Walsh Group

Camden Lock, London – Proposed School Site

Geotechnical and Geoenvironmental Interpretative Report

December, 2014

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Reference	CG/18067	Revision	0	Issue Date December 2014

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EXECUTIVE SUMMARY

Card Geotechnics has been commissioned by Walsh Group to undertake a Geotechnical and Geoenvironmental Interpretative Report for a site at Camden Lock, London. The site currently comprises a MOT testing garage, residential properties and light industrial units. With the exception of some of the industrial units, the site is vacant. It is proposed to demolish the existing buildings and construct a new primary school. The existing Grade II listed house at No. 1 Hawley Road is to be renovated and will form part of the proposed school.

The historical development of the site was previously investigated by RPS in their reports of October 2009 and November 2009. In summary, the site comprised open fields until the *Regent's Canal* was constructed in the early 1800s, with associated wharf buildings and residential properties constructed across the site. These buildings were subsequently redeveloped or were demolished during construction of the North London Overground Railway viaducts in the mid-1800s. No further significant changes were noted at the site.

The area experienced some bombing during the Second World War, with a number of properties along Torbay Street suffering serious blast damage. A detailed unexploded ordnance (UXO) risk assessment was undertaken by 6 Alpha Associates Limited in September 2014 which noted that there is a low risk due to UXO at this site.

Local geotechnical mapping indicates that the site is directly underlain by the London Clay Formation. This is supported by historical BGS records from the surrounding area. An intrusive investigation, comprising one cable percussion borehole to 15mbgl and three window sampler boreholes to a maximum depth of 3.15mbgl, was undertaken from 1st October to 6th November 2014. Ground gas and groundwater monitoring wells were installed in the boreholes.

The investigation encountered limited Made Ground (0.9m to 1.2m) underlain by the London Clay Formation, which extended to the base of the boreholes. No groundwater strikes were encountered during the investigation, although slight seepage was noted from a claystone band at 7.85mbgl to 8.0mbgl in BH1. Groundwater was encountered in WS1 and WS3 during the subsequent monitoring visits at 1.26mbgl to 1.28mbgl (WS1) and 0.63mbgl to 0.38mbgl (WS3).

Negligible concentrations and flow of ground gas were recorded during the subsequent monitoring visits and a gas screening value of 0.0168 has been calculated for the site. The site therefore conforms to Characteristic Situation 1 and no ground gas protection measures are therefore required.

With the exception of lead in the Made Ground, contaminant concentrations were found to be below the assessment criteria for the *Residential (with plant uptake)* land use.

In order to mitigate the potential risk to Human Health due to the exceedances of lead, it is recommended that a capping layer is installed across the site. The capping layer should generally comprise a minimum of 150mm topsoil over 450mm subsoil and a geotextile membrane, however this may be reduced to a minimum of 150mm topsoil over 300mm subsoil and a geotextile membrane in areas of permanent communal landscaping.

Based on the three ground gas monitoring visits undertaken to date, the site appears to conform to Characteristic Situation 1 and no ground gas protection measures are therefore required in the development. A further three monitoring visits are due to be undertaken. These will be reported as an addendum to this report.

A preliminary assessment of the Topsoil/Made Ground for waste classification purposes indicates that the majority of this material may be classified as 'not hazardous' with respect to waste disposal. Waste acceptance criteria (WAC) testing demonstrates that the 'not hazardous' samples may be disposed of in an inert landfill.

It is understood that the proposed structure is to be founded on pad and strip foundations. A bearing capacity of 100kPa is considered to be appropriate for the site, with foundations founded a minimum of 1.5m below ground level and 0.5m below the surface of the London Clay Formation and with regard to future planting compliance with NHBC or similar recommendations for foundation depths in clay soils . The floor slabs should therefore be designed as suspended. It is anticipated that shallow excavations will remain stable in the short term.

As the underlying London Clay Formation will be disturbed during construction, buried concrete within this stratum should be designed to Design Class DS-3 and ACEC Class AC-2s.

1. INTRODUCTION

CGL has been commissioned by Walsh Group on behalf of to undertake a geotechnical and geoenvironmental intrusive investigation to assess the ground conditions at a site proposed for development at Camden Lock, London.

The proposed development of the site is divided into two sections; the 'School Site', which comprises the eastern half of the wider site and 'Building W', which comprises the western half. This report relates to the proposed School Site area (herein referred to as the 'site'). A separate report will be produced for the remaining areas of the Camden Lock Village site.

The objectives of this report are to:

- provide a summary of the site history and environmental setting;
- provide information on the ground conditions;
- provide an assessment and recommendations relating to the potential for soil and groundwater contamination and ground gas; and
- provide geotechnical recommendations to assist with foundation, floor slab and pavement design.

The site has been the subject of a number of previous reports, including;

- Phase 1 Environmental Risk Assessment (RPS 2009)[1]
- Archaeological Desk Based Assessment (RPS 2009)[2]

Pertinent information within these reports is summarised in Section 2, but the reports should be referred to for further details.

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[1] RPS (2009) Camden Lock Village London Borough of Camden. *Phase 1 – Environmental Risk Assessment*. Ref: HLEI4880/001R. October 2009

[2] RPS (2009) Camden Lock Village London Borough of Camden. *An Archaeological Desk Based Assessment*. Ref: JLK0617 RO1. November 2009

2. SITE LOCATION AND DESCRIPTION

2.1 Site location

The site is situated off Hawley Road in Camden, northwest London. The Ordnance Survey grid reference for the approximate centre of the site is 528881N, 184225E.

A site location plan is presented as Figure 1.

2.2 Site description

The site is bordered by a car park to the west, Hawley Road to the north, residential properties to the east and a National Rail viaduct to the south.

At the time of the site works, the site comprised a road (Torbay Street), a MOT testing garage with associated parking and storage, residential properties and a number of small storage areas, including areas under the arches of the railway viaduct. Several of the properties were vacant and have been boarded up for security.

A site layout plan is presented as Figure 2.

2.3 Proposed development

It is proposed to demolish the existing buildings and road and construct a new primary school at the site, with associated soft landscaping, multi-use games area, parking and hardstanding areas. The existing Grade II listed building at No. 1 Hawley Road is to be refurbished and will form part of the proposed school buildings. In addition, the storage areas beneath the railway arches are to be opened up to allow pedestrian access. A below ground attenuation tank is proposed to be located in the southeast of the site, beneath the multi-use games area.

Proposed development plans are included as Appendix A.

2.4 Historical development

The historical development of the site was established by RPS in their October 2009[1] and November 2009[2] reports and is summarised below.

The site consisted of open fields until the *Regent's Canal* was constructed in the early 1800s, with associated wharf buildings and residential properties constructed across the site. A number of these buildings were subsequently redeveloped into vehicle maintenance garages or were demolished during construction of the North London Overground Railway viaducts in the mid-1800s. No further significant changes were noted at the site.

2.5 Bomb damage and unexploded ordnance

The area experienced some bombing during the Second World War, with a number of properties along Torbay Street suffering serious blast damage. Principally this damage was a V1 strike in 1944. The affected properties appear to be in the same configuration as the current properties at the site, indicating that they were repaired rather than being demolished.

A detailed unexploded ordnance (UXO) risk assessment[3] was undertaken by 6 Alpha Associates Limited in September 2014. The report notes that the risk posed by UXO at the site is low.

2.6 Anticipated ground conditions

2.6.1 Published and unpublished geology

The British Geological Survey map sheet 256 indicates that the site is directly underlain by the London Clay Formation, which consists of stiff blue grey silty clay, weathering to brown silty clay.

The BGS holds records of a number of historical ground investigations within 300m of the site. Selected logs are summarised in Table 1 and are included in Appendix B.

[3] 6 Alpha Associates Limited (2014) *Detailed Unexploded Ordnance (UXO) Risk Assessment*. Ref: P4063. September 2014

Table 1 - Summary of BGS historical borehole records

BH record reference	Distance (m)	Direction	Depth to base of BH (mbgl)	Ground water level (mbgl)	Depth to top of stratum (mbgl)				
					Made Ground	London Clay Formation	Lambeth Group	Thanet Sand	Chalk
TQ28SE5	90	SW	91.4	NR	-	0.0	42	NR	64
TQ28SE1203	230	SE	18.7	1.1	0.0	1.5	-	-	-
TQ28SE1204	230	SE	18.4	NR	0.0	0.9	-	-	-
TQ28SE1206	230	SE	9.6	1.1	0.0	2.1	-	-	-
TQ28SE1208	230	SE	9.4	NR	0.0	1.37	-	-	-
TQ28SE1239	180	NW	3.0	-	0.0	0.63	-	-	-
TQ28SE1240	180	NW	3.0	-	0.0	0.5	-	-	-
TQ28SE1241	180	NW	3.0	-	0.0	0.8	-	-	-
TQ28SE1242	180	NW	3.0	-	0.0	0.6	-	-	-
TQ28SE1491	120	SE	198.7	91.7	0.0	6.7	44.8	53.9	125.0
TQ28SE2272	260	SW	1.1	-	0.0	1.08	-	-	-

NR – not recorded

2.6.2 Hydrogeology and hydrology

The Environment Agency[4] has produced an aquifer designation system consistent with the requirements of the Water Framework Directive. The designations have been set for superficial and bedrock geology and are based on the importance of aquifers for potable water supply and their role in supporting surface water bodies and wetland ecosystems.

The underlying London Clay Formation is classified as an 'Unproductive Strata' and the site is not within a Groundwater Source Protection Zone (SPZ)

The Environment Agency indicates that the site is not at risk from flooding. The nearest surface water to the site is the *Regent's Canal*, situated approximately 35m south of the site.

[4] www.environment-agency.gov.uk (September 2014)

2.7 Environmental setting

The previous report by RPS[1] provides information on the environmental setting of the site and possible sources of soil and groundwater contamination. The key points are summarised below:

- There are no recorded landfill sites within 500m of the site. However, there are two waste transfer sites, located 120m southwest and 130m south of the site.
- No ‘major’ or ‘significant’ pollution incidents are noted within 500m of the site.
- There is the potential for arsenic and lead contamination to be present within the soils at the site, resulting from the spreading of ash in private gardens during the pre-Victorian period to the 1950s.
- There are eleven industrial activities within 500m of the site, including vehicle respraying, petrol stations and dry cleaners.
- The site is not in a radon affect area.

2.8 Preliminary risk assessment

The October 2009 RPS report[1] included a preliminary risk assessment, the key points of which are summarised below:

- It is likely that contamination is present within the soils due to historical land use on site and in the surrounding area.
- The potential pathways to human health receptors include dermal contact, inhalation and ingestion of contaminants. Due to the underlying London Clay Formation, there is not considered to be a pathway for contaminants to reach the underlying Chalk aquifer.
- Overall, RPS considered the risk associated with potential contamination within the Made Ground to be low due to the absence of a source-pathway-receptor linkage (hardstanding across the site).

In addition to the potential risks identified by RPS, due to the age of the buildings on site, it is considered that there is the potential for asbestos-containing material to be present within the building fabric.

3. CURRENT GROUND INVESTIGATION

3.1 Fieldwork

An intrusive investigation was undertaken at the wider development site from 21st October to 6th November 2014. The investigation at the School Site comprised one cable percussion borehole (BH1) to 15mbgl and three window sampler boreholes (WS1 to WS3) to a maximum depth of 3.15mbgl. Due to access restrictions, the window sampler boreholes were undertaken using a hand-held window sampler rig. The investigation was broadly undertaken in accordance with the requirements of BS 5930:1999[5].

The borehole arisings were recorded and representatively sampled by a suitably qualified geotechnical engineer from CGL in order to obtain samples for laboratory testing, and to characterise the near surface ground conditions across the site. Soil samples were obtained for chemical and geotechnical laboratory analysis. Standpipes were installed in all boreholes to enable subsequent gas and groundwater monitoring to be undertaken.

A plan showing the exploratory locations is presented as Figure 3 and the borehole logs are included as Appendix C.

3.2 Monitoring

Three ground gas and groundwater monitoring visits have been undertaken to date, on 5th and 19th November 2014. Copies of the monitoring records are included as Appendix D. Three further visits are scheduled to be undertaken. The results of these monitoring visits will be reported as an addendum to this report.

3.3 Laboratory testing

3.3.1 Chemical

Six representative soil samples were submitted to i2 Analytical Limited (a UKAS and MCERTS accredited laboratory) for chemical testing. The analysis included the following determinants.

- Soil Organic Matter (SOM);
- Heavy metals including; arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc;

[5] BS 5930:1999*; Code of practice for site investigations, Incorporating Amendment 2*, British Standards Institute. 1999.

- Total Petroleum Hydrocarbons (TPH) and Polycyclic Aromatic Hydrocarbons (PAH);
- Total Monohydric Phenols;
- Total Cyanide;
- Asbestos identification; and
- pH determination.

The laboratory analysis results are presented in Appendix E.

3.3.2 Geotechnical

Soil samples were sent for geotechnical laboratory analysis at Geolabs Limited. The analysis included:

- Moisture Content;
- Atterberg Limits and;
- Quick Undrained Triaxial testing.

The results of the analysis are presented in Appendix F.

4. GROUND AND GROUNDWATER CONDITIONS

4.1 Summary

The ground conditions encountered are summarised in Table 2. The borehole and window sampler logs are included in Appendix C.

Table 2. Summary of ground conditions

Stratum	Depth to top of stratum (mbgl)	Typical thickness (m)
MADE GROUND Concrete overlying soft dark brown sandy gravelly silt. Sand is fine to coarse. Gravel is fine to coarse subrounded to subangular of brick, flint and occasional concrete.	0.0	0.9 to 1.2
Firm dark orange brown occasionally mottled grey slightly silty CLAY. 2.9mbgl: Becoming stiff 7.4mbgl: Becoming dark grey 7.85-8.0mbgl: Claystone noted [LONDON CLAY FORMATION]	0.9 to 1.2	>14.1 Base not proved in borehole

The ground conditions encountered during the ground investigation generally correlated with the BGS mapping of the area, with limited Made Ground directly overlying the London Clay Formation. The upper surface of the London Clay Formation was found to be relatively consistent across the site. The results are consistent with other boreholes from the investigations completed for other elements of the Camden Lock Village development and these have informed the interpreted view.

4.2 Made Ground

The Made Ground at the site was found to be relatively consistent across the site and comprised concrete or cobblestones overlying soft dark brown sandy gravelly silt or gravelly silty clay. The gravel comprised brick and flint, with occasional concrete. No visual or olfactory evidence of contamination was noted in the boreholes.

4.3 London Clay Formation

The London Clay Formation was proved to a maximum depth of 15.0mbgl. The upper 6.5m of the clay was found to consist of firm silty clay (Weathered London Clay Formation), becoming stiff (unweathered) from 7.4mbgl. SPT 'N' values in this stratum ranged from 10 to 26. Undrained shear strength values can be derived from these values using established correlations[6] and range from 45kPa to 117kPa, indicating that the clay is medium to high strength.

Laboratory testing on the London Clay Formation gave undrained shear strength (c_u) values of 70kPa to 137kPa, increasing with depth. Plots of SPT 'N' values and undrained shear strength against depth are presented as Figure 5 and Figure 6, respectively. The moisture content and Atterberg limits of the clay are summarised in Table 3.

Table 3. Summary of liquid limits and atterberg limits

Strata	Moisture content (%)	Liquid limit (%)	Plastic limit (%)	Modified plasticity index, I' (%)
London Clay Formation	22 to 34	45 to 80	19 to 28	26 to 53

These results indicate that the material at this site is an intermediate to very high plasticity clay of medium to high volume change potential.

4.4 Groundwater

No groundwater was encountered in the boreholes during drilling, with the exception of slight seepage through a claystone band at 7.85mbgl to 8.0mbgl in BH1. However, perched water was encountered in the boreholes during the subsequent monitoring visits at 1.29mbgl (BH1), 1.26mbgl to 1.29mbgl (WS1), 0.62mbgl (WS2) and 0.62mbgl to 0.38mbgl (WS3).

[6] Tomlinson, M.J. (2001) *Foundations Design and Construction (7th Ed.)*. Pearson Prentice Hall

5. CONTAMINATION ASSESSMENT

5.1 Risks to human health (long-term chronic risks)

The proposed use of the site is a school. On this basis, the site has been assessed against criteria for a "Residential (with plant uptake)" land use, which is considered to provide a conservative assessment for the proposed use, given the potential for vegetables to be grown within the school. Currently, SGVs have only been issued by the Environment Agency for a limited number of contaminants, namely selenium, mercury, arsenic, nickel, the BTEX compounds, phenol, polychlorinated biphenyls and cadmium. The SGVs have all been issued for a sandy loam soil with a Soil Organic Matter of 6% as standard.

Where SGVs are not available, the soil results have been compared to *Generic Assessment Criteria* (GACs) that have been derived in-house by CGL using the *Contaminated Land Exposure Assessment (CLEA)* model[7] and version 1.06 of the CLEA software. The GACs represent conservative screening criteria and have been calculated using the default parameters for the standard land use scenario set out in the CLEA technical report and toxicological inputs in line with the requirements of *Science Report SC050021/SR2*[8] and, in the case of petroleum hydrocarbons, Science *Report P5-080/TR3*[9]. The GACs have been generated assuming a sandy loam soil type and a Soil Organic Matter of 2.5% for Made Ground and 1% for natural soils, which are suitable assumptions for the site in question. More detailed information on the derivation of the CGL GACs can be provided upon request. The results of the assessment are set out below in Table 4 to Table 7.

In March 2014, the Department for Environment, Food and Regional Affairs (DEFRA) issued SP1010 Development of Category 4 Screening Levels (C4SLs) for assessment of land affected by contamination - Policy companion document[10], along with the results of the work by the C4SLs development team[11]. This includes a set of C4SL values for arsenic, benzene, benzo(a)pyrene, cadmium, chromium VI and lead for sandy loam soil with SOM =6%.

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[7] Environment Agency. (January 2009). *Updated technical background to the CLEA model*. Science Report SC050021/SR3.

[8] Environment Agency. (January 2009). *Human health toxicological assessment of contaminants in soil*. Science Report SC050021/SR2.

[9] Environment Agency. (February 2005). *The UK Approach for Evaluating Human Health Risks from Petroleum Hydrocarbons in Soils*. Science Report P5-080/TR3.

[10] DEFRA (March 2014) *SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination – Policy Companion Document*

[11] CL:AIRE (March 2014) *SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination*

These values are primarily to support site assessment with respect to Part 2A of the Environmental Protection Act 1990, being indicative of low health risk and therefore of a site not determinable under Part 2A. This is in comparison with the SGVs and GACs which represent minimal risk. The C4SLs are based on revised slightly less conservative exposure models and toxicology based on Low Level of Toxicological Concern (LLTC) rather than the Heath Criteria Values (HCV) on which the SGVs/GACs are based. The difference in risk level between HCV (minimal risk) and LLTC (low risk) is slight, and it is noted that both are still within the Category 4 level and below the Category 3/4 level boundary considered by DEFRA to be the likely de facto minimum standard chosen by developers. The C4SLs are still strongly conservative in accordance with the Contaminated Land Regulations and meet the objectives of the NPPF that:

- *the site is suitable for its new use taking account of ground conditions and land instability, including from natural hazards or former activities such as mining, pollution arising from previous uses and any proposals for mitigation including land remediation or impacts on the natural environment arising from that remediation; and*
- *after remediation, as a minimum, land should not be capable of being determined as contaminated land under Part IIA of the Environmental Protection Act 1990.*

On this basis CGL considers it is appropriate to use C4SLs for the published contaminants. In the event impacts are identified on a site above the GAC/SGV level for these contaminants, CGL will utilise the C4SLs to assess whether these pose a low risk to developments and Public Open Space applications.

It is noted that the BGS has published background levels for a number of organic and inorganic constituents. In the event that the C4SL or a GAC is found to be exceeded, the risk may still be considered to be low, unlikely to meet the definition of contaminated land under Part IIA and potentially suitable for use from a development perspective, if the contaminant concentrations are below local background levels, assuming no other contributing factors.

It is noted that the SGV for lead has been withdrawn and that the C4SL for lead will be used in its place, based on latest toxicology research.

Table 4. Summary of soil contamination (risks to human health) – Made Ground

Contaminant	SGV or GAC @ 2.5% SOM for Residential (with plant uptake) land-use (mg/kg)	Notes on soil saturation limits (SSL)[1]	Measured range (mg/kg)	Measured values > Assessment Criteria? (Y/N)
SOM (%)	*[2]		2.5 to 3.6	*
Arsenic	32[3]	-	14.0 to 17.0	N
Cadmium	10[3]	-	<0.2 to 0.6	N
Chromium (total)	37	-	28 to 33	N
Lead	200	-	**230 to 750**	**Y**
Mercury (inorganic)	170[3]	-	0.3 to 1.0	N
Selenium	350[3]	-	<1.0	N
Boron	*		1.0 to 6.1	*
Copper	3,700	-	56 to 100	N
Nickel	130[3]	-	19 to 22	N
Zinc	18,000	-	81 to 420	N
Barium	*		100 to 290	*
Beryllium	23	-	1.0 to 1.4	N
Vanadium	130	-	50 to 65	N
Phenols[4]	290[3]	-	<1.0	N
Cyanide	*		<1.0	*
BTEX compounds				
Benzene	0.16	-	<0.001	N
Toluene	270	-	<0.001	N
Ethyl benzene	150	-	<0.001	N
m-xylene[6]	100	-	<0.001	N
o-xylene[6]	110	-	<0.001	N
p-xylene[^]	98	-	<0.001	N

Notes:
1. - = green; (a) = amber i.e. GAC set to model output, [SSL provided in square brackets] ; (b) = red i.e. SSL exceeded & considered to affect interpretation. GAC calculated in accordance with the CLEA Software Handbook ; (c) = based on direct contact; (d) GAC limited to SSL.
2. * = no value currently defined
3. Based on the published Soil Guideline Value (Environment Agency, 2009), adjusted for no plant uptake and 2.5% SOM
4. GAC relates to Phenol (C_6H_5OH) only.
5. Based on the published SGVs for BTEX at 6% SOM (Environment Agency, 2009), adjusted for 2.5% SOM and no plant uptake
6. Concentrations for total xylenes should be compared to the value for m-xylene for fresh spills and to o-xylene for all other cases.
7. Published C4SL for lead (DEFRA, 2014)

Table 5. Summary of soil contamination (risks to human health) - Made Ground cont.

Contaminant	SGV or GAC @ 2.5% SOM for Residential (with plant uptake) land-use (mg/kg)	Notes on soil saturation limits (SSL)[1]	Measured range (mg/kg)	Measured values > Assessment Criteria? (Y/N)
Total Petroleum Hydrocarbons (TPH)				
TPH aliphatic EC5-6	41	-	<0.1	N
TPH aliphatic EC>6-8	100	-	<0.1	N
TPH aliphatic EC>8-10	25	-	<0.1	N
TPH aliphatic EC>10-12	420	(b)	<1.0	N
TPH aliphatic EC>12-16	4,300	(b)	<2.0 to 4.9	N
TPH aliphatic EC>16-35	88,000	(b)	<16.0 to 37.0	N
TPH aromatic EC5-7	0.16	-	<0.1	N
TPH aromatic EC>7-8	270	-	<0.1	N
TPH aromatic EC>8-10	37	-	<0.1	N
TPH aromatic EC>10-12	130	-	<1.0	N
TPH aromatic EC>12-16	290	(b)	<2.0 to 2.2	N
TPH aromatic EC>16-21	490 [150]	(a)	<10.0 to 16.0	N
TPH aromatic EC>21-35	1,100 [12]	(a)	<10.0 to 19.0	N
Polycyclic Aromatic Hydrocarbons (PAH)				
Acenaphthene	1,200	(b)	<0.1	N
Anthracene	13,000 [19]	(a)	<0.1 to 0.31	N
Benzo(a)anthracene	13 [4.3]	(a)	<0.1 to 2.1	N
Benzo(a)pyrene	2.4 [2.3]	(a)	<0.1 to 2.1	N
Benzo(b)fluoranthene	23 [3.0]	(a)	<0.1 to 2.3	N
Benzo(g,h,i)perylene	240 [0.05]	(a)	<0.05 to 0.94	N
Benzo(k)fluoranthene	24 [1.7]	(a)	<0.1 to 1.2	N
Chrysene	200 [1.1]	(a)	<0.05 to 2.1	N
Dibenzo(a,h)anthracene	2.3 [0.01]	(a)	<0.1 to 0.23	N
Fluoranthene	1,500 [47]	(a)	<0.1 to 4.2	N
Fluorene	1,200 [381]	(b)	<0.1	N
Indeno(1,2,3-cd)pyrene	23 [0.15]	(a)	<0.1 to 0.73	N
Naphthalene	3.7	-	<0.05 to 0.13	N
Pyrene	1,000 [5.5]	(a)	<0.1 to 3.7	N

Notes:

1. - = green; (a) = amber i.e. GAC set to model output, [SSL provided in square brackets] ; (b) = red i.e. SSL exceeded & considered to affect interpretation. GAC calculated in accordance with the CLEA Software Handbook ; (c) = based on direct contact; (d) GAC limited to SSL.

Table 6. Summary of soil contamination (risks to human health) - Natural soils

Contaminant	SGV or GAC @ 1% SOM for Residential (with plant uptake) land-use (mg/kg)	Notes on soil saturation limits (SSL)[1]	Measured range (mg/kg)	Measured values > Assessment Criteria? (Y/N)
SOM (%)	*[2]	-	0.9 to 1.6	*
Arsenic	32[3]	-	11.0 to 14.0	N
Cadmium	10[3]	-	<0.2	N
Chromium (total)	37	-	**45.0 to 46.0**	**Y**[8]
Chromium (III)	1,100	-	45.0 to 46.0	N
Chromium (VI)	3.0	-	<1.2	N
Lead	200[7]	-	17.0 to 31.0	N
Mercury (inorganic)	170[3]	-	<0.3	N
Selenium	350[3]	-	<1.0	N
Boron	*		0.9 to 1.8	*
Copper	3,700	-	20.0 to 23.0	N
Nickel	130[3]	-	28.0 to 36.0	N
Zinc	18,000	-	58.0 to 71.0	N
Barium	*		78.0 to 92.0	*
Beryllium	23	-	1.3 to 1.6	N
Vanadium	130	-	70.0 to 78.0	N
Phenols[4]	180[3]	-	<1.0	N
Cyanide	*		<1.0	*
BTEX compounds				
Benzene	0.080[5]	-	<0.001	N
Toluene	120[5]	-	<0.001	N
Ethyl benzene	65[5]	-	<0.001	N
m-xylene[6]	44[5]	-	<0.001	N
o-xylene[6]	45[5]	-	<0.001	N
p-xylene[6]	42[5]	-	<0.001	

Notes:
1. - = green; (a) = amber i.e. GAC set to model output, [SSL provided in square brackets] ; (b) = red i.e. SSL exceeded & considered to affect interpretation. GAC calculated in accordance with the CLEA Software Handbook ; (c) = based on direct contact; (d) GAC limited to SSL.
2. * = no value currently defined
3. Based on the published Soil Guideline Value (Environment Agency, 2009), adjusted for no plant uptake and 1% SOM
4. GAC relates to Phenol (C_6H_5OH) only.
5. Based on the published SGVs for BTEX at 6% SOM (Environment Agency, 2009), adjusted for 1% SOM without plant uptake
6. Concentrations for total xylenes should be compared to the value for m-xylene for fresh spills and to o-xylene for all other cases.
7. Published C4SL for lead (DEFRA, 2014)
8. Exceedance is for Total Chromium. Further analysis indicates that the exceedance is due to Chromium III. The concentration of the more toxic Chromium VI is below the assessment criteria.

Table 7. Summary of soil contamination (risks to human health) - Natural soils cont.

Contaminant	SGV or GAC @ 1% SOM for Residential (with plant uptake) land-use (mg/kg)	Notes on soil saturation limits (SSL)[1]	Measured range (mg/kg)	Measured values > Assessment Criteria? (Y/N)
Total Petroleum Hydrocarbons (TPH)				
TPH aliphatic EC5-6	24	-	<0.1	N
TPH aliphatic EC>6-8	49	-	<0.1	N
TPH aliphatic EC>8-10	10	-	<0.1	N
TPH aliphatic EC>10-12	430	(b)	<1.0	N
TPH aliphatic EC>12-16	4,200	(b)	<2.0 to 5.9	N
TPH aliphatic EC>16-35	88,000	(b)	<16.0	N
TPH aromatic EC5-7	0.080	-	<0.1	N
TPH aromatic EC>7-8	120	-	<0.1	N
TPH aromatic EC>8-10	15	-	<0.1	N
TPH aromatic EC>10-12	56	-	<1.0	N
TPH aromatic EC>12-16	130	(b)	<2.0	N
TPH aromatic EC>16-21	250 [60]	(b)	<10.0	N
TPH aromatic EC>21-35	890 [4.8]	(a)	<10.0	N
Polycyclic Aromatic Hydrocarbons (PAH)				
Acenaphthene	570	(b)	<0.1	N
Anthracene	8,000 [7.7]	(b)	<0.1	N
Benzo(a)anthracene	7.5 [1.7]	(a)	<0.1	N
Benzo(a)pyrene	2.2 [0.9]	(a)	<0.1	N
Benzo(b)fluoranthene	21 [1.2]	(a)	<0.1	N
Benzo(g,h,i)perylene	240 [0.02]	(a)	<0.05	N
Benzo(k)fluoranthene	22 [0.7]	(a)	<0.1	N
Chrysene	160 [0.4]	(a)	<0.05	N
Dibenzo(a,h)anthracene	2.0 [0.004]	(a)	<0.1	N
Fluoranthene	820 [19]	(a)	<0.1	N
Fluorene	650	(b)	<0.1	N
Indeno(1,2,3-cd)pyrene	20 [0.06]	(a)	<0.1	N
Naphthalene	1.5	-	<0.05	N
Pyrene	560 [2.2]	(a)	<0.1	N

Notes:

1. - = green; (a) = amber i.e. GAC set to model output, [SSL provided in square brackets] ; (b) = red i.e. SSL exceeded & considered to affect interpretation. GAC calculated in accordance with the CLEA Software Handbook ; (c) = based on direct contact; (d) GAC limited to SSL.

The assessment indicates that concentrations of lead exceed the assessment criteria in all Made Ground samples analysed. The locations where exceedances were recorded are summarised in Table 8.

Table 8. Summary of contaminant exceedances

Borehole	**Depth (mbgl)**	**Contaminants which exceed acceptable limit**	**Contaminant concentration (mg/kg)**	**Acceptable limit for the *Residential (with plant uptake)* land use (mg/kg)**
WS1	0.4	Lead	750	200
WS2	0.3	Lead	570	200
WS3	0.6	Lead	270	200
BH1	0.5	Lead	230	200

The testing indicated that concentrations of total chromium recorded in the London Clay at a depth of 1.5mbgl in WS1 and WS3 were above the assessment criteria (which is based chromium VI). However, further testing of these samples indicates that the concentrations of total chromium were both due to chromium III, with the recorded concentrations of the more toxic chromium VI being below the laboratory limit of detection and assessment criterion. Therefore the concentrations of chromium recorded are not considered to present an unacceptable risk to human health.

In addition, an asbestos screen was undertaken on three samples of Made Ground. No asbestos was detected in the samples.

5.2 Risks to plant growth

As indicated in Section 5.1, concentrations of phytotoxic chemicals are below the human health assessment criteria prescribed by the Sludge Regulations. The risks to plant growth are therefore considered to be low.

5.3 Ground gas assessment

Three rounds of ground gas monitoring were completed on 5th and 19th November and 1st December 2014, during atmospheric pressures in the range of 999mb to 1019mb. The local pressure system was noted to be rising during both visits. The monitoring records are presented in Appendix D and are summarised below:

- Maximum carbon dioxide concentration: 0.8 % v/v;
- Maximum methane concentration: <0.1 % v/v;
- Maximum flow rate: 2.1 l/hr; and
- Minimum oxygen concentration: 18.5 % v/v.

Based on these findings, and with reference to CIRIA guidance[12], a gas screening value (GSV) of 0.0168 l/hr has been calculated for the site, corresponding to a Characteristic Situation 1 site.

[12] CIRIA (2007) *Assessing the risks posed by hazardous ground gases to buildings*

6. REFINED RISK ASSESSMENT

6.1 Introduction

In accordance with Contaminated Land Report (CLR) 11[13], the conceptual site model has been updated based on the information gathered during the intrusive investigation and the potential pollutant linkages have been evaluated through a semi-quantitative risk assessment. The risks ratings identified have been assigned in accordance with the DEFRA and Contaminated Land Report (CLR) 6[14], site prioritisation and categorisation rating system which is summarised in Table 9.

Table 9. Risk Rating Terminology

Risk Rating	Description
High Risk	Contaminants very likely to represent an unacceptable risk to identified targets Site probably not suitable for proposed use Enforcement action possible, Urgent action required
Medium Risk	Contaminants likely to represent an unacceptable risk to identified targets Site probably not suitable for proposed use Action required in the medium term
Low Risk	Contaminants may be present but unlikely to create unacceptable risk to identified targets Site probably suitable for proposed use Action unlikely to be needed whilst site remains in current use
Negligible Risk	If contamination sources are present they are considered to be minor in nature and extent Site suitable for proposed use No further action required

Based on the terminology within this table, a refined assessment of the risks posed by the potential pollutant linkages at the site is outlined in Table 10. A diagrammatic representation of the conceptual site model is provided in Figure 4.

[13] The Environment Agency. (2004). *Model Procedures for the Management of Land* Contamination. CLR 11.
[14] M.J. Carter Associates. (1995*). Prioritisation and Categorisation Procedure for Sites which may be Contaminated*. Department of the Environment. CLR 6

Table 10. Semi-quantitative risk assessment

Source/Medium	Receptor	Potential Exposure Route	Risk Rating
Organic/inorganic contaminants within Made Ground	Construction workers	Direct ingestion of soil & dust, inhalation of particulates & vapours and dermal contact	Medium *(due to concentrations of lead recorded in Made Ground)*
	Future site occupiers	Direct ingestion of soil & dust, inhalation of particulates & vapours, indirect ingestion by means of vegetable uptake and dermal contact	Medium *(where soil is exposed due to concentrations of lead recorded in Made Ground)*
	Vegetation and plants	Root uptake	Low
	Buildings & structures	Direct contact and migration & accumulation within building spaces. Damage to water supply pipes.	Low *(assumes appropriate concrete design and agreement of water pipe materials)*
	Groundwater	Leaching and vertical migration of contaminants	Negligible
	Surface water	Leaching and vertical migration of contaminants	Low
Explosive / asphyxiating gases from Made Ground on site, if present.	Internal building spaces & future occupiers	Migration of gases through the surface and via permeable soils	Negligible *(based on the results of the three rounds of monitoring)*
Asbestos in existing building fabric.	Construction workers	Direct ingestion of dust and inhalation of particulates	Medium

6.1.1 Risks to human health

The risk to future site occupiers is considered to be medium where soils are exposed in soft landscaped areas, given the elevated concentrations of lead encountered on site. Risks to site users will be mitigated by the presence of buildings and hardstanding, where present.

The risk to construction workers from the Made Ground and possible asbestos containing material within the fabric of the existing buildings is considered to be medium. It is considered that the potential risks can be controlled through site working practices, including PPE.

6.1.2 Risks to controlled waters

The site is not situated above an aquifer and therefore the risk to groundwater is considered to be negligible. The nearest surface water receptor (*Regent's Canal*) is some 37m south of the site and consists of a clay-lined man-made canal. Given the generally low concentrations of contaminants and cohesive nature of the underlying London Clay Formation, the risk to controlled waters is considered to be low.

6.1.3 Risks to buildings and structures

Due to the generally limited nature of the Made Ground and low concentrations of contaminants recorded, the risk to buildings and structures is considered to be low. The design of buried concrete should take into consideration the pyritic nature of the London Clay Formation and the resultant risk of sulfate attack on the concrete.

6.1.4 Risks to vegetation and plants

No exceedances of phytotoxic chemicals were noted at the site and only limited soft landscaping is proposed. Therefore, the risk to vegetation and plants is considered to be low.

7. GEOTECHNICAL RECOMMENDATIONS

7.1 General

The following sections provide recommendations for the proposed development with regard to geotechnical aspects, based on the information obtained during the intrusive investigation and the laboratory results.

7.2 Geotechnical design parameters

Geotechnical design parameters are recommended based on the available information from the intrusive investigation and published information. These are summarised in Table 11. The values are unfactored (Serviceability Limit State) parameters and are considered to be characteristic values for the local soils.

Table 11. Geotechnical parameters

Stratum	γ (kN/m^3)	ϕ' (°)	Cu (kPa) [c']	Eu (MPa) [E']
Made Ground	18	30[a]	30 [0]	18[b] [13.5[c]]
London Clay Formation	20	24[d]	50+6.9z[e] [5]	30+4.14z [22.5+3.11z]

a. Burland et. al (Eds) (2001) Building response to tunnelling, CIRIA Special Publication 200, CIRIA
b. Based on 600c_u
c. Based on 0.75Eu
d. BS 8002:1994 Code of practice for Earth retaining structures, British Standards institution.
e. z = depth below surface of London Clay

7.3 Foundations

It is recommended that the proposed structure will be supported by a combination of pad and strip foundations. An allowable bearing pressure of 100kPa should be assumed for the purposes of design. The foundations should be founded a minimum of 1.5m below ground level and a minimum of 0.5m into the surface of the London Clay Formation in order to contain settlement to within acceptable limits (i.e. <25mm). Foundation formations should set in accordance with minimum depths in accordance with NHBC recommendations or similar with regard to future landscape planting.

7.4 Excavations

It is anticipated that shallow excavations within the Made Ground and London Clay Formation will remain stable over the short term if dry. Where water is encountered in excavations, such as perched water within Made Ground or surface run-off, temporary sidewall support and dewatering (sump pumping) may be required to maintain excavation stability.

No operatives should enter unshored or otherwise protected excavations identified as unstable by a competent person, however shallow they are, in accordance with the guidelines presented in CIRIA Report 97[15].

7.5 Floor slabs and pavement design

The underlying London Clay Formation has been found to have a high volume change potential. Floor slabs should therefore be designed as suspended in order to prevent damage due to heave movements.

Based on the geotechnical testing undertaken at the site, a design CBR of 2.5% is recommended for pavement design.

7.6 Drainage

Soakaway drainage is not considered suitable for the site, given the cohesive nature of the underlying ground. Permeability of the London Clay Formation can be assumed to be some 1×10^{-9} m/s, which is typical for such a plastic clay.

7.7 Buried concrete

With the exception of one anomalous result, thought to be due to selenite crystals within the sample, the results of pH and sulfate testing undertaken at the wider development site indicate that buried concrete within the London Clay Formation should be designed to Design Class DS-3 and ACEC Class AC-2s due to the pyritic nature of the stratum.

The availability of total potential sulfate (TPS) in pyritic soils is dependent on the extent to which the soils are disturbed, and the level to which the soils may oxidise, resulting in sulfate ions that may reach the concrete. In this regard, BRE SD1 guidance[16] states that *"Concrete in pyritic ground which is initially low in soluble sulfate does not have to be designed to withstand a high potential sulfate class unless it is exposed to ground which*

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[15] CIRIA (1992). *Trenching Practice (Second Edition).* Construction Industry Research and Information Association Report 97.

[16] BRE Construction Division (2005) Special Digest 1: *Concrete in aggressive ground*.

has been disturbed to the extent that contained pyrite might oxidise and the resultant sulfate ions reach the concrete. This may prompt redesign of the structure or change to the construction process to avoid ground disturbance; for example, by using precast or cast-in-situ piles instead of constructing a spread footing within an excavation".

The proposed foundation solution for the site (strip and pad foundations founded within the London Clay Formation) requires excavation of soils, which will cause disturbance and oxidisation of the soils. Buried concrete at the site should therefore be designed to Design Class DS-3 and ACEC Class AC-2s.

8. GEOENVIRONMENTAL RECOMMENDATIONS

8.1 Contamination and remediation

The concentrations of lead recorded within the Made Ground present a potential unacceptable risk to human health where soil is exposed. In order to mitigate the potential risk to human health, it is recommended that a capping layer is installed in soft landscaped areas. Risks to site users will be mitigated by the presence of buildings and hardstanding, where present.

The capping layer should generally comprise a minimum of 150mm topsoil over 450mm subsoil and a geotextile membrane. However, this may be reduced to a minimum of 150mm topsoil over 300mm subsoil and a geotextile membrane in areas of communal landscaping. It should be confirmed that these areas will remain as communal landscaping and will not be redeveloped, for example as a vegetable garden. Should the Made Ground be removed for disposal off-site at an appropriate facility, only a growth medium will be required.

Based on the results of the three ground gas monitoring visits undertaken to date, the site conforms to Characteristic Situation 1 and no ground gas protection measures are therefore required in the development.

It is noted that an attenuation tank is included in the southeast of the proposed development of the site. It is anticipated that that the tank will be founded within the London Clay Formation. The cohesive nature of this stratum will therefore restrict potential leakage of contaminates from the tank..

8.2 Material management

A preliminary assessment of the results of analysis of Made Ground for waste classification purposes indicates that the majority of this material may be classified as 'not hazardous' with respect to waste disposal. Waste acceptance criteria (WAC) testing indicates that the 'not hazardous' samples may be disposed of at an inert landfill.

Uncontaminated natural soils, as encountered at the site, can be disposed of at an inert landfill as listed inert waste.

It should be noted that in May/June 2012 HMR&C issued Briefs 15/12 and 18/12 clarifying how construction spoil and excess soils will be assessed for landfill tax purposes. Detailed accurate descriptions of waste are required for all wastes to support the landfill tax assessment. Uncontaminated naturally occurring soils will remain inert by default and eligible for the lower rate of landfill tax. Similarly 'reworked soils' and demolition 'stone' comprising ONLY materials listed in the Schedule of the Landfill Tax (Qualifying Material) Order 2011 (SI 2011/1017) will also be eligible for the lower rate of landfill tax. However, Made Ground containing soil and foreign objects such as timber, plastic, rubber, metal, paper, plasterboard, asbestos, etc., regardless of the results of chemical analysis for waste classification purposes, will be eligible for the standard (higher) rate of landfill tax. Therefore, to maximise eligibility for lower rate landfill tax on waste construction spoil/ reworked ground, careful waste segregation and controls are necessary.

All material intended for offsite disposal should be transported and disposed in accordance with the Environmental Protection (Duty of Care) Regulations, 1991 and the Landfill (England and Wales) Regulations, 2002 (as amended). Waste legislation stipulates that hazardous and not hazardous waste should be pre-treated prior to disposal. Pre-treatment can be undertaken either at the site of origin or may be carried out at a licensed off-site facility and can include selective segregation of soils conducted on site.

8.3 Buried services

Based on the measured concentrations of contaminants within the Made Ground, it is anticipated that PE or PVC pipes will be suitable for use at the site. However, it is recommended that the water supply company is contacted to confirm this recommendation is acceptable to them.

8.4 Discovery Strategy

The investigation was limited by the presence of buildings across the majority of the site. A watching brief should therefore be undertaken by the Contractor during earthworks and construction works. Should areas of unexpected contamination be encountered or suspected, a qualified geoenvironmental engineer should be informed and the risk associated with the contamination assessed. Where necessary, an appropriate remediation strategy will be devised and implemented. The regulators will be informed of any additional areas of contamination so identified and will be provided with the risk assessment and proposed remediation methodology for agreement before undertaking such works. Appropriate verification works to be completed if remedial measures are required will also be identified and agreed.

The following nominal discovery strategy is recommended:

1. Work to cease in that area.
2. Notify geoenvironmental engineer, to attend site and sample material. Notify Environmental Health Officer at Camden Council.
3. Geoenvironmental engineer to supervise the excavation of contaminated material, which should be placed in a bunded area and covered to prevent rainwater infiltration.
4. Soil samples should be obtained by the geoenvironmental engineer from both the excavated material and the soils in the sides and base of the excavation to demonstrate that the full area of contamination has been excavated. If appropriate, in-situ testing should be undertaken on the sides and base of the excavation to assess the presence of residual contamination in the soils.
5. On receipt of chemical test results, the soils may be appropriately classified for treatment or disposal, and dealt with accordingly.
6. Detailed records, including photographs and duty of care records, of the excavations, stockpile sizes, source and location should be kept and regularly updated to allow materials to be easily tracked from excavation until disposal off site.
7. Backfilling to be undertaken with material certificated as suitable for the proposed end land use.

8.5 Health and safety

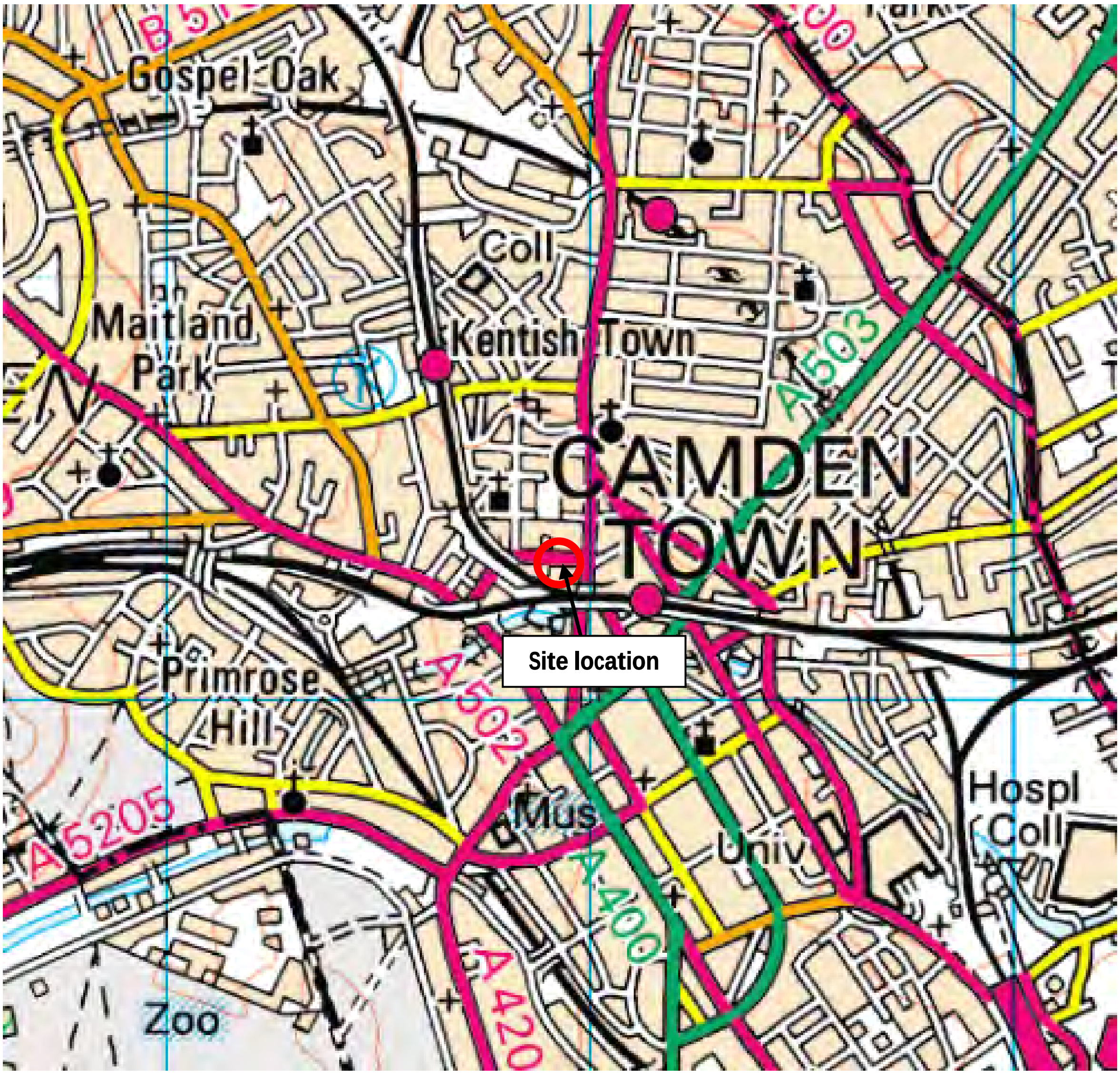
Precautions should be taken to minimise exposure of workers and the general public to any potentially harmful substances during earthworks.

The risks to construction workers can be controlled through the implementation of site safety procedures and the use of suitable personal protective equipment (PPE). Attention should also be paid to restricting possible off-site nuisance such as dust and odour emissions. All work should be carried out in accordance with the Contractor's Construction Health and Safety Plan.

Precautions will include but not be limited to:

- Personal hygiene, washing and changing procedures.
- Adequate personal protective equipment.
- Dust and vapour suppression methods, including damping down, minimising the working face exposed and covering stockpiles, where required.
- Regular cleaning of all site roads, access roads and the public highway.
- Safe storage of fuel and other potentially polluting liquids and the provision of spill control and clean up facilities.
- Positive collection and disposal of on-site run-off.

FIGURES



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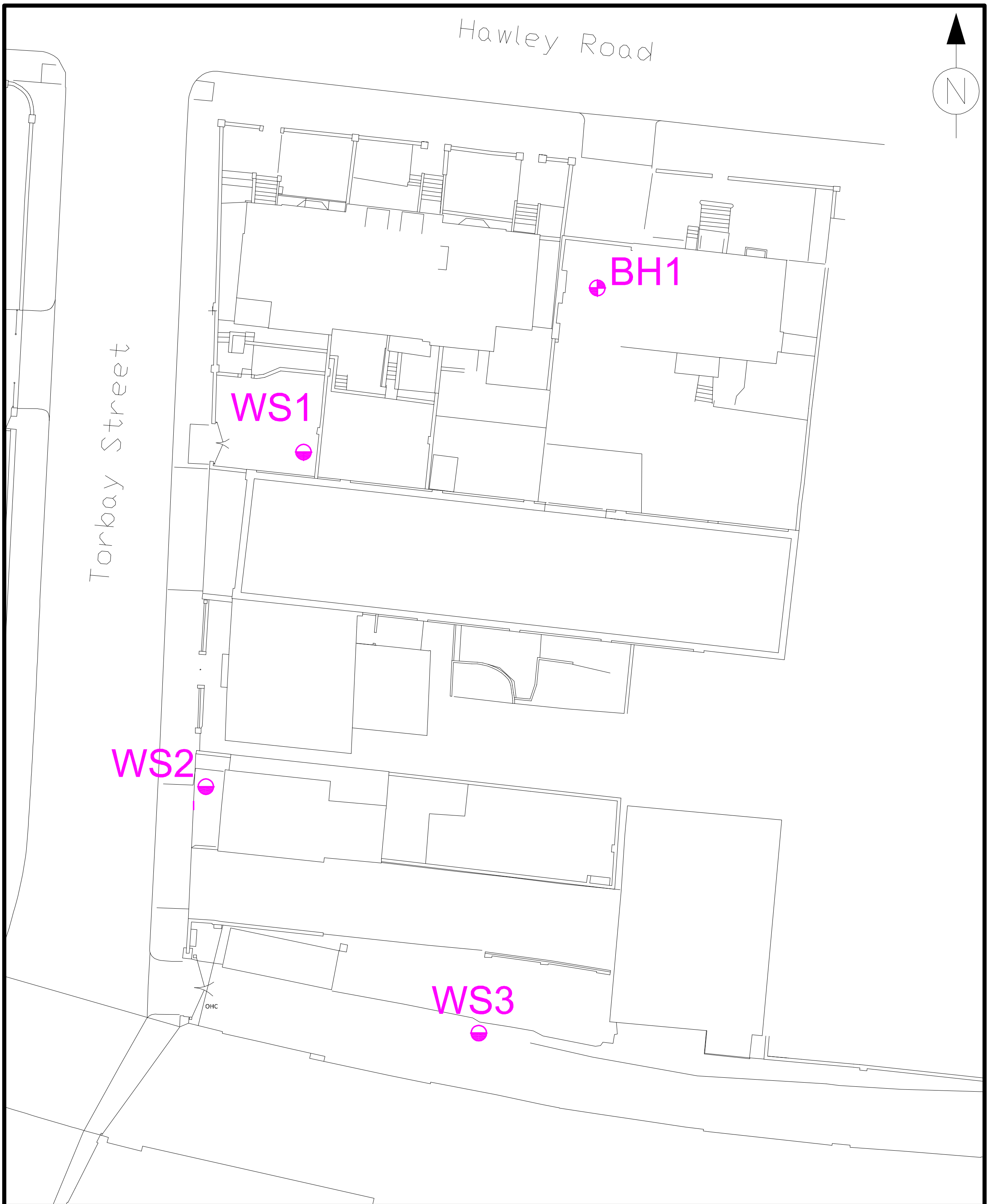
Client	Project	Job No
Walsh Group	**Camden Lock, London – Proposed School Site**	**CG/18067**
CGL	Title **Site location plan**	**Figure 1**

Figure provided by the client
Not to scale

Client	Project	Job No
Walsh Group	**Camden Lock, London – Proposed School Site**	**CG/18067**
CGL	Title **Site layout plan**	**Figure 2**



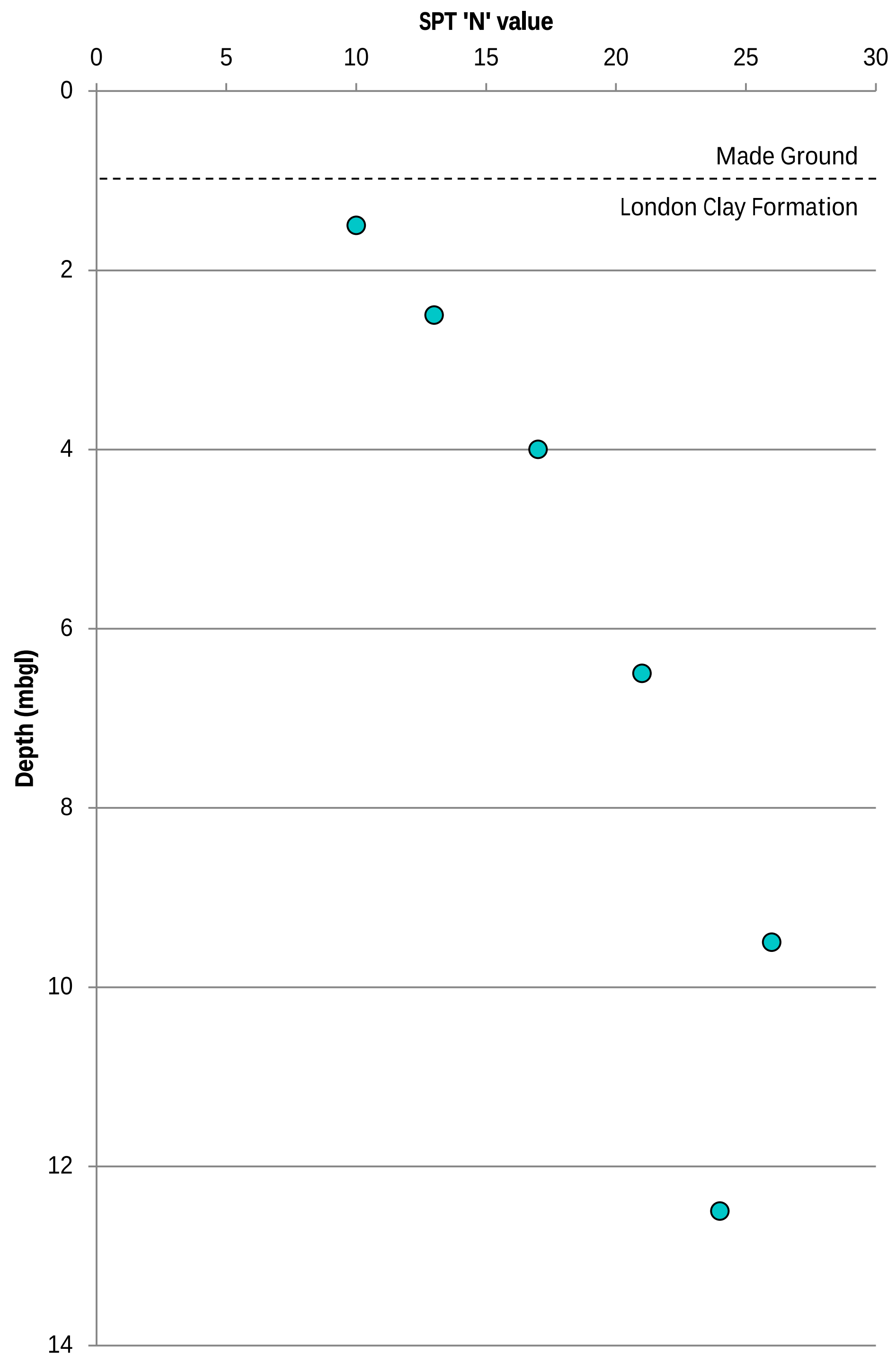
Client	Project	Job No
Walsh Group	**Camden Lock, London - Proposed School Site**	**CG/18067**
CGL	Title **Exploratory hole location plan**	**Figure 3**

Source
A. Elevated lead concentrations within Made Ground
B. Ground gas
C. Asbestos in building fabric

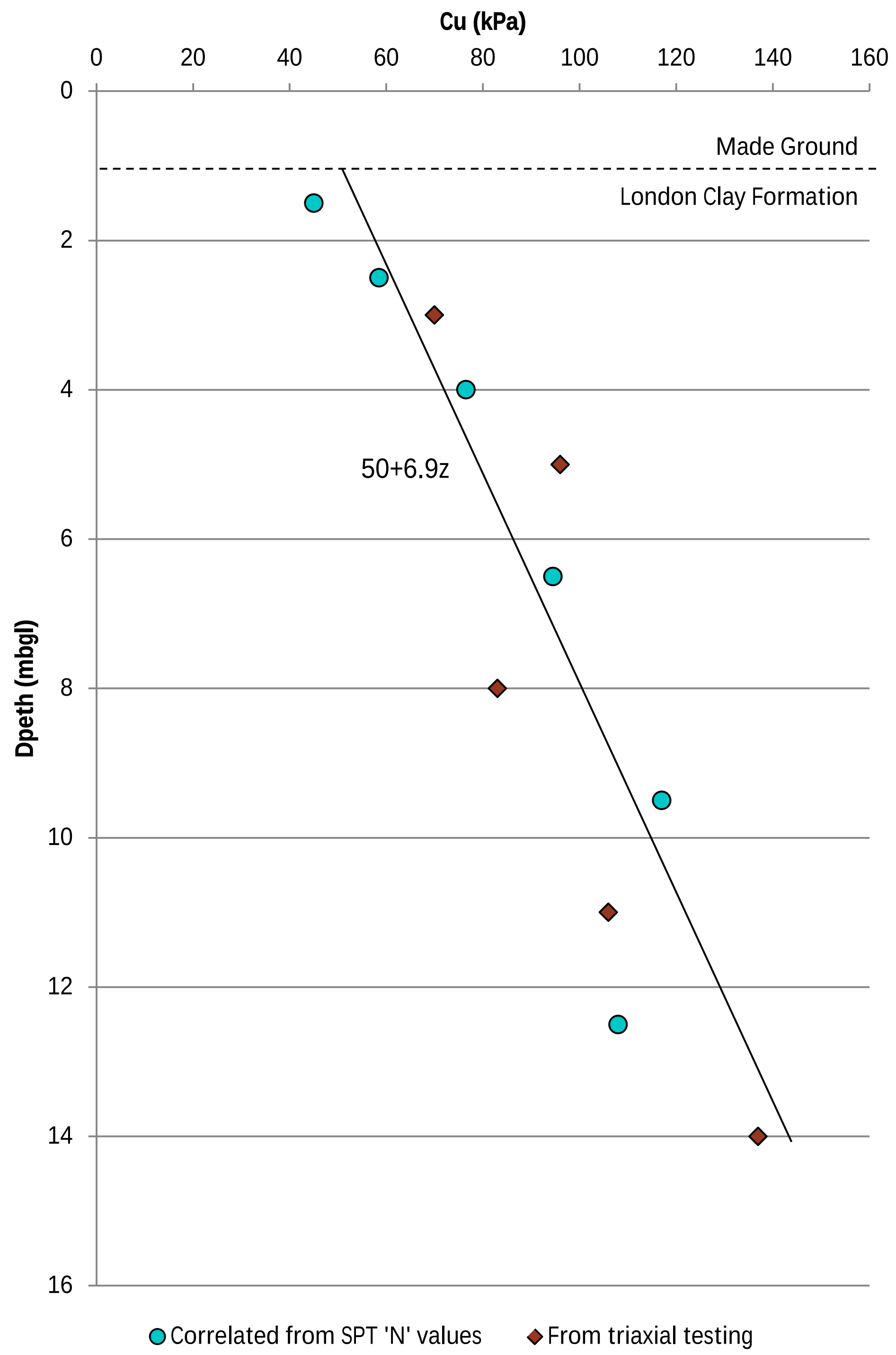
Pathway
1. Ingestion, inhalation and direct contact
2. Root uptake
3. Vertical and lateral migration

Receptor
i. Current/future occupants
ii. Construction workers
iii. Vegetation and plants
iv. Groundwater or surface water
v. Buildings and structures

Client	Project	Job No
Walsh Group	**Camden Lock, London – Proposed School Site**	**CG/18067**
CGL	Title **Conceptual site model**	**Figure 4**



Client	Project	Job No
Walsh Group	**Camden Lock, London – Proposed School Site**	**CG/18067**
CGL	Title **Plot of SPT 'N' values against depth**	**Figure 5**



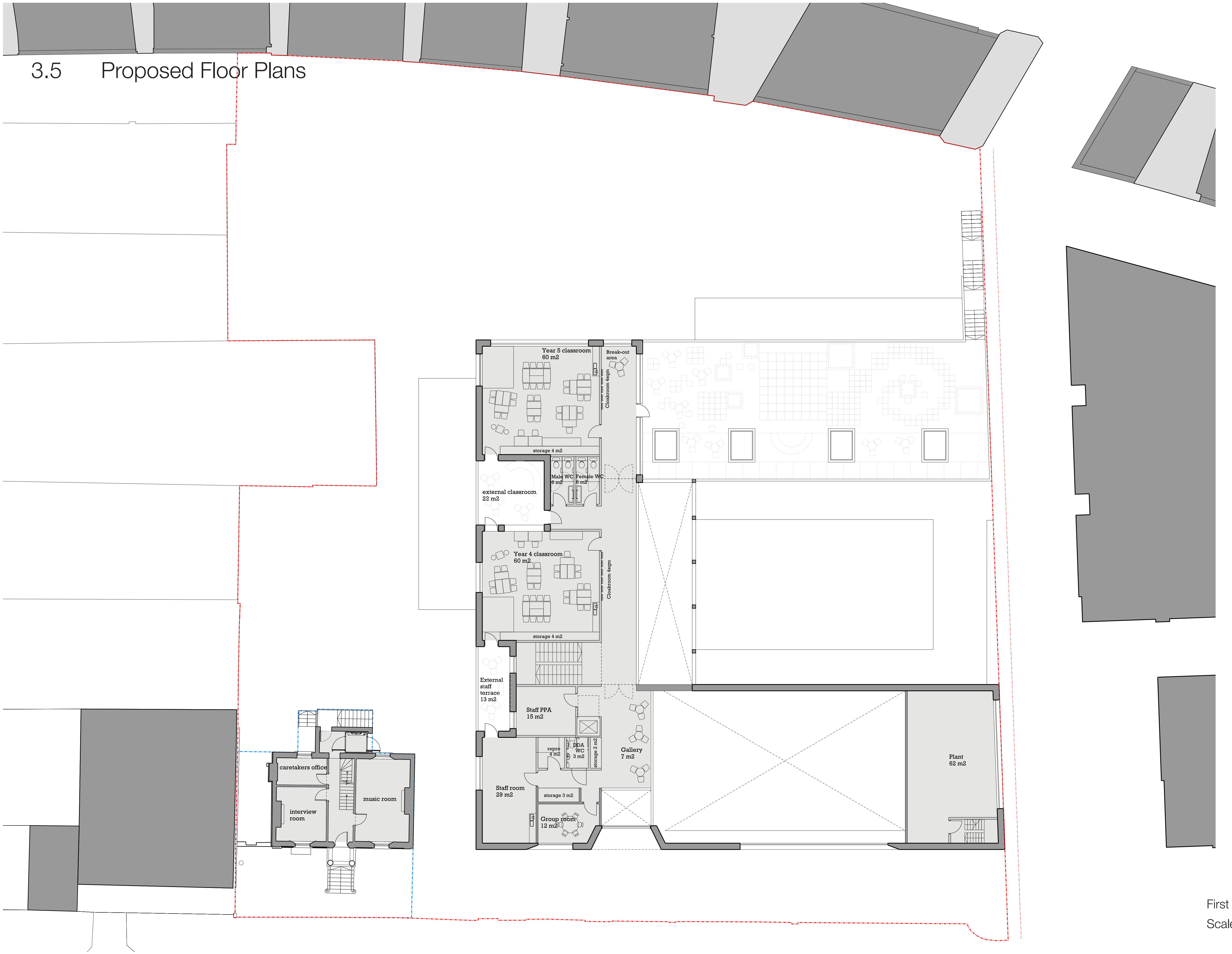
Client	Project	Job No
Walsh Group	**Camden Lock, London – Proposed School Site**	**CG/18067**
CGL	Title **Plot of Cu against depth**	**Figure 6**

APPENDIX A

Proposed development plans

Ground floor plan
Scale 1:250

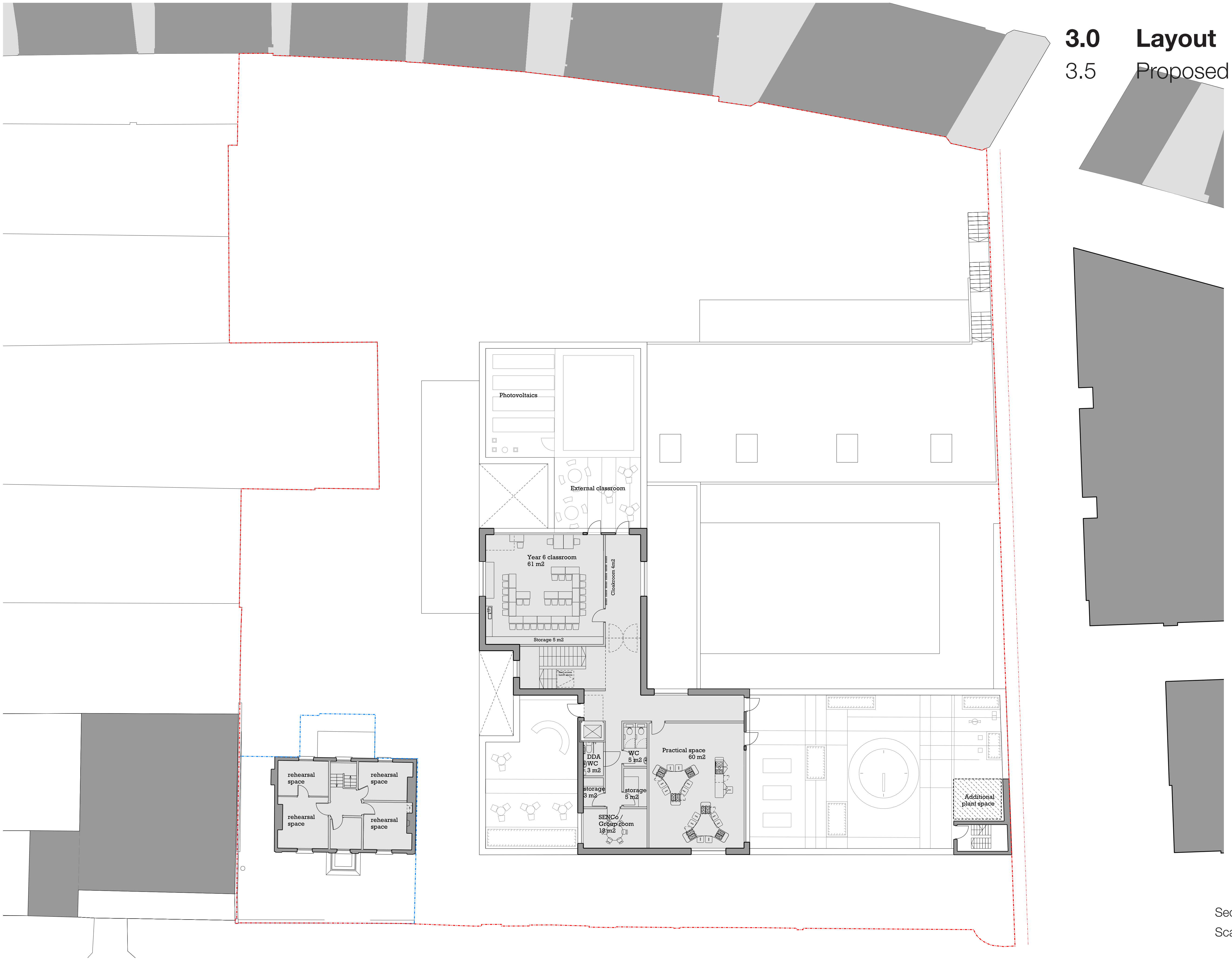
3.5 Proposed Floor Plans



First floor plan
Scale 1:250

3.0 Layout

3.5 Proposed Floor Plans



Second floor plan
Scale 1:250