survey (BGS) 1:50,000 series sheet 256 (Solid & Drift edition) for North London indicates that the site is underlain by Eocene London Clay Formation (LCF). Approximately 100 metres north and west of the site the geological map indicates the presence of Eocene Claygate Beds overlying the LCF. Head deposits are shown 150 metres south and 200 metres northeast of the site, and are associated with steep slopes.

Five historic exploratory hole / water well records available from the BGS website confirm the anticipated geology identified from the BGS map. The historic exploratory hole logs also indicate the presence of possible Head deposits overlying the LCF. Borehole logs do not extend beneath the base of the London Clay. The boreholes lie approximately 60 metres west of the site boundary.

The exploratory hole logs do not reach the base of the LCF. Weathered London Clay is recorded from 3.3 metres below ground level (mbgl) and the unweathered London Clay from 10.0 mbgl. The LCF is described in the historical logs as firm brown clay (weathered) to stiff dark grey fissured clay (unweathered). The BGS describes the basal LCF as a hard dark shelly loam at the transitional zone with the Lambeth Group.

Made Ground was also noted, described as soil and stones and brown clay.

2.5 Hydrology and Hydrogeology

No surface water features are currently present within the site and there are no known culverts.

The nearest main surface water feature is the Thames River located 5km to the southeast. Regents Canal is located approximately 1.5km to southeast and there are various ponds and minor watercourse within Hampstead Heath to the north and northwest.

The site is underlain by the London Clay Formation which is of low permeability.

2.6 Existing Investigations and Reports

One historic ground investigation had been undertaken in the vicinity of Kiln Place as follows:

- Site Investigation Report, Kiln Bank, Kiln Place, Gospel Oak, London NW5, Ground Engineering report ref. C12381 (May 2011)

2.7 UXO Assessment

A Detailed Unexploded Ordnance (UXO) Threat Assessment has been carried out by 1st Line Defence UXO Solutions (Report Reference – 1594RV00). The site has been assessed as being medium risk with areas of low risk for UXO's. The report is attached in Appendix C.

3. GROUND INVESTIGATION

3.1 General

The 2014 ground investigation was designed by Ramboll and comprised two cable percussive boreholes constructed to a maximum depth of 15.0 metres below ground level (mbgl) and seven windowless sampler holes drilled to a maximum of 8.0 mbgl. The fieldwork was carried out by Harrison Group Environmental Ltd (HGEL) between 3rd March 2014 and 5th March 2014. The results of the ground investigation are presented in HGEL factual report Ref: GL18084 GI.

WS1 was moved from its original proposed location due to restricted access. The exploratory hole was then terminated at 2.2 mbgl due to an unknown obstruction.

WS3 was terminated at 1.0 mbgl due to a concrete obstruction.

A site plan showing the exploratory hole locations is included within the HGEL Factual Report in Appendix B.

3.2 Sampling and In-situ Testing

Standard Penetration Tests (SPTs) were carried out within the exploratory boreholes and windowless sampler holes in both cohesive and granular deposits. Samples for geotechnical and contamination laboratory testing were obtained from the exploratory hole locations and typically comprised the following:

- In the granular materials, bulk disturbed samples were taken.
- In the cohesive materials, undisturbed U100 samples were taken and sealed on site to preserve their natural moisture contents; in addition small and bulk disturbed samples were taken.
- In both materials, contamination samples were taken.

3.3 Laboratory Testing

Geotechnical and contamination laboratory tests were scheduled by Ramboll. The geotechnical tests were carried out at the HGEL laboratory. The contamination tests were carried out at the i2 Analytical Ltd laboratory.

The following geotechnical tests were carried out on the disturbed samples to aid classification and define the soil nature:

- Moisture content
- Atterberg limits (in cohesive soils)
- Grading analyses by sieve in granular materials
- Sulphate content and pH values

On the "undisturbed" samples the following tests were also carried out:

- Unconsolidated Undrained triaxial testing
- One-dimensional consolidation tests (oedometer tests).

A summary of the geotechnical laboratory tests and number carried out is given in Table 3.1.

Test	No. of Tests Carried Out
Moisture content	29
Atterberg Limits	29
PSD	3
Unconsolidated undrained single stage triaxial tests	6
Oedometer tests	3
BRE SD1 pH and Sulphate chemical tests	18

Table 3.1 Geotechnical laboratory tests and number carried out

The unconsolidated undrained triaxial (single stage) tests were carried out to determine the undrained strength and Youngs Modulus of the London Clay Formation.

4. GROUND CONDITIONS

4.1 Geology

A summary of the site wide ground conditions is presented in Table 4.1. Detailed descriptions of each geological stratum and material thickness are presented in this section. For full descriptions this report should be read in conjunction with the exploratory hole logs presented in the HGEL factual report presented in Appendix B.

Stratum		General Description
Made Ground	Cohesive	Very soft to soft yellowish brown to dark grey sandy gravelly CLAY. Granular inclusions of brick, concrete, clinker, slag, glass, chalk, ash and flint. Light brown clayey gravelly SILT. Granular inclusions of brick, chalk and coal.
	Granular	Loose, grey to brown and red clayey gravelly ashy SAND. Granular inclusions of brick, concrete, clinker, slag, glass, chalk, ash and flint.
London Clay Formation	Weathered	Firm orangish brown to brownish grey fissured CLAY. Occasional pockets of grey and brown silt. Occasional selenite crystals. Rare calcareous nodules.
	Unweathered	Firm to stiff grey CLAY

Table 4.1 Simplified geological sequence of the site

4.1.1 Made Ground

Made Ground is present across the whole site and has been encountered in all of the exploratory holes. The material varies in thickness between 3.8 metres and 7.5 metres and is variable in composition; it comprises both cohesive and granular material and is described as soft sandy gravelly clay or loose clayey, gravelly sand with flint, brick, concrete, slag, clinker, chalk, and glass with cobbles. Three exploratory holes (WS2, WS6 and WS7) encountered light brown clayey, gravelly silt with brick, chalk and coal.

In-situ SPTs carried out within the cohesive silty Made Ground recorded uncorrected 'N' values ranging between 0 (i.e. SPT equipment penetrating the ground under self-weight) and 17 blows for 300 mm, with an average 'N' value of 4. The SPT 'N' values indicate and confirm the observed strength of the silty Made Ground as soft.

In-situ SPTs carried out within the granular Made Ground recorded uncorrected 'N' values ranging between 2 and 16 blows for 300 mm, with an average 'N' value of 6. The SPT 'N' values indicate and confirm the observed density of the granular Made Ground as loose.

Two undrained single stage triaxial tests were undertaken within the cohesive Made Ground giving undrained shear strengths (c_u) of 24 kPa and 26 kPa.

One dimensional oedometer tests were undertaken on two samples of the cohesive Made Ground. Results of testing gave a modulus of compressibility (m_v) of 0.169 m^2/MN to 0.998 m^2/MN during the loading phase. During the unloading phase the modulus of compressibility (m_v) was recorded as 0.047 m^2/MN to 0.133 m^2/MN.

4.1.2 London Clay Formation

The London Clay Formation (LCF) was encountered beneath the Made Ground within the majority of boreholes at depths of between 3.8 mbgl and 7.5 mbgl, but was not encountered in windowless samples WS1, WS3 and WS7 as these were of insufficient depth. The stratum can be separated into weathered LCF and unweathered LCF. Weathered LCF is described as firm, orangish brown to brownish grey fissured clay. Fissures are closely spaced, randomly orientated, rough, matt and in-filled with silt. Occasional selenite crystals and occasional pockets of grey and brown silt were observed. Rare calcareous nodules were observed within BH2. Weathered LCF was encountered at depths of between 3.8 mbgl and 7.0 mbgl. The SPT N values increase with depth.

Unweathered LCF is described as firm to stiff grey clay and was encountered at depths of between 12.0 mbgl and 13.0 mbgl.

SPTs carried out within the weathered LCF recorded uncorrected 'N' values from 7 to 25 blows with an average 'N' value of 13. These results indicate and confirm the observed strength of the clay as firm.

Two SPTs were carried out within the unweathered LCF and recorded uncorrected 'N' values of 32 blows. These results indicate and confirm the observed strength of the clay as stiff.

Four undrained single stage triaxial tests were undertaken on samples from BH1 and BH2 within the London Clay Formation. Within the weathered LCF undrained shear strengths (c_u) of 19 kPa and 137 kPa were recorded from the two samples. Within the unweathered LCF undrained shear strengths (c_u) of 69 kPa and 85 kPa were recorded from the two samples.

A single one dimensional oedometer test was undertaken on a sample from the weathered LCF (BH1 at 10.0 mbgl). Results of testing gave a modulus of compressibility (m_v) of 0.059 m^2/MN to 0.163 m^2/MN during the loading phase. During the unloading phase, the modulus of compressibility (m_v) was recorded as 0.034 m^2/MN.

4.2 Groundwater

Groundwater levels of 1.5 mbgl (WS1) to 5.6 mbgl (BH2) were encountered within six exploratory holes during the ground investigation.

Observations from post site work groundwater monitoring are presented in the HGEL Geotechnical Report ref. GL18084 GI in Appendix A and are summarised in Table 4.2.

Exploratory Hole	Date	Groundwater Level (mbgl)
BH1	28/03/2014	3.03
	01/04/2014	3.03
	08/04/2014	3.02
	15/04/2014	3.02
	09/05/2014	3.81
BH2	28/03/2014	1.52
	01/04/2014	1.54
	08/04/2014	1.59
	15/04/2014	1.59
	09/05/2014	1.52
WS2	28/03/2014	5.32
	01/04/2014	5.37
	08/04/2014	5.08
	15/04/2014	5.08
	09/05/2014	4.15
WS5	28/03/2014	3.52
	01/04/2014	3.51
	08/04/2014	3.51
	15/04/2014	3.51
	09/05/2014	3.47
WS7	28/03/2014	2.23
	01/04/2014	2.22
	08/04/2014	2.24
	15/04/2014	2.24
	09/05/2014	2.27

Table 4.2 Post ground investigation groundwater monitoring

4.3 Chemical Analysis

The range of chemical analysis results for pH and water soluble sulphate content (2:1 water extract as SO_4) of the soils are presented in Table 4.3.

Stratum		pH	Water Soluble Sulphate Content (2:1 Water Extract as SO_4) mg/l	No. of Tests
Made ground	Granular	8.0 – 8.3	150 – 1300	3
	Cohesive	7.5 - 10.5	160 - 1300	9
London Clay Formation	Weathered	7.6 - 8.2	400 - 1700	4
	Unweathered	7.9 – 8.1	660 – 720	2

Table 4.3 pH and sulphate results

5. GROUND CONDITIONS AND MATERIAL PROPERTIES

This section describes the characteristic values of the geotechnical soil parameters that have been established from the exploratory holes and laboratory test results from the ground investigation. Table 5.3. represents the suggested characteristic values of the geotechnical soil parameters for use in design.

5.1 Soil Parameters

Characteristic values are defined as a cautious estimate of the value affecting the occurrence of a limit state based on clause 2.4.5.2 from BS EN 1997-1: 2004 (Eurocode 7). Characteristic values will be used with appropriate partial factors or to achieve appropriate factors of safety, as and where required.

The derivation of characteristic values of geotechnical parameters is described for the soils that are expected to be encountered in the construction of the works. Where direct measurement of parameters has not been carried out, established correlations with measured properties have been used to derive values for design. The following sets out how the characteristic values have been determined for this report.

5.1.1 Strength

Cohesive Soils – Undrained Strength Parameters

For cohesive soils the undrained strength for design will be assessed by the following methods.

- Laboratory quick undrained triaxial test,
- Derived from SPT 'N' values using Stroud and Butler (1975), with factor f_1 derived from Figure 31 CIRIA 143 (1995) using the Plasticity Index (PI),
- Material descriptions provided in the HGEL exploratory hole records which are based on British Standard (BS) 5930: 1999 (British Standards Institute (BSI), 1999) and EC7 (1997)

Sampling disturbance on soft clays will adversely affect strength measurement, therefore extreme values, particularly low values, will be scrutinised to ensure that they are representative.

Using the results of the UU triaxial tests and the following expression by Stroud (1974), the undrained shear strength has been derived for the weathered and unweathered London Clay Formation:

$$c_u = f_1 \times \text{'N'}$$

Where ‘N’ is the SPT value in which the characteristic SPT ‘N’ values are:

- 4 for cohesive Made Ground
- 13 for weathered LCF
- 32 for unweathered LCF

These values were obtained from analysis of all SPT data from the ground investigation. An f_1 value of 4.2 was adopted based on a characteristic Plasticity Index of 48% for the LCF. An f_1 value of 4.8 was adopted based on adopted characteristic Plasticity Index of 25% for the cohesive Made Ground.

The following characteristic undrained shear strength values have been adopted for total stress analysis and design:

- 17 kPa for cohesive Made Ground
- 4+(7.75z) where z is depth below ground level for weathered LCF
- 154 kPa for unweathered LCF

Cohesive Soils - Effective Stress Strength Parameters

Effective stress ('drained') strength parameters are determined from laboratory effective stress tests using triaxial tests, as available. However, where absent for the cohesive deposits the relationship established by Bowles between Plasticity Index (PI) and Φ´ have been used. A conservative value of Φ´ has been derived based on a cautious upper bound value of PI:

- Φ´ = 26° for cohesive Made Ground
- Φ´ = 22° for weathered LCF
- Φ´ = 22° for unweathered LCF

Granular Soils – Effective Stress Strength Parameter

Effective strength parameters have been assessed based on indirect methods. For soils described as sands and/or gravels, and assessed as well-graded, SPT 'N' values have been used to interpret the effective angle of shearing resistance (Φ´) using the relationship of Peck, Hanson and Thorburn, (1953).

The results obtained above have been checked as appropriate against the method described in BS8002 (1994) where the following relationship for peak effective angle of shearing resistance is described as:

Φ´ = (30 + A + B + C)°.

Where,

A: Angularity of particles (rounded A = 0, sub-angular A = 2, angular A = 4),

B: Grading of soil (uniform B = 0, moderate grading B = 2, well-graded B = 4),

C: Results of Standard Penetration Tests (N´ < 10 then C = 0, N´ = 20 then C = 2, N´ = 40 then C = 6, N´ = 60 then C = 9).

The soil descriptions from the ground investigation factual report and the results of the laboratory testing were used to derive the effective angle of internal friction:

- Φ´ = 32° for granular made ground

For sands and gravels, a value of c´ = 0 kN/m^2 is recommended for design.

5.1.2 Stiffness

Cohesive Soils

Where determination of settlement of foundations on cohesive soils is required, then stiffness has been assessed from the following:

- One Dimensional Consolidation Tests (Oedometer Test)
- SPT 'N' values using the relationships described in CIRIA Report 143 (CIRIA, 1995)
- $E_v' = 200 \times c_u$ (kN/m^2)
- $E_u = 400 \times c_u$ (kN/m^2)

Based upon the previously assessed total stress parameters for the LCF.

Two Oedometer Tests were carried out on samples of cohesive Made Ground. For the purpose of design, the stress range has been based on typical strip foundation bearing pressures of a typical one to two storey dwelling and therefore the stress increment of 200 kN/m^2 and 225 kN/m^2 has been used to obtain the coefficient of volume compressibility (m_v). At this stress increment m_v values of 0.444 m^2/MN (225 kN/m^2) and 0.418 m^2/MN (200 kN/m^2) were measured. The values were derived from load-unload loop test results.

A single Oedometer test was carried out on a sample of weathered LCF. For the purpose of design, the stress range has been based on pile foundation bearing pressure developed from the following equation:

$$q_{b;k} = 9.c_u$$

Where c_u =60kPa for the weathered LCF and hence a bearing capacity of 540 kPa. The oedometer test increments for the sample were 200 kPa, 400 kPa, 800 kPa and 1600 kPa. At 400 kPa and 800 kPa the coefficients of volume compressibility (m_v) measured were 0.110 m^2/MN and 0.091 m^2/MN respectively. The values were derived from load-unload loop test results.

These m_v values were plotted together with m_v values derived from the following expression by Stroud (1974):

$$m_v = 1 / (f_2 \times N)$$

Where; N = 4 and f_2 = 0.49 for the cohesive Made Ground

N = 13 and f_2 = 0.44 for the weathered LCF

N = 32 and f_2 = 0.44 for the unweathered LCF

The resulting characteristic m_v value is:

- 0.45 m^2/MN for the cohesive Made Ground
- 0.15 m^2/MN for the weathered LCF
- 0.10 m^2/MN for the unweathered LCF

The coefficient of consolidation (c_v), defined as the rate of volume change, can be used with the coefficient of volume compressibility to assess the proportion of volume change over a period of time.

For an applied stress comparable to 200 kPa to 225 kPa in addition to the effective overburden pressure of the in-situ soil at the depth of sampling, the corresponding c_v values for cohesive Made Ground are 0.418 m^2/year (200 kPa) and 4.627 m^2/year (225 kPa) with an average of 2.52 m^2/year. The c_v values obtained from the Oedometer test show variability in results, possibly due to the highly variable composition of the Made Ground. For design purposes, a c_v value of 4.5 m^2/year is considered appropriate.

For an applied stress comparable to 400 kPa and 800 kPa in addition to the effective overburden pressure of the in-situ soil at the depth of sampling, the corresponding c_v values for cohesive weathered LCF are 5.386 m^2/year (400 kPa) and 3.133m^2/year (800kPa) with an average of 4.25 m^2/year. For design purposes, a c_v value of 4.25 m^2/year is considered appropriate.

The vertical effective Young's Modulus (E_v') and undrained Young's Modulus (E_u) for the cohesive materials are:

- E_v' = 3 MN/m^2 and Eu = 6 MN/m^2 cohesive Made Ground
- E_v' = 1625+(1575z) and Eu = 3250+(3150z) for weathered LCF where z is depth below ground level.
- E_v' = 30.8 MN/m^2 and E_u = 61.6 MN/m^2 unweathered LCF

Granular Soils

For the non-cohesive deposits the drained stiffness is based upon the following relationship, where the characteristic SPT "N'" value is used:

- E_v' = 1000 x SPT 'N' (kN/m²) - for settlement analysis

From the SPT results using an average 'N' value of 6, the drained stiffness of the granular Made Ground is:

- E_v' = 6000 kN/m² - for settlement analysis

5.2 Groundwater

During the ground investigation groundwater was encountered in both exploratory boreholes and in three of the seven windowless sample holes.

Groundwater monitoring undertaken after the ground investigation measured groundwater levels from 1.52 mbgl (BH2) to 5.37 mbgl (WS2). There was one significant rainfall event (>10mm) of 14.5mm during the monitoring period.

A worst case design groundwater level of between 1.0 mbgl and 2.0mbgl should be taken for this site, with the changes in depth dependant on seasonal variations.

Groundwater levels for ULS design are those that represent the most unfavourable conditions which could realistically occur during the design lifetime of the structure. For SLS, where there are less severe consequences, design values shall be the most unfavourable values which could occur in normal circumstances. This follows clause 2.4.6.1 (6) Eurocode 7 (CEN, 2004).

5.3 Interpretation of Geological Ground Models

An assessment of the ground profile encountered is provided in Section 5.4. The ground profile is based on the information obtained from the HGEL ground investigation undertaken during 2014.

A design ground model has been produced for the site and is detailed in the relevant sections. The ground model represents a characteristic assessment of the ground conditions broadly in accordance with the recommendations of BS EN1997-1: 2004.

The characteristic values of the geotechnical parameters based on laboratory and in-situ testing are given in Section 5.5.

5.4 Detailed Design Ground Model

Based on the available information for the site, the following ground profile has been derived for design purposes.

Stratum		**Depth to Base of Stratum**	
		mbgl	**mAOD**
Made Ground	Granular	3.0	38.0
	Cohesive	7.0	34.5
London Clay Formation	Weathered	13.0	29.5
	Unweathered	15.0 (base unproven)	26.5 (base unproven)

Table 5.1 Ground profile for design purposes

The existing ground levels at site varied from 40.83 mAOD (WS1) to 45.24 mAOD (WS4). The depth to base in mAOD has assumed the deepest occurrence of the soil horizon.

5.5 Geotechnical Parameters

Based on the stratigraphy encountered, the site wide in-situ testing and laboratory tests results are summarised in Table 5.2. The characteristic values of the geotechnical parameters derived from the testing are presented in Table 5.3 and pH and water soluble sulphate content are presented in Table 5.4.

Strength vs depth plots are presented in Appendix D.

Stratum		NMC (%)	NHBC Modified PI (%)	SPT 'N' Values		Factor (Stroud)	
				Range	Average	f_1	f_2
Made Ground	Granular	15 (10-15)	6 (6-7)	2-16	6	N/A	N/A
	Cohesive	35 (16-66)	20 (4-45)	0-16	4	4.8	0.49
LCF	Weathered	32 (25-40)	48 (46-52)	7-25	13	4.2	0.44
	Unweathered	30 (29-34)	49	32	32	4.2	0.44

Table 5.2 Geological strata and summary of strata properties

Stratum		Unit Weight kN/m^3	Φ´ °	Undrained Shear Strength (kPa)	E_v' MN/m^2	E_u MN/m^2	Modulus of Compressibility (m_v)
Made Ground	Granular	18	32	N/A	6	N/A	N/A
	Cohesive	19	26	17	3	6	0.45
LCF	Weathered	19	22	4+(7.75z)	1625+(1575z)	3250+(3150z)	0.15
	Unweathered	19	22	154	31	62	0.10

Table 5.3 Geotechnical characteristic parameters

Stratum		pH	Water Soluble Sulphate Content (2:1 Water Extract as SO_4) mg/l
Made Ground	Granular	8.0	1200
	Cohesive	7.5	1250
LCF	Weathered	7.6	1500
	Unweathered	7.9	690

Table 5.4 Design pH and water soluble sulphate content

6. GEOTECHNICAL RISK REGISTER

	Geotechnical Hazard Description	Current Risk Rating (Prior to Risk Control Measures being applied)	Description of Current Risk	Risk Control Measures
1	Unexpected/ unfavourable Ground Conditions	Low to medium	• Areas of Made Ground have been identified during the ground investigation. There is a risk of further and more extensive made and poor ground being present. • The extent of the soil shown on drawings was assessed based on the results of ground investigations comprising boreholes at specific locations. There remains a risk that the extent of soil may vary, or other types of ground may be present that have not been identified from the ground investigation.	• Review exploratory hole information and determine the extent of the Made Ground, and design to allow for a maximum depth of the Made Ground in design. • Use experienced site geotechnical personnel to provide advanced warning of potential problems. • Allow for additional engineering fill replacement. • Foundation design to be suitable to be founded on potential founding materials as identified through the site investigation.
2	Unexploded Ordnance (UXO)	Low to Medium	• The 1st Line Defence Threat Assessment for the site indicates that the area has been assessed as low to medium risk from unexploded ordnance.	• Site specific ordnance awareness briefings to all personnel conducting intrusive works • Shallow intrusive works in areas of medium risk to have a UXO specialist present on site during shallow intrusive works • Intrusive magnetometer survey to all boreholes and pile locations to a maximum bomb depth penetration • Contractor to excavate with care and be aware as always of the potential threat of unexploded ordnance.

	Geotechnical Hazard Description	Current Risk Rating (Prior to Risk Control Measures being applied)	Description of Current Risk	Risk Control Measures
3	Unexpectedly high groundwater levels adversely affecting slopes/ foundation/ formation levels	Medium	• The groundwater level observed at site varied between boreholes. • The actual groundwater level encountered during excavation may be higher than that observed during the geotechnical investigation. • Removal of trees may locally increase the ground water level.	• Use experienced site geotechnical personnel to provide advanced warning of potential problems, particularly seepage/springs on slopes. • Dewatering or water exclusion techniques may be required during the construction works and contingency solutions should be developed to accommodate the risk. • Consider timing construction to occur in the seasonally drier months, or to avoid seasonally wetter months.
4	Chemical attack on buried structural elements due to acid and/or sulphate in soil or groundwater	Low	• Risk of aggressive ground conditions resulting in costly protective measures to buried structures.	• Design to include assessment of aggressivity of soil/groundwater.
5	Encountering uncharted buried services	Low	• Risk of delay where uncharted services are encountered.	• Carry out surveys prior to excavations. • Monitor all excavations during construction.
6	Obstructions to construction due to existing foundations	Medium	• Risk of delay where foundations are encountered.	• Specification of demolition works to include the removal of existing foundations especially in areas of former brickworks. • Review archive information and drawings for the existing buildings and identify possible locations of foundations. • Contractor to develop and implement necessary measures to minimise the impact of relic foundations on construction.
7	Contaminated Soils	Low to Medium	• Carry out groundwater monitoring and sampling to establish base-line data prior to the start of works.	• Contractor to review Geotechnical Investigation Report and carry out additional testing to assess risks further if considered necessary.

	Geotechnical Hazard Description	Current Risk Rating (Prior to Risk Control Measures being applied)	Description of Current Risk	Risk Control Measures
8	Ground heave due to excavation or tree removal	Low to Medium	• Risk of ground heave within excavations. • Risk of hydraulic heave/ piping. • Risk of ground heave after the removal of trees.	• Consider use of appropriate pumping/dewatering techniques during temporary works. • Limit exposure time of excavations to avoid potential failure. • Design to allow for heave precautions (e.g. suspended slab, in-situ concrete slab with a compressible material or a void former) based on arboriculture information and ground investigation findings where applicable.
9	Long term settlement of compressible soil and made ground	Low	• Risk of long term settlement of shallow foundations over compressible soil and made ground.	• Construction of the substructures to include allowance for any soft/compressible soils which are sensitive to excessive settlement to be removed and replaced with compacted granular engineering fill. • Use experienced site geotechnical personnel to provide advanced warning of potential problems.
10	Long term differential settlement	Medium	• Variation in the depth of Made Ground may lead to differential settlement for shallow founded structures.	• Assessment to take into account potential levels of settlement on the different stratum.

Table 6.1 Geotechnical Risk Register

7. REFERENCES

British Geological Survey 1:50,000 Solid and Drift Edition Sheet 256 – North London.

British Standards Institute (1999), Code of practice for site investigations. BS 5930:1999.

BSEN ISO 14688-2:2004 – Geotechnical investigation and testing – Identification and classification of a soil - Part 2: Principles for a classification

BS EN 1997-1 (2004), Eurocode 7 Geotechnical design – Part 1: General rules

BS EN 1997 – 2:2007 – Geotechnical Design – Part 2: Ground investigation and testing

CIRIA (1995), The Standard Penetration Test (SPT): Methods and Use. CIRIA Report 143. C.R.I. Clayton.

Harrison Group Environmental Ltd – Ground Investigation Report, Project No. GL18084 GI

R.B. Peck, W.E. Hanson and T.H. Thornburn (1953). Foundation Engineering, John Wiley, New York.

Stroud, M.A. and Butler, F.G. (1989). The Standard Penetration Test – its Application and Interpretation. Penetration Testing in the UK, Thomas Telford, 1989, pp. 29-49.

APPENDIX A

PLAN OF PROPOSED DEVELOPMENT

A 31 OCT 2013 STAGE C ISSUE

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DO NOT SCALE OFF THIS DRAWING
ALL DIMENSIONS MUST BE CHECKED ON SITE
INFORM THE ARCHITECT OF ANY DISCREPANCIES PRIOR TO CONSTRUCTION
PLOT SIZE: A1

JOB: Kiln Place, Gospel Oak
CLIENT: London Borough of Camden / E C Harris
SCALE: 1:200 @ A1
1:500 @ A3
DRAWN: FS

STAGE D

TITLE: PROPOSED SITE inc. ROOF PLAN (FIGURE GROUND)
DRAWING NO: 116_P_01P
REV: B

APPENDIX B

HARRISON GROUP ENVIRONMENTAL LTD FACTUAL REPORT

Document: Ground Investigation Factual Report

Project: Kiln Place, Camden

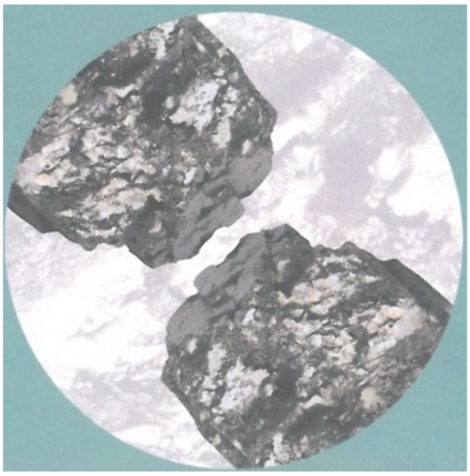
Project No.: GL18084 GI

Date: June 2014

Prepared for: EC Harris LLP

Engineer: Ramboll Uk Limited

harrisongeotechnical
ENGINEERING



HARRISON GROUP ENVIRONMENTAL LIMITED

Document: **Ground Investigation Factual Report**

Project: **Kiln Place, Camden**

Reference No.: GL18084

Date: **June 2014**

Prepared For: **EC Harris LLP**

Engineer: **Ramboll UK Limited**

REPORT STATUS:

		Init Sign Comments Date	Init Sign Comments Date	Init Sign Comments Date	Init Sign Comments Date
		Init Sign Comments Date	Init Sign Comments Date	Init Sign Comments Date	Init Sign Comments Date
1	FINAL	Init GP Sign PP Comments Date 10/06/14	Init JK Sign Comments Date 10/06/14	Init GP Sign PP Comments Date 10/06/14	Init JK Sign Comments Date 10/06/14
0	DRAFT	Init GP Sign Comments Date 22/05/14	Init JK Sign Comments Date 22/05/14	Init GP Sign Comments Date 22/05/14	Init JK Sign Comments Date 22/05/14
Revision	**Comments**	**Prepared By**	**Approved By**	**Issued By**	**Audited By**

This sheet to be kept on PSI / Report file.
Auditors to insert their comments on the table, to annotate the report itself or provide comments on a separate sheet. (Please state which)
For final reports a hard copy of the signed off form will be kept on the appropriate QA file.

CONTENTS

FOREWORD

General Conditions Relating To Site Investigation

This investigation has been devised to generally comply with the relevant principles and requirements of BS10175: 2001 "Investigation of potentially contaminated sites - Code of practice" and where directed by the principles and application rules of Eurocode 7 (EC7 – Part 1 and Part 2). The recommendations made and opinions expressed in this report are based on the information obtained from the sources described using a methodology intended to provide reasonable consistency and robustness.

The opinions expressed in this report are based on the ground conditions revealed by the site works, together with an assessment of the site and of laboratory test results. Whilst opinions may be expressed relating to sub-soil conditions in parts of the site not investigated, for example between exploratory positions, these are only for guidance and no liability can be accepted for their accuracy.

Boring, sampling and field test procedures are undertaken in accordance with BS5930:1999+A2:2010 "Code of Practice for Site Investigations". Likewise in-situ and laboratory testing complies with B.S.1377, "Methods of Tests for Soils for Civil Engineering Purposes", unless stated otherwise in the text.

The groundwater conditions entered on the boring records are those observed at the time of investigation. The normal rate of boring usually does not permit the recording of an equilibrium water level for any one water strike. Moreover, groundwater levels are subject to seasonal variation or changes in local drainage conditions.

Some items of the investigation have been provided by third parties and whilst Harrison Group have no reason to doubt the accuracy, the items relied on have not been verified. No responsibility can be accepted for errors within third party items presented in this report.

This report is produced for the benefit of the client alone. No responsibility can be accepted for any consequences of this information being passed to a third party who may act upon its contents/recommendations.

GROUND INVESTIGATION

DRAFT FACTUAL REPORT

KILN PLACE, CAMDEN

1.0 TERMS OF REFERENCE AND INTRODUCTION

The work covered by this report was undertaken on behalf of EC Harris by Harrison Group Environmental Ltd (HGE) in accordance with the relevant contract documentation, Infrastructure Conditions of Contract, Ground Investigation Version (dated August 2011) received from Ramboll, dated January 2014. Ramboll acted as Consulting Engineers for the project.

The proposed new development comprises the redevelopment of the existing site with the construction of a number of buildings.

The purpose of the investigation was to provide factual geotechnical and geoenviromental data from the fieldwork and subsequent laboratory testing that will be used to assist with the preliminary assessment of the site.

This report presents the results of the fieldwork, post fieldwork monitoring and associated laboratory testing.

2.0 LOCATION AND DESCRIPTION OF SITE

The site was located at the Kiln Place, Camden, London centred at approximate National Grid Reference 528370, 185492. Access to the site was gained via Lamble Street At the time of the investigation the site is a residential estate with dwellings, car parking with areas of grass and communal play areas. The site was sloped mainly to the north and laid predominantly to hardstanding, with a grassed bank which rose steeply in the eastern portion the site.

The site was situated in a mainly residential setting and was bound to the north by Lamble Street and to the west by Grafton Road. To the south and east was railway land.

A site location plan (GL18084-DR001) has been presented in Appendix A.

3.0 EXPECTED GEOLOGY

The British Geological Survey (BGS) Sheet 256 – North London 1:50 000 scale, indicates that the site is underlain by the London Clay Formation. Part of the site is within an area of ‘Worked ground, some wholly or partially backfilled’.

4.0 FIELDWORK

The scope of the site works was generally in accordance with that proposed by the Engineer and comprised the following:

- Cable Percussive Boreholes (2 No. maximum depth 15.00m)
- Window Sample Boreholes (7 No. maximum depth 8.00m)

- Surveying of the exploratory locations.

The fieldworks were carried out between the 3rd to 5th March 2014 at the locations shown on the appended drawing GL18084–DR002.

The sampling strategy was designed by the engineer and took into account local constraints, but included reference to the topography of the site, the geology encountered, including made ground and the development proposals.

Prior to intrusive activities bomb risks maps provided by 1st Line Defence identified the site as of medium risk from unexploded ordinance. The site works were overseen by an explosive ordnance supervisor from Macc International Limited.

During and immediately following completion of the fieldwork geotechnical samples were transported to Harrison Group's Laboratory in Norwich via in house transportation and/or couriers where they were logged into our sample management system upon arrival.

Environmental samples were dispatched to the nominated chemical test laboratory on a daily basis using cool boxes and refrigerant blocks. Chain of Custody (CoC) Sheets were prepared, copies of which accompanied the samples.

4.1 Cable Percussive Boreholes

Two cable percussive boreholes, namely BH1 and BH2 were required in order to sample, test and log the sub-soils underlying the site. These boreholes were progressed using 150mm diameter casing and equipment to a maximum depth of 15.00m bgl.

Upon completion the boreholes were installed with combined gas and groundwater monitoring wells, as summarised in Table 4.3.

A detailed description of all the strata encountered, position and types of samples taken along with any groundwater observations made at the time of drilling are included on the borehole logs presented in Appendix B.

4.2 Window Sample Boreholes

Seven window sample boreholes, namely WS1 through to WS7 were drilled to a maximum depth of 8.00m bgl using a tracked premier window sampling rig. These boreholes were required in order to sample, test and log the sub-soils underlying the site.

Window samples WS1 and WS3 were terminated at 2.20m and 1.00m respectively due to encountering an obstruction. WS7 was terminated at 5.10m due to the borehole backfilling to depths of between 5.10m and 3.80m when extracting the window sample tubes.

Upon completion some of the window sample boreholes were installed with combined gas and groundwater monitoring wells, as summarised in Table 4.3.

A detailed description of all the strata encountered, position and types of samples taken along with any groundwater observations made at the time of drilling are included on the window sample borehole logs presented in Appendix B.

4.3 Installations

The boreholes and some of the window sample boreholes were installed to instructions received from the engineer with standpipes for monitoring the gas and groundwater within the soils encountered, Table 4.3 below summarises these installations.

Monitoring Point I.D	Diameter of Installation (mm)	Base Depth of Installation (m bgl)	Response Zone (m bgl)		Target Strata
			Top	Base	
BH1	50	6.00	1.00	6.00	Made Ground
BH2	50	7.00	1.00	7.00	Made Ground
WS2	50	6.10	1.00	6.10	Made Ground & London Clay
WS5	50	4.00	1.00	4.00	Made Ground
WS7	50	5.10	1.00	5.10	Made Ground

Table 4.3: Summary of Gas and Groundwater Installations.

Detailed descriptions of the installations and their corresponding backfill materials are included on the relevant exploratory hole logs presented in Appendix B.

4.4 Surveying

Following completion of the intrusive works a survey was carried out to establish the co-ordinates of the exploratory locations, the details of which are shown on the appropriate logs.

4.5 Gas and Groundwater Monitoring

The specification details 9 No. gas and groundwater monitoring rounds to be undertaken over a 6 month period. Currently 5 out of 9 No. scheduled rounds of gas and groundwater monitoring have been completed so far on the dates as set out below:

Round 1 on the 25th/28th March 2014

Round 2 on the 1st April 2014

Round 3 on the 8th April 2014

Round 4 on the 15th April 2014

Round 5 on the 9th May

The results of gas and groundwater monitoring rounds are presented in Appendix C.

Gas monitoring

Gas monitoring was undertaken prior to groundwater monitoring and sampling. This was carried out to and in accordance with Rambolls specification.

Groundwater monitoring

Determination of the groundwater levels were derived using an interface dip-meter.

Samples of the groundwater were obtained for subsequent laboratory analysis using low flow techniques. Samples were stored in cool boxes with ice packs and were sent to the laboratory within 24 hours of being sampled along with chain of custody sheets.

5.0 GEOTECHNICAL TESTING

5.1 General

Use of the laboratory and field tests presented below to establish geotechnical parameters should be carried out in accordance with BS EN 1997-2 Eurocode Part 2.

5.2 In-situ Testing

In-situ testing was undertaken for geotechnical purposes and samples were obtained for appropriate laboratory analysis. Site based geotechnical testing is summarised in Table 5.2.

Test Type and Reference	Number	Comments / Limitations
Standard penetration test (BS EN ISO 22476-3:2005)	42	Standard Penetration Tests (SPTs) display a degree of scatter, with some elevated values likely to be due to encountering bricks, gravels and cobbles within the made ground. Uncalibrated SPT hammers can result in a wide variance between reported results. Calibration certification for the equipment used is presented in appendix E. It should be noted we report raw SPT N values rather than corrected $N_{(60)}$ values

Table 5.2: Summary of Insitu Geotechnical Testing

5.3 Geotechnical Laboratory Testing

Geotechnical laboratory testing was scheduled by Ramboll on selected soil samples recovered from the exploratory holes was carried out to identify the physical characteristics of the soils encountered.

The results of this work are presented in Appendix D and are summarised below (table 5.3).

Test Type and Reference (BS 1377: 1990 unless stated)	Stratum	No of tests	Results (Range)	Comments / Limitations
Natural moisture content (Part 2:3.2)	Made Ground London Clay Formation	18 11	10 - 66% 25 - 44%	Moisture content determinations on disturbed samples, including those obtained from window sample holes, may not be wholly representative due to disturbance arising from the sampling process.
Liquid limits (Part 2:4.3)	Made Ground London Clay Formation	18 11	40 - 77% 38 – 79%	-
Plastic limits (Part 5.4)	Made Ground London Clay Formation	18 11	21 - 42% 26 – 28%	-
Particle size distribution - wet sieving (Part 2:9.2)	Made Ground	3	n/a	The recovery of an adequate mass of coarse grained soils for particle distribution analysis can be difficult in window sample holes. In obtaining such samples from cable tool boreholes it should also be noted that some loss of fine material generally occurs due to the nature of the sampling process.
pH value (part 3:5)	Made Ground London Clay	10 8	7.5 – 10.5 7.6 – 8.2	-

	Formation			
Water Soluble Sulphate (Part 3:5)	Made Ground London Clay Formation	10 8	0.15 – 1.3 gl^{-1} 0.35 – 1.7 gl^{-1}	-
One dimensional consolidation (Part 5:3.0)	Made Ground London Clay Formation	2 1	As per sheets As per sheets	-
Single stage 100mm UU triaxial compression test (Part 7:8.0)	Made Ground London Clay Formation	2 4	24 - 26KPa 19- 137KPa	Triaxial tests undertaken on highly fissured samples and disturbance during sampling can result in low values of shear strength being recorded and results have been compared to published data and in situ test results.

Table 5.3: Summary of Geotechnical Laboratory Testing

6.0 CONTAMINATION TESTING

6.1 Contamination Observations

Samples recovered from the exploratory holes have been examined for potential contamination. Olfactory and visual evidence of potential contamination is summarised in Table 6.1.

Monitoring Point I.D	Depth (mbgl)	Stratum	Comments
BH1	0.15 – 2.50	Made Ground	Clinker/slag fragments, metal fragments
BH1	6.00 - 7.00	Made Ground	Charcoal fragments
WS1	0.10 – 1.10	Made Ground	Ash and coal fragments
WS2	0.50 – 2.20	Made Ground	Ash and coal fragments
WS3	0.00 – 0.70	Made Ground	Charcoal fragments
WS4	0.15 – 4.20	Made Ground	Ash and clinker fragments
WS5	0.15 – 1.00	Made Ground	Ash, charcoal and clinker fragments
WS5	4.00 – 6.50	Made Ground	Metal fragments
WS6	0.10 – 1.10	Made Ground	Ash
WS7	0.50 – 2.50	Made Ground	Clinker fragments
WS7	4.50 – 5.10	Made Ground	Metal fragments

Table 6.1: Summary of Evidence of contamination.

6.2 Environmental Laboratory Testing

Table 6.2 summarises the chemical suites that were analysed from both the detailed and preliminary investigations based upon the preliminary conceptual model and observed site conditions, together with the number of tests undertaken on soils and waters.

The results of this work are presented in Appendix D and are summarised below (table 6.2).

Test Type (Soil)	**Number**
Suite E: Arsenic, Cadmium, Chromium, Lead, Mercury, Selenium, Copper, Nickel, Zinc, Vanadium, pH, Sulphate (as SO4) - Water Soluble (2:1), Phenols - Total (monohydric), Cyanide – Total, FOC (Fraction Organic Carbon), PAH - Speciated (EPA 16), TPH8 band, Asbestos screen	5
Asbestos ID	
Suite E excl. PAH & Phenols	2
Suite E with TPH CWG	6
Suite E with TPH CWG excl. PAH & Phenols	3
Volatile Organic Compounds	2
Semi-volatile Organic Compounds	6
Clea Metals	2
Chromium VI	4
Test Type (Water)	**Number**
Suite F: Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Zinc, Selenium, Mercury, PAH - Speciated (EPA 16), Sulphate as SO4, Phenols - Total (monohydric), Cyanide – Total, Total Organic Carbon (TOC), Hardness - Total (as CaCO3), TPH 5 band	1
Suite F: excl.PAHs and Phenol.	2
Volatile Organic Compounds	2
Semi-volatile Organic Compounds	2

Table 6.2: Summary of Environmental Testing

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Geotechnical Engineer.

Report Checked by

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Associate Director Geotechnical.

REFERENCES

BSI British Standard, BS5930:1999+A2:2010 "Code of Practice for Site Investigations”.

BSI British Standard. 1990. BS1377:1990, “Methods of Test for Soils for Civil Engineering Purposes”.

BS EN 1997-1 Eurocode 7 Part 1 “General Rules”

BS EN 1997-2 Eurocode 7 Part 2 “Ground Investigation and Testing”

BS EN ISO 22475-1:2006 & 22475-2/3:2011 Geotechnical investigation and testing. Sampling methods and groundwater measurements.

BS EN ISO 22476:2005+A1:2011 Geotechnical investigation and testing. Various.

BS EN ISO 14688-1:2002 Geotechnical investigation and testing. Identification and classification of soil. Part 1 Identification and description

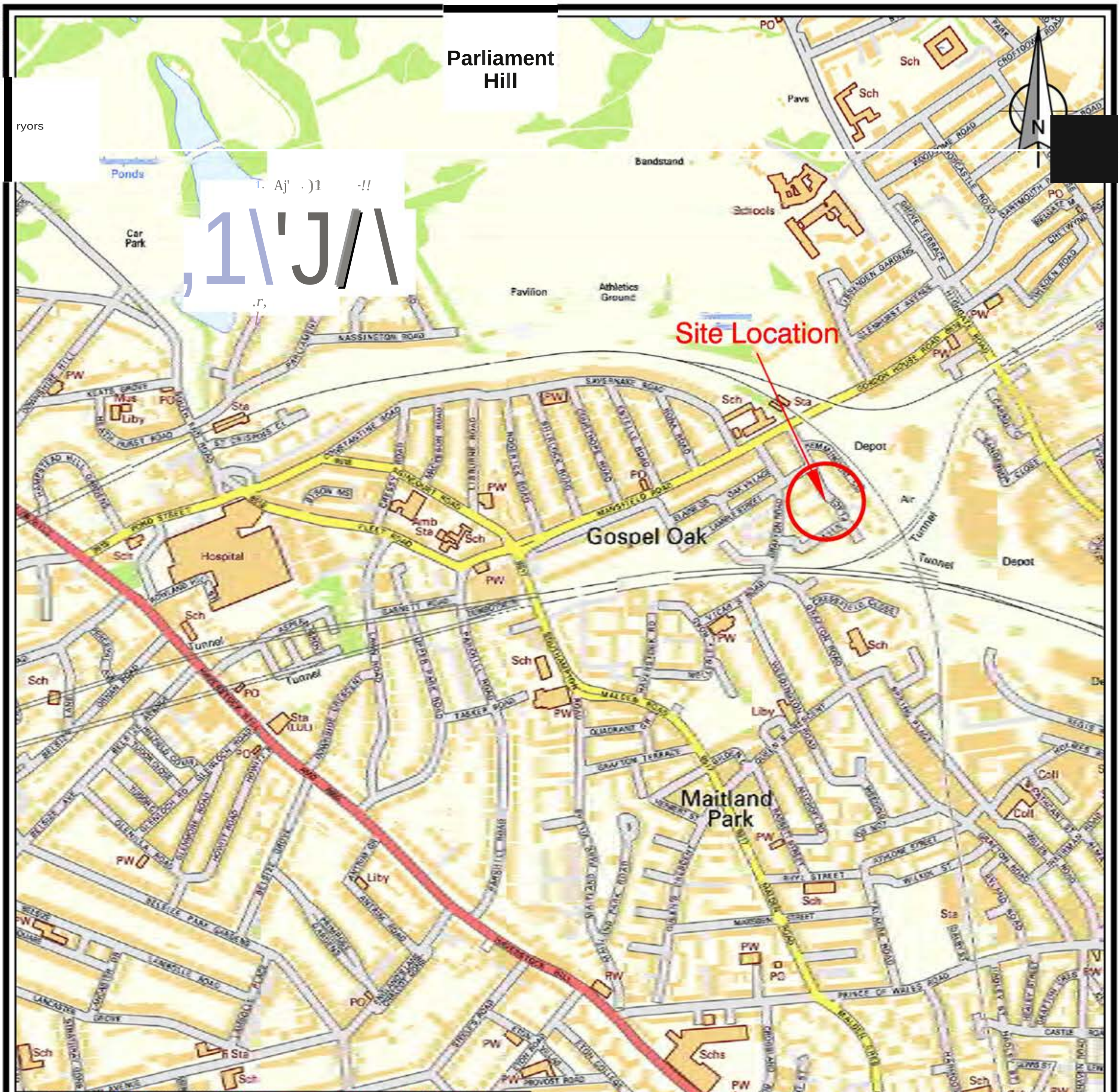
BS EN ISO 14688-2:2004 Geotechnical investigation and testing. Identification and classification of soil. Part 2 Principles for a classification.

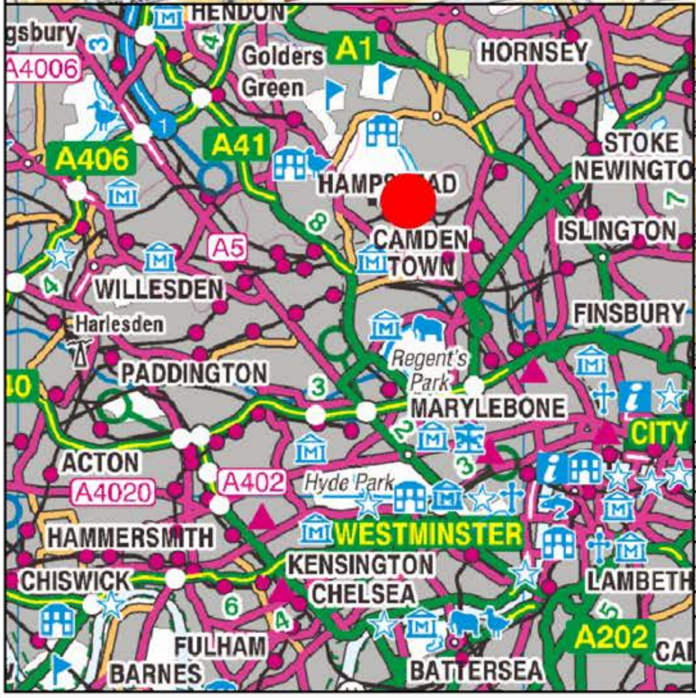
LIST OF APPENDICES

APPENDIX A

DRAWINGS

FM-Hn-D-103 Rev A





Client: EC Harris LLP

Project: Kiln Place, Camden

Job No: GL18084 | Date: May 2014

Drawing No: GL18084 - DR001

Scale: 1 : 10000 @ A4

Drawn by: YN | Checked by: GP

Eastings: 528340 | Northings: 185520

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Certificate Number 5933
ISO 9001, ISO 14001