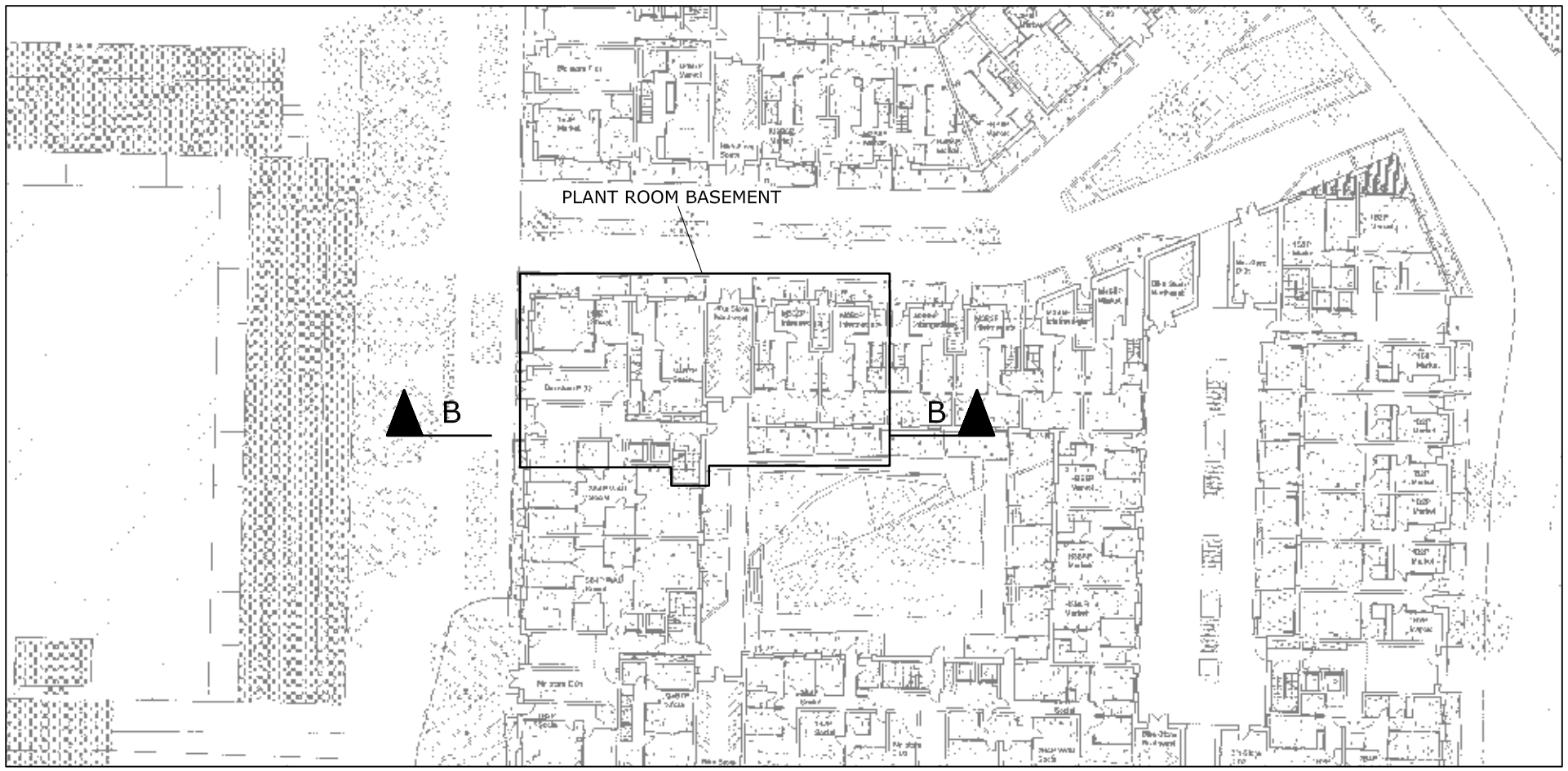

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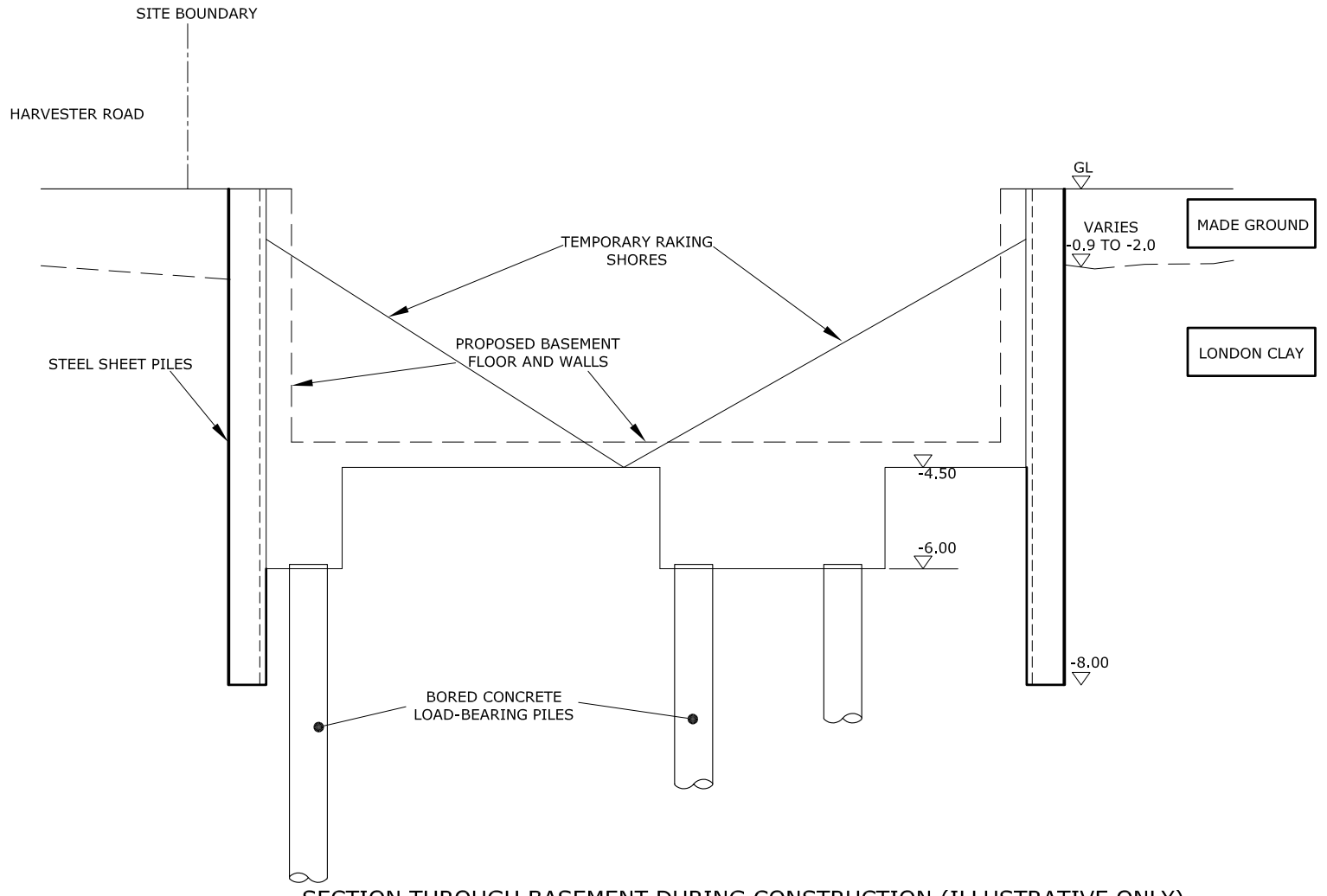

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Revisions

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EC HARRIS
BACTON LOW RISE
CAMDEN

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APPENDIX E
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Appendix C . Site Investigation reports

Geotechnical and Geo-environmental report by Rolton Group Ltd dated November 2012

12-0083

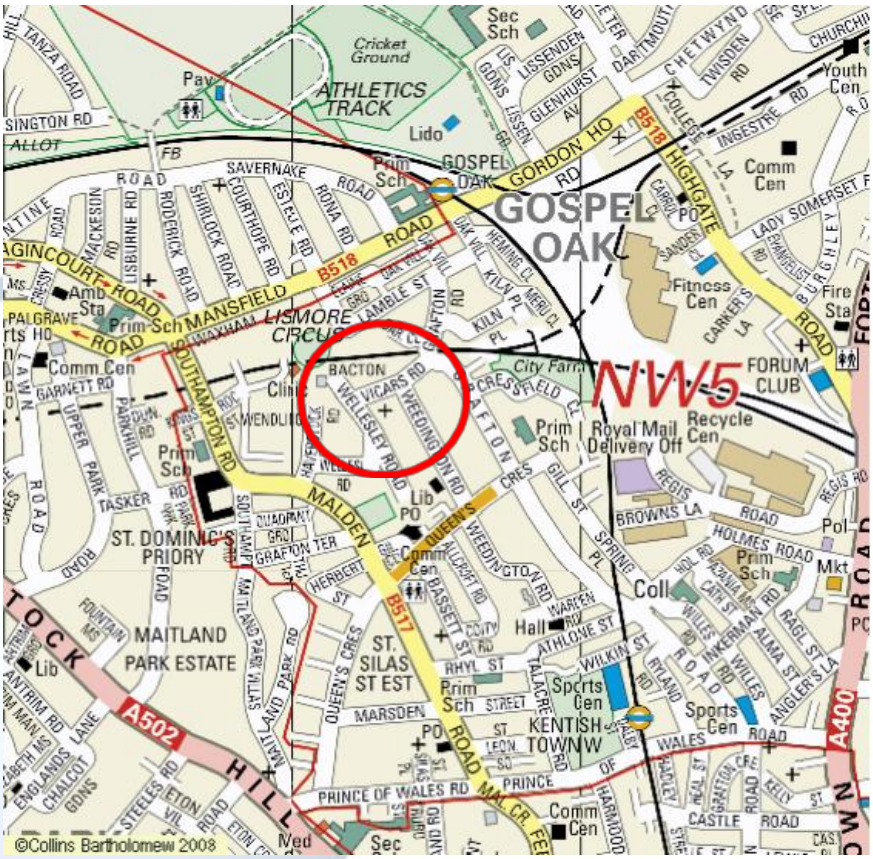
GEOTECHNICAL AND GEO-ENVIRONMENTAL REPORT

FOR

E C HARRIS LLP

AT

BACTON LOW RISE REDEVELOPMENT
GOSPEL OAK, LONDON



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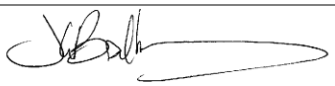
REVISION & ISSUE RECORD

Revision	Date	Name	Position	Signature
/	October 2012	Peter Atkinson	Senior Engineer	
		Julian Bradbury	Associate Director	

Revision	Date	Name	Position	Signature
A	Nov 2012	Peter Atkinson	Senior Engineer	
		Julian Bradbury	Associate Director	

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CONTENTS

PREFACE

a) The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site work and on the results of tests made in the field and laboratory. However, there may be special conditions prevailing at the site which have not been disclosed by the investigation and which have not been taken into account in the report. Accordingly, a careful watch should be maintained in any future groundworks and the findings and recommendations of this report reviewed, if necessary, as work proceeds.

b) The comments on groundwater conditions are based on observations made at the time the site work was carried out. It should be noted that groundwater levels vary owing to seasonal and other effects.

SUMMARY

Client Details	EC Harris LLP on behalf of the London Borough of Camden Council
Proposed Development	3 to 7 storey blocks of residential flats plus community facilities.
The Site	
Location	To the east of Haverstock Road and north of Wellesley Road and Vicars Road in Gospel Oak, north London.
National Grid Ref	528090 185290
Topography	The site falls slightly from west to east from around 45m AOD to 41m AOD. The northern boundary is defined by a railway in a cutting; the remaining boundaries are formed by roads serving the site and surrounding residential housing. There are no surface water features.
Area	The site is of 2 parcels of 7 hectares and 4 hectares respectively.
Description	The northern parcel consists of Camden Council offices, a hall, workshops and a yard. The southern parcel consists of residential blocks of flats around 3 landscaped courtyards.
Site Surface Features and Vegetation	Most of the site is built upon or is covered by hardstanding and parking areas. The courtyards are of grass with trees.
Site History	Developed with a school and mainly terraced housing by 1873. Part of the southern edge destroyed in WWII. The school replaced by Corporation offices and yard by 1954. The southern parcel redeveloped in the 1960s with flats.
Environmental Setting	
Geology	The British Geological Survey (BGS) map for the area, Sheet 256 'North London' (1:50,000) shows the site and surrounding land to be underlain by the London Clay Formation.
Hydrology	A tributary of the River Fleet used to flow north to south across the site – this was culverted to the west in the 1860s. No surface water features remain.
Hydro-geology	The London Clay is not an aquifer.
Ground Conditions	
Soils/Rock	Investigations show up to 0.9-2.0m of made ground (fill) consisting of clay with brick, concrete and ash or clinker overlying firm to stiff gravelly clay becoming stiff to very stiff clay with claystones.
Groundwater	Present at varying depths between 1.59m and 9.55m in borehole standpipes. Encountered at 0.5m in one borehole during drilling.
Excavations	Should generally be possible by use of normal mechanical excavators. Made ground will tend to be unstable where old foundations, service trenches etc are encountered.

Foundation Design Overview	
Type	Pads and strip foundations placed in the natural ground could be considered but piling will likely be required for over 3 storeys. CFA piling or Helical Displacement piles recommended because of proximity of houses and commercial businesses.
Allowable Bearing Pressure	An allowable bearing pressure of 100-150kN/m² for pads or strips in natural strata dependent on depth.
Concrete Mix	Mass (unreinforced) concrete design environment is DS-3, AC-3.
Ground Floor Slabs	Suspended – either precast or reinforced generally recommended. If the made ground can be removed or compacted and a suitable sub-base provided then ground-bearing slabs could be considered.
Infrastructure Design	
Soakaways	Soakaways should not be used in made ground (fill) because of the risk of inducing uncontrolled settlements and, here, it would not be recommended because of the local elevations of hydrocarbons. Gravity disposal should be used to off-site.
Roads and Hardstandings	Formations in the made ground are likely to have a CBR of around 2-5%. Capping will likely be required. Further testing of formations is recommended.
Contamination and Remediation Works	
Soil Contamination	There is local contamination presence – Lead and Hydrocarbons. Generally the site does not appear to be seriously impacted with contaminants. Further testing is however recommended once the site is cleared.
Gas Contamination	No significantly degradable materials found in the made ground (fill) and no plausible sources of hazardous gases have been identified in the near vicinity. Monitoring shows no Methane and low concentrations of Carbon Dioxide (up to 4.5%). Further monitoring is recommended.
Remedial Works / Mitigation Measures	Private gardens and areas for vegetable or fruit production should receive 600mm of clean validated soils. It is likely that any water supplier will require non-polymer supply mains because of the Hydrocarbon presence in soils – this should be confirmed by the relevant water supplier.
Waste Classification	Chemical testing suggests soils from site may be classified as 'inert' or 'non-hazardous' for disposal purposes but further testing is recommended once the site is cleared.

1.0 INTRODUCTION

EC Harris LLP has been appointed by the London Borough of Camden to provide Design and Build Consultancy services in respect of the regeneration of a predominantly residential area in Gospel Oak. Rolton Group Ltd (RGL) has been appointed by EC Harris to provide Geo-environmental, Civil and Structural Engineering design services for the project.

The site comprises two adjoining irregularly shaped parcels of land. The larger, to the south, known as the Bacton Low Rise Estate consists of a series of residential blocks built around three courtyards. The smaller parcel known as the District Housing Office Site lies along the southern side of a railway (First Capital Connect overground route) – it consists of Camden Council offices, small commercial/business units and a Hall.

It is proposed to redevelop the site with multi-storey blocks of residential units and communal facilities.

A Phase 1 Desk Study has already been prepared by RGL to which reference should be made for details of the site history and its environmental setting. The report is:

- *Phase 1 Geo-environmental Desk Study for EC Harris LLP, at Bacton Low Rise, Gospel Oak, London*, dated May 2012.

Additionally, a Basement Impact Assessment is in preparation by RGL. This specifically considers how construction below ground may affect or be affected by existing structures and ground stability and groundwater presence. The report reference is:

- *Basement Impact Assessment for EC Harris at Bacton Low Rise, Gospel Oak, London* [anticipated issue date – October 2012]

The present report summarises the findings of the Desk Study and presents the findings of Geo-environmental investigation works carried out at the site for the purposes of foundation and infrastructure design and to identify remediation or mitigation works required in respect of contamination presence. The report has been prepared to support a full planning application.

Investigations to date have been conducted while the site was still fully occupied. It is not anticipated that extensive remediation works or reclamation works will be required but some further investigations and testing are recommended once the site has been cleared of existing buildings and prior to redevelopment commencing. A further report will therefore be necessary to present the findings of these additional works and any amendments to the recommendations of the present report.

Ultimately, it is envisaged that a letter/report will be required upon completion of all groundworks to confirm that any required remediation works have been successfully undertaken and that no unanticipated ground conditions or previously unidentified contaminative substances were found during redevelopment (if that proves to be the case).

This report makes comments with respect to demolition and site clearance only in so far as these activities may affect the ground. This report does not assess the risk of contaminative substances (such as asbestos) being present in the existing buildings or in buried services. The risk of such substances being present should be assessed by appropriate hazardous materials surveys. It is assumed however that demolition and site clearance will be conducted carefully to ensure that there is no release of any contaminative substances.

2.0 THE SITE

For full details of the site's history and environmental setting reference should be made to the Phase 1 Desk Study mentioned in Section 1.0 above. The Sections below provide a summary of the site and its environmental setting.

2.1 SITE LOCATION AND DESCRIPTION

The site is located in Gospel Oak in north London. The southern parcel is bounded to the west by Haverstock Road while the remaining boundaries are formed by Wellesley Road which loops round the site leading to and from Haverstock Road. The northern parcel is on the south side of a 5-7m deep railway cutting in which there is an electrified line (First Capital Connect) running between Kentish Town and West Hampstead. The northern parcel is further bounded by Vicars Road and flats and a Nursery to the south and by Wellesley Road at the western end.

Ground levels in the area fall from around 45m AOD at the west of the site to around 41m AOD in the east. The southern parcel of land covers around 7 hectares and is approximately centred on National Grid Reference 538085 185250; the northern parcel covers around 4 hectares and is centred at approximately National Grid Reference 528150 185350.

The southern parcel is occupied by 4-storey blocks of flats arranged on a grid basis around 3 courtyards. Parking and garages are present in between the blocks and under some of the flats. The northern parcel includes a 2-storey block of business/commercial units, a 3-storey office block and single storey temporary offices used by Camden Housing and Social Services and a Hall used by local residents. The hardstanding area to the rear of the commercial block and Camden Council's Offices is currently used for storage of building materials and also for vehicle parking.

A number of semi-mature trees and grassed areas are present between the blocks of flats and along the roadsides to the southern parcel of land. A few trees are present in front of the commercial block and beside Camden Council's offices. Remaining ground surfaces are generally paved with tarmac or concrete.

A Site Location Plan is included in Annex A to this report.

2.2 SITE ENVIRONS

Land around the site is largely occupied by residential housing of 2-4 storeys – mainly private flats together with care home accommodation. Communal facilities include schools, shops, public houses and, mainly along Malden Road, there are the usual High Street businesses including restaurants. A 20+ storey block of flats is present to the immediate north west of the site.

The railway to the north is in a 5-7m (estimated) cutting with sides formed by mass brickwork retaining walls – it enters a short tunnel to the north west of the site beneath an area of public open space. To the immediate east of the southern land parcel and to the south of the northern parcel is St Martin's Church, a mid-Victorian Grade I listed church.

The present arrangement of the site is shown on the Exploratory Hole Location Plan in Appendix 5 of the Factual Ground Investigation Report by Geotechnics which is included in Annex B.

2.3 ENVIRONMENTAL SETTING

Geology

The British Geological Survey (BGS) map for the area, Sheet 256 'North London' (1:50,000) (Ref. 9.1) shows the site and surrounding land to be underlain by the London Clay Formation. This is described as 'clay, silty in part' and is shown to be of up to 71-110m in thickness.

Hydro-geology

The London Clay is a Non-Aquifer (described by the Environment Agency as comprising 'Unproductive Strata'). There are no strata in the vicinity (within 750m) with an Aquifer designation.

Hydrology

The nearest surface water feature is indicated from the Envirocheck Report to be almost 400m to the north of the site. This is an open-air swimming pool at the southern end of Hampstead Heath.

Historic records show that a tributary of the River Fleet probably flowed across the site – very approximately entering the site at the north and flowing in a south east direction but then turning westwards and south. This watercourse appears to have been culverted or piped before 1872. It was until this time only a few metres wide – less than 5m and probably more of the order of 2 or 3m wide.

3.0 PROPOSED REDEVELOPMENT

The redevelopment will consist of:

- Complete demolition and clearance of the flats and garages on the southern land parcel.
- Demolition and clearance of the Camden Offices and Commercial units on the northern parcel
- Retention of the Hall in the north west corner of the site adjacent to the tower and railway.
- Construction of two 3 to 6 storey blocks predominantly of flats on the southern land parcel – each of these will be built around a central landscaped communal area.
- Construction of a 6-7 storey block of flats in the east of the northern land parcel; construction of a long 3-4 storey block of flats adjacent to the railway; construction of 2 smaller 3-5 storey blocks on the northern land parcel.
- Further local areas of landscaped public open space will be provided.
- Despite the high density of the development it is understood that some areas of the site may be used for cultivation of home produce (fruit and vegetables).
- Retention of Haverstock Road, Wellesley Road and Vicar's Road in their present locations with changes at junctions and new entries to the development only.
- It is not anticipated that significant changes in ground levels will be required.

4.0 RECOMMENDATIONS FROM DESK STUDY

From the findings of the RGL Phase 1 Desk Study, including a Conceptual Site Model of potential pollutant linkages, the following objectives for intrusive site investigation were derived:

1. To confirm the extent of made ground resulting from past development of the site and over what part and to what depth.
2. Determine the geotechnical properties of any made ground at the site.
3. Determine whether contaminative substances are present at site - most likely associated with made ground but potentially in near-surface natural soils
4. Determine the geotechnical properties of the natural ground – including at depth for spread foundations and piled foundations.
5. Determine whether landfill gas is likely to be generated in made ground and whether migration and emission is likely at the surface.
6. Determine the presence of groundwater at the site and whether this is likely to have been impacted by contaminants and what effect it will have on the development – eg foundation construction.

It was concluded that investigations would be best undertaken by a combination of trial pits and boreholes.

5.0 INVESTIGATIONS

5.1 FIELDWORK

Between 13 August and 20 August 2012 a total of 9 boreholes were formed at site by percussion drilling techniques to depths of between 19.65m and 30.15m. The boreholes were located by RGL to give a general coverage across the site but the site was fully occupied and access for the drilling rig and the many buried services present meant that the investigation was constrained to a degree – it was not possible, for example, to drill in the south west corner of the site because of the many services here and lack of convenient space.

It was not considered worthwhile to attempt to undertake any trial pits at this stage because of the disturbance that these would have caused, the restricted available locations and limited additional data that they would likely have yielded. Further investigation works are recommended once the site is cleared and trial pits may be more suitable at this time.

The drilling was undertaken by Geotechnics Ltd, a specialist site investigation contractor, to the instructions of RGL. Insitu strength testing was undertaken by performing Standard Penetration Tests (SPTs) and selected disturbed and undisturbed soil samples were taken for later laboratory testing including for chemical contaminants. Standpipes were installed in 7 of the 9 boreholes to allow monitoring of ground gases and groundwater.

The fieldwork findings and subsequent laboratory testing are presented in the Factual Ground Investigation Report by Geotechnics which is included in Annex B.

5.2 GAS AND GROUNDWATER MONITORING

Two rounds of gas monitoring have been undertaken to date – on 13 September when the atmospheric air pressure was at around 1012-1013mb and on 3 October 2012 when atmospheric air pressure was at around 997-999mb.

On each occasion explosive gas was measured (Methane) plus Carbon Dioxide, Carbon Monoxide, Hydrogen Sulphide and Oxygen together with any flow pressure.

The depth to groundwater in each standpipe (if present) was also measured.

The results of the first round of gas monitoring are presented in Appendix 6 of the Geotechnics Report in Annex B; the results of the second round of gas monitoring are presented in Annex C.

5.3 LABORATORY TESTING

Chemical testing was scheduled by RGL on selected recovered soil samples from the boreholes. Samples were generally from the made ground – this is where contaminants were considered most likely to be present given the history of the site and the impermeability of the natural soils beneath. Chemical analysis for a broad range of determinands was undertaken by a UKAS accredited laboratory, Derwentside Environmental Testing Services Ltd (of Consett). Chemical testing included:

- Heavy metals – Cadmium, Chromium, Lead, Nickel, Selenium & Mercury
- Phytotoxic Metals – Copper & Zinc
- Speciated Polyaromatic Hydrocarbons (PAH) - the USEPA priority 16
- Extractable Petroleum Hydrocarbons (EPH)
- Other compounds – Boron, Phenolc & Cyanide

- Soil pH, organic matter and soluble sulphate (SO_4) were also measured

Geotechnical testing was carried out by Geotechnics on disturbed and undisturbed soil samples. Testing was carried out to determine the following:

- The shear strength of undisturbed clay samples
- Soil pH and soluble sulphate (SO_4)

The results of all the laboratory testing are presented in Appendices 7 & 8 in the Geotechnics Report in Annex B.

6.0 GROUND CONDITIONS

6.1 SOIL STRATA

The boreholes have shown reasonably similar ground conditions to exist across the site and conditions that are consistent with the site history and geological setting.

The boreholes found made ground (fill) across the site of between 0.9m and 2.0m thickness. This made ground consisted (in addition to any road/hardstanding present at the surface) mainly of reworked gravelly clay with brick, concrete and clinker present. It was noted generally to be soft to firm but with no evidence of voids.

Natural ground consists generally of a layer of firm sandy or gravelly clay underlain by stiff to very stiff fissured clay with claystones. These strata are considered to represent the London Clay including its weathered upper surface. The sandy or gravelly upper surface extended to a maximum of 4.0m. All the boreholes terminated in very stiff London Clay.

Insitu strength testing showed the natural soils across the site to increase in strength with depth with SPT values increasing from 10 or below in the upper 3-4 metres to consistently in excess of 20 below 10m and up to in excess of 50 at beyond 20m depth.

A correlation between SPT values and undrained shear strength of 4.5 is frequently used in geotechnical design (with an SPT of 10 equivalent to an undrained shear strength of around 45kN/m²). The results of the triaxial shear strength testing show values somewhat below this correlation figure when compared to the SPT results. This may be the result of fissuring in the clay causing the laboratory testing to give a lower measure of strength that the insitu SPT.

It must be borne in mind that the investigations undertaken to date have deliberately not intercepted foundations or buried services and that these features may be present to depths considerably in excess of 2m. Also we have avoided drilling in close proximity to the railway in the cutting at the north of the site (for safety reasons) and here too the ground may have been disturbed and made up as part of the construction of the retaining walls that form the cutting to a depth well in excess of 2m – the cutting is approximately 5-7m deep.

Full details of the strata encountered together with the results of insitu testing are shown on the borehole logs in Appendix 4 of the Geotechnics Report in Annex B.

6.2 GROUNDWATER

Groundwater was encountered in only one borehole (BH7 at 0.5m depth) during drilling – all other boreholes were dry.

Post-installation monitoring of the borehole standpipes showed groundwater to be present at a variety of depth of between 1.59m and 9.55m depth with BH4 remaining dry.

The presence of groundwater across the site appears unrelated to location or depth of made ground and more to perhaps do with nearby drainage or the presence of granular layers in the London Clay.

There was no evidence of the presence of the former tributary of the River Fleet that is shown on historic maps to cross the site flowing north to south.

It should be noted that groundwater presence may also vary seasonally.

7.0 ENGINEERING ASSESSMENT

7.1 GROUND STABILITY AND SITE CLEARANCE

The made ground although logged generally as soft has been in place for many years. No voids or especially loose or soft conditions were encountered that would appear to demand special construction techniques.

It is possible (but unlikely) that old basements or similar buried features may be present at the site and therefore demolition, clearance and construction works should be planned accordingly.

It is considered that generally the ground across the site will be capable of supporting normal plant and equipment during future demolition, clearance and redevelopment.

Suitable construction surfaces and working platforms will be required in wet weather conditions where existing hardstandings or roads are not present or are not to be retained. Working platforms will need to be specifically designed for piling rigs and especially large cranes or items of plant.

Works in proximity to the railway line at the north boundary of the site should be planned so as to prevent any possible adverse loading of the existing retaining walls here. Network Rail will have to approve any works in proximity to the railway, particularly those such as piling or use of cranes or scaffolding where these could potentially fall on to the track or trackside equipment.

During general site clearance, such as removal of existing foundations and buried services or other features, a careful record should be kept of these (preferably by accurate survey) so that new foundations and infrastructure is designed to take account of the disturbance to the ground that will have resulted. The method of backfilling any voids resulting during site demolition and clearance should be agreed in advance – voids under hardstandings and roads should be backfilled with granular material conforming to capping material or 6F2 according to the *Specification for Highway Works* (Ref 9.16).

The route of the former tributary of the River Fleet that appears to have crossed the site has been completely intercepted by the railway line at the northern site boundary. This former watercourse has also been infilled for in excess of 100 years. It may consist of slightly deeper made ground and with possibly more compressible Alluvium present but it unlikely to cause serious problems of ground stability or groundwater presence.

7.2 FOUNDATIONS

Ground conditions across the site would suggest that traditional spread foundations might be used to some of the proposed development, dependent on loadings and ground levels. This will need to be confirmed once the site has been cleared and the design of the proposed scheme is more advanced.

Spread foundations taken at least 500mm into the surface of the weathered London Clay may be suitable to support 100-150kN/m² depending on their depth. It would have to be ensured that such footings were not affected by deeper made ground or disturbed ground however resulting from old foundations or services.

A typical depth for such foundations would be of the order of 2m below existing ground level – this would therefore require specific health and safety assessment.

For the proposed medium- to high-rise blocks however the above allowable bearing pressure and foundation depth is unlikely to provide cost-effective foundations.

Piling is likely to be the most effective foundation type for most of the site. The London Clay at depth is suitable to support either driven or bored piles although considerations of noise and vibration are likely to preclude a driven system. Continuous Flight Auger (CFA) piles or Helical Displacement piles are considered to be the preferred types – they produce minimal noise and vibration.

A preliminary assessment would suggest the following potential safe working loads for CFA piles constructed to a Factor of Safety of 2.5

Pile depth (m)	SWL for piles of different diameter (kN)		
	300mm	**450mm**	**600mm**
12	200	300	450
15	300	450	625
18	400	600	800
21	500	750	1000

Table 1 – Preliminary Pile Designs

The ground across the site is predominantly shrinkable clay. All foundations must be designed to take account of the presence of existing, removed and proposed trees and vigorous shrubs. Guidance is given by National House-Building Council (NHBC) Standards (Ref 9.5); the clay across the site, near surface and to depth, should be assumed to be of 'High' shrinkability/plasticity when using the NHBC Standards.

Specifically, foundations, including piles and ground beams, should be designed to cater for heave where in proximity to existing and removed trees. Compressible liners such as 'claymaster' may be required to the inside face of trench fill foundations or to the underside of ground beams.

7.3 GROUND FLOORS

In general, because of the presence of made ground across the site and the disturbance that will result from demolition and clearance, it is envisaged that all ground floors at the site will need to be of suspended form. These may be of reinforced concrete or precast concrete.

If a ground bearing slab is proposed to any building then it will be necessary to ensure that:

- There are no voids or old services such as pipes or manholes under the formation;
- Any made ground has been well compacted and is stable durable and inert – there must be no topsoil, wood or other degradable materials;
- Any make-up is placed and well compacted and also consists of durable inert granular fill;
- The clay at depth is not liable to heave or shrink as a result of trees, shrubs or significant changes in ground levels.

No gas membrane is considered to be required to ground floors and no hazardous ground gas mitigation measures are considered necessary.

Ground floors located in proximity to existing or removed trees should be designed with a sufficient void to cater for heave recovery of the ground – guidance is given in NHBC Standards (Ref. 9.5).

7.4 ROADS AND HARDSTANDINGS

No California Bearing Ratio (CBR) testing has been carried out at the site. It is anticipated that CBR values in the made ground or near-surface natural soils will only be of the order of 2%.

It is recommended that once the scheme has been designed and the site has been cleared, insitu testing should be carried out on the proposed formation to the agreement of the Highways Authority.

7.5 EXCAVATIONS AND GROUNDWATER CONTROL

Once the site has been cleared, excavations for foundations and buried services should be possible using conventional plant. It is possible that old foundations and buried features may remain from earlier developments and the presence of voids as a result of old basements or services cannot be ruled out.

The made ground (fill) across the site is likely to be quickly unstable in excavation locally – where for example old service trenches or foundations are encountered or where it is particularly loose. Excavations should be planned accordingly – excavations beyond 1m that require entry should be battered back, propped or shored.

Groundwater is likely to be encountered in made ground in the form of perched seepages; it is also likely to be encountered in redundant pipes and services trenches or where deep foundations have been removed. Provision should be made for the disposal of groundwater by use of sumps and pumps.

All excavation works carried out during construction at the site must strictly adhere to current legislation & guidance (Refs. 9.6 to 9.9), including, but not limited to, design, inspections, reporting and provision of appropriate support or other safety measures.

7.6 BURIED CONCRETE

Soluble sulphate testing and pH determination was carried out on shallow soils during the analysis for contaminants and on deeper soils as part of the geotechnical testing.

The results show the shallow soils including made ground have a pH in the range 8.6 to 11.5 and a soluble sulphate concentration (as SO_4) in the range 0.037 to 1.10 g/litre. The generally high pH is considered very probably due to the presence of concrete and associated harmless lime products.

Testing of deeper soils (below 3m) shows a soil pH in the range 7.69 to 8.78. Soluble sulphate concentrations were in the range 0.30 to 2.98 g/litre – with the highest concentrations being at around 4m depth.

In accordance with BRE Special Digest 1:2005 *Concrete in Aggressive Ground* (Ref. 9.10), the site may be considered 'brownfield' and with a mobile groundwater regime. Buried unreinforced mass concrete should therefore be designed to a Design Sulphate Class of DS-3 and a required Aggressive Chemical Environment for Concrete Class of AC-3.

7.7 SOAKAWAYS

Soakaways should not generally be placed in made ground because of the risks of mobilising contaminants and causing uncontrolled collapse settlements of the ground. The predominant clay to be found across the site will in any case likely prove impermeable. Soakaways are not therefore recommended for stormwater disposal and disposal off-site will be required.

8.0 GEO-ENVIRONMENTAL ASSESSMENT

8.1 LEGISLATION AND GUIDANCE

Prior to any development, the Local Planning Authority is required to satisfy itself that the potential for contamination has been properly assessed and that any necessary remedial works will be appropriately incorporated within the development. For any future development, it is the responsibility of the landowner and/or developer to carry out the necessary investigation, assessment and remediation.

Current governmental legislation defines contaminated land in the Environment Act 1995 and Part IIA of the Environmental Protection Act 1990 (DETR Circular 01/2006), as:

'Any land which appears to the local authority to be in such a condition, by reasons of substances in, on or under the land, that:

- significant harm is being caused or there is significant possibility of such harm being caused;

or

- pollution of controlled waters is being, or is likely to be caused'.

Current legislation and guidance recommends the use of source – pathway – receptor linkage model to assess the risk of contamination within a site. These three essential elements are described as:

Source – a contaminant or hazard which is in, on or under the land and has the potential to cause harm or pollution of controlled waters.
Pathway – means by which a receptor can be exposed to, or affected by, a contaminant or hazard.
Receptor – something that could be adversely affected by a contaminant or hazard e.g. end-users and controlled waters.

A risk can only exist if all three elements are present. For example, even if a contaminant and a receptor are present, they can only create a risk when there is a pathway link between them. The table below represents a Conceptual Site Model with respect to possible contamination presence; it considers plausible pollutant linkages given the site's history, its environmental setting and the initial visual and physical findings of the borehole investigation.

8.2 CONCEPTUAL SITE MODEL

The following table present the Conceptual Site Models for the separate parcels of land that together form the site.

Main residential area between Haverstock Road and Wellesley Road:

Contaminative Source	Pathway	Receptor(s)	Initial Risk Assessment
Spillage of fuels or oils	Ingestion, inhalation or direct contact by residents or neighbours	Residents, site users, neighbours, construction personnel	Recent/modern use of the site suggests few or no significant spillages are likely to have occurred. Initial risk is assessed as **Low**
	Leaching to groundwater and flow off site or to surface waters	Controlled waters, neighbouring properties	Even if spillages have occurred there are no controlled waters nearby or neighbouring land uses likely to be adversely affected by hydrocarbons in groundwater. Initial risk is assessed as **Very Low**
	Contact with building materials eg water mains	Residents, building materials	Polymer water mains can be affected by even low concentrations of hydrocarbons although the result is usually tainted water rather than a serious health risk. Initial risk is assessed as **Low to Moderate**
Spillage of other hazardous chemicals such as solvents or acids	Ingestion, inhalation or direct contact by residents or neighbours	Residents, site users, neighbours, construction personnel	Recent/modern use of hazardous liquids other than fuel and oil appears unlikely. Initial risk is assessed as **Very Low**
	Leaching to groundwater and flow off site or to surface waters	Controlled waters, neighbouring properties	As spillages are unlikely and no controlled waters in vicinity initial risk is assessed as **Negligible**
	Contact with building materials eg water mains	Residents, building materials	Polymer water mains in particular are vulnerable to solvents etc and so initial risk is assessed as **Low**
Deposition of wastes at the surface or of burnt wastes or combustion products	Ingestion, inhalation or direct contact by residents or neighbours	Residents, site users, neighbours, construction personnel	Recent/modern use of the site suggests deposition of wastes directly or by activities such as burning is unlikely to have been significant. Air-borne compounds such as polyaromatic hydrocarbons or hazardous dusts are likely to some degree from vehicles, trains and the urban environment more generally. Collected concentrations are unlikely to be high however. Initial risk is assessed as **Low**
	Leaching to groundwater and flow off site or to surface waters	Controlled waters, neighbouring properties	Even if hazardous compounds are present in soils from this source, leaching to groundwater and flow from site in any significant concentration appears very unlikely. Initial risk is assessed as **Negligible**
	Contact with building materials eg water mains	Residents, building materials	Concentrations in soils are likely to be low and of limited mobility. Initial risk is assessed as **Very Low**

Contaminative Source	Pathway	Receptor(s)	Initial Risk Assessment
Presence of persistent contaminants (eg metals and other inorganic compounds such as asbestos or sulphates or organic compounds such as polyaromatic hydrocarbons) in historic made ground or buried waste	Ingestion, inhalation or direct contact by residents or neighbours	Residents, site users, neighbours, construction personnel	From past use of site and redevelopment there is likely to be significant presence of made ground (fill) and it is likely that this will contain ash, demolition waste and possible old domestic wastes (although with limited organic content). Initial risk is assessed as **Moderate**
	Leaching to groundwater and flow off site or to surface waters	Controlled waters, neighbouring properties	Historic buried waste compounds are likely now to be relatively immobile. Initial risk is assessed as **Low**
	Contact with building materials eg water mains or concrete	Residents, building materials	Polymer water/gas mains and buried concrete can be vulnerable to sulphates and other compounds. Initial risk is assessed as **Low to Moderate**
Landfill gas from degradable buried wastes on site or in the near vicinity	Inhalation or asphyxiation	Residents, Construction personnel	Past use of the site is unlikely to have resulted in deposition of significant organic materials. There is no record of landfill waste nearby and ground conditions are in any case of limited ability to transmit gas or groundwater. Initial risk is assessed as **Low**
	Build up in voids and explosion	Residents, site users, neighbouring properties	
Contaminants in groundwater from adjacent polluted land or other sites	Inhalation of vapours or ingestion via plants	Residents	Surrounding past and recent land uses have limited potential for release of mobile hazardous compounds. Ground conditions will limit transmission of groundwater. Initial risk is assessed as **Very Low**
	Contact with building materials eg water mains or concrete	Residents, building materials	Polymer water/gas mains and buried concrete can be vulnerable to sulphates and other compounds. Initial risk is assessed as **Low**

Table 2 - Conceptual Site Model (Southern Land Parcel)

Camden Council offices and commercial units off Vicar's Road:

Contaminative Source	Pathway	Receptor(s)	Initial Risk Assessment
Spillage of fuels or oils	Ingestion, inhalation or direct contact by residents or neighbours	Residents, site users, neighbours, construction personnel	Recent/modern use of the site suggests few or no significant spillages are likely to have occurred. Initial risk is assessed as **Low**
	Leaching to groundwater and flow off site or to surface waters	Controlled waters, neighbouring properties	Even if spillages have occurred there are no controlled waters nearby or neighbouring land uses likely to be adversely affected by hydrocarbons in groundwater. Initial risk is assessed as **Very Low**
	Contact with building materials eg water mains	Residents, building materials	Polymer water mains can be affected by even low concentrations of hydrocarbons although the result is usually tainted water rather than a serious health risk. Initial risk is assessed as **Low to Moderate**

Contaminative Source	Pathway	Receptor(s)	Initial Risk Assessment
Spillage of other hazardous chemicals such as solvents or acids	Ingestion, inhalation or direct contact by residents or neighbours	Residents, site users, neighbours, construction personnel	Recent/modern use of hazardous liquids other than fuel and oil appears limited. Initial risk is assessed as **Low**
	Leaching to groundwater and flow off site or to surface waters	Controlled waters, neighbouring properties	As spillages are unlikely and no controlled waters in vicinity initial risk is assessed as **Very Low**
	Contact with building materials eg water mains	Residents, building materials	Polymer water mains in particular are vulnerable to solvents etc and so initial risk is assessed as **Low**
Deposition of wastes at the surface or of burnt wastes or combustion products	Ingestion, inhalation or direct contact by residents or neighbours	Residents, site users, neighbours, construction personnel	Recent/modern use of the site suggests deposition of wastes directly or by activities such as burning is unlikely to have been significant. Air-borne compounds such as polyaromatic hydrocarbons or hazardous dusts are likely to some degree from vehicles, trains and the urban environment more generally. Collected concentrations are unlikely to be high however. Initial risk is assessed as **Low**
	Leaching to groundwater and flow off site or to surface waters	Controlled waters, neighbouring properties	Even if hazardous compounds are present in soils from this source, leaching to groundwater and flow from site in any significant concentration appears very unlikely. Initial risk is assessed as **Negligible**
	Contact with building materials eg water mains	Residents, building materials	Concentrations in soils are likely to be low and of limited mobility. Initial risk is assessed as **Very Low**
Presence of persistent contaminants (eg metals and other inorganic compounds such as asbestos or sulphates or organic compounds such as polyaromatic hydrocarbons) in historic made ground or buried waste	Ingestion, inhalation or direct contact by residents or neighbours	Residents, site users, neighbours, construction personnel	From past use of site and redevelopment there is likely to be significant presence of made ground (fill) and it is likely that this will contain ash, demolition waste and possible old domestic wastes (although with limited organic content). Initial risk is assessed as **Moderate**
	Leaching to groundwater and flow off site or to surface waters	Controlled waters, neighbouring properties	Historic buried waste compounds are likely now to be relatively immobile. Initial risk is assessed as **Low**
	Contact with building materials eg water mains or concrete	Residents, building materials	Polymer water/gas mains and buried concrete can be vulnerable to sulphates and other compounds. Initial risk is assessed as **Low to Moderate**
Landfill gas from degradable buried wastes on site or in the near vicinity	Inhalation or asphyxiation	Residents, Construction personnel	Past use of the site is unlikely to have resulted in deposition of significant organic materials. There is no record of landfill waste nearby and ground conditions are in any case of limited ability to transmit gas or groundwater. Initial risk is assessed as **Low**
	Build up in voids and explosion	Residents, site users, neighbouring properties	
Contaminants in groundwater from adjacent polluted land or other sites	Inhalation of vapours or ingestion via plants	Residents	Surrounding past and recent land uses have limited potential for release of mobile hazardous compounds. Ground conditions will limit transmission of groundwater. Initial risk is assessed as **Very Low**
	Contact with building materials eg water mains or concrete	Residents, building materials	Polymer water/gas mains and buried concrete can be vulnerable to sulphates and other compounds. Initial risk is assessed as **Low**

Table 3 - Conceptual Site Model (Northern Land Parcel)

8.3 DISCUSSION OF CHEMICAL TEST RESULTS

From the above model it was considered appropriate to test made ground and shallow soils for a broad range of contaminants. A series of guideline values has been published to facilitate assessment of risk of soil contamination in the UK – these include for Residential or Commercial land use. The CLEA Soil Guideline Values (SGVs), which were first issued from March 2002 and in the process of being updated and reissued on a piecemeal basis relate solely to human health and land use assessment (Refs. 9.11 & 9.12). Other generally accepted values exist derived by the Chartered Institute of Environmental Health and Land Quality Management (LQM), known as 'Generic Assessment Criteria' (GAC) (Ref. 9.13).

The table below summarises the chemical test results and compares these against SGVs or GAC for Residential housing use of the site.

Determinand	**Concentrations (mg/kg)**		**Relevant SGV or GAC for Residential land use (mg/kg)***
	Range	**Average**	
Arsenic	7.9 - 20	11.4	GAC = 32
Boron	0.5 – 3.7	1.38	GAC = 291
Cadmium	0.1 – 0.8	0.36	GAC = 3
Total Chromium	18 - 53	34.7	NA
Chromium VI	All <0.1	<0.1	GAC = 4.3
Copper	15 - 88	30.8	GAC = 2330
Cyanide	<0.1 - 0.2	<0.12	NA
Lead	10 - 770	187.4	NA Former SGV was 450
Mercury	<0.05 – 0.67	<0.19	SGV = 1.0
Nickel	15 - 43	25.4	SGV = 130
Phenols	<0.3 – 0.6	<0.32	GAC = 210
Selenium	<0.5 – 1.2	<0.54	SGV = 350
Zinc	42 - 200	99	GAC = 3750
Extractable Petroleum Hydrocarbons (EPH)	<10 - 290	<37.7	NA
Polyaromatic Hydrocarbons (PAH)	<1.6 - 71	<6.5	NA
Benzo[a]pyrene (BaP)	<0.1 – 5.9	<0.52	GAC = 0.83
Other soil properties:			
pH	8.6 – 11.5	NA	NA
Organic matter (%)	0.3 – 3.6	1.3	NA
Soluble Sulphate (SO_4)	0.037 – 1.10	0.311	NA

Table 4 – Chemical Test Results for Typical Contaminants

NA= Not Available or Not Applicable
* Where different values are indicated dependent on the form of the compound or the nature of the soil the lower value has been used.

From the above (and the full test results in Appendix 8, Annex B) it may be seen that the following instances of elevated contaminant presence have been identified:

Contaminant	Location	Concentration (mg/kg)
Lead	BH7 at 0.3m	640
	BH8 at 0.3m	770
EPH	BH2 at 1.0m	290
PAH (total)	BH2 at 1.0m	71
BaP	BH2 at 1.0m	5.9

Table 5 – Contaminants of Concern

These few instances of elevated contaminant presence are showing only slightly elevated results. The precise origin of the Lead and Hydrocarbons is unclear but these areas are subject to vehicle traffic and minor spillages of fuels, oils are possible and release of paints or other Lead-containing compounds are possible. Equally these contaminants may result in part from older use of the site and placement of ash and clinker (both noted to be present). Ash and clinker tends to contain metals and Polyaromatic Hydrocarbons (as a result of incomplete combustion of organic materials).

The results would indicate soils that are unsuitable to remain in gardens where there is a risk of children coming into contact with soils or where home-grown produce may be consumed.

8.4 DISCUSSION OF GAS MONITORING RESULTS

The following table summarises the results of the 2 rounds of gas testing to date – it shows the highest values of Methane and Carbon Dioxide and the lowest values of Oxygen recorded.

Borehole Ref	Methane (%LEL)		Carbon Dioxide (%)	Oxygen (%)	Flow (litre/hr)	Comments
	Peak	Steady				
BH1	<2	<2	0.2	20.2	0.0	Round 1
	0.0	0.0	0.2	20.3	0.0	Round 2
BH2	<2	<2	3.8	14.6	0.0	Round 1
	0.0	0.0	4.5	12.1	-0.3	Round 2
BH3	<2	<2	0.9	18.1	0.0	Round 1
	0.0	0.0	1.3	17.2	0.0	Round 2
BH4	<2	<2	1.1	19.1	0.0	Round 1
	0.0	0.0	0.7	18.5	0.0	Round 2

Borehole Ref	Methane (%LEL)		Carbon Dioxide (%)	Oxygen (%)	Flow (litre/hr)	Comments
	Peak	Steady				
BH5	<2	<2	2.0	19.2	0.0	Round 1
	0.0	0.0	3.6	17.6	+0.1	Round 2
BH7	<2	<2	1.0	16.9	0.0	Round 1
	0.0	0.0	2.5	16.1	+0.4	Round 2
BH9	<2	<2	0.2	20.1	0.0	Round 1
	0.0	0.0	0.1	20.4	0.0	Round 2

Table 6 – Gas Monitoring Summary

It may be seen that Methane has not been detected in any standpipe and that the maximum value of Carbon Dioxide is 4.5% - with all standpipes showing some Carbon Dioxide presence. Two boreholes have shown slight flows of up to 0.4 litres per hour.

The results suggest that there is no landfill gas being generated at the site. The elevated Carbon Dioxide is likely due to weathering of soils and perhaps weathering of concrete within the made ground.

These results would initially indicate that the gas regime at the site corresponds to Characteristic Gas Situation 1 according to *BS 8485: 2007 'Code of practice for the characterization and remediation from ground gas in affected developments* (Ref. 9.17) and therefore no gas protection measures would be required. This will be confirmed however upon completion of at least one further round of gas monitoring and upon completion of the further investigations recommended in Section 8.0 below.

8.5 RECOMMENDATIONS WITH RESPECT TO CONTAMINATION PRESENCE

At present no remediation or mitigation measures are considered necessary with respect to the presence of hazardous ground gases at the site. This is to be confirmed following the additional investigations described below but the probability of such further works identifying the need for remediation or mitigation measures in respect of gas is considered low.

The slightly elevated concentrations of Lead and Hydrocarbons identified on site are not considered suitable to remain in garden areas where prolonged exposure could result directly or by home-grown produce. It is recommended that all such areas receive a 600mm minimum cover of clean validated soils. This should include a capping layer of dense hardcore or similar to act as a capillary break and physical deterrent to deep excavation.

Polymer water supply mains can be affected by even low concentrations of Hydrocarbons causing 'tainting' of the water. Because of the slight Hydrocarbon presence it is likely that new water supply mains will have to be in non-polymer material. The results of the chemical testing should be provided to the water supplier.

Soils from site are likely to be classified as either 'inert' or 'non-hazardous' for disposal purposes. Once the site has been cleared and there is a better understanding of what materials can be reused and what balance exists of soils to remain and those to be removed, further testing should be carried out for waste classification purposes (see below).

9.0 RECOMMENDATIONS FOR FURTHER INVESTIGATIONS

9.1 GROUND GAS MONITORING

At least one further round of gas monitoring should be undertaken of the existing boreholes with standpipes. Although considered unlikely, if significant quantities of degradable materials are found in future investigations then it may be necessary to install additional standpipes to enable further gas monitoring. This need should be assessed once the site has been demolished and cleared of existing buildings.

9.2 DURING DEMOLITION AND SITE CLEARANCE

It is recommended that inspections should be carried out by a geo-environmental engineer during the demolition and site clearance works to determine the nature of the ground presently covered by buildings and hardstandings and also to confirm the suitability of materials in the ground for reuse. The following should be considered during such inspections:

- What foundations have been used to the existing buildings? Is there evidence of ground conditions different to those recorded to date and to what depth have existing foundations (and their removal) affected the ground.
- If piles have been employed and these cannot be removed, to what depth should they be cut down and will the remaining parts affect foundations, buried services or hardstandings (by acting as 'hard spots').
- Is there any evidence of wastes or spills or any other contaminant releases having taken place – for example from garage areas, underground tanks/pipes, waste collection areas or the like?
- Have service routes acted to transmit contaminants?
- Are existing concrete slabs and foundations suitable for crushing and reuse? Similarly is brickwork from substructures and existing hardcore sub-base material suitable for reuse as fill? Do these materials need any form of treatment before reuse or disposal?

Any suspicious materials in the ground uncovered during demolition and site clearance should be reported to Rolton Group immediately for assessment and testing as required. Such materials might include:

- Odorous soils or groundwater.
- Discoloured soils.
- Cement sheets, insulation board or similar that might contain asbestos.
- Organic wastes.

9.3 POST-DEMOLITION AND SITE CLEARANCE

The soil sampling and testing to date has been constrained by the existing buildings, roads, hardstanding areas and buried services. It is considered that a greater density of sampling and testing is required before redevelopment commences – for the following purposes:

- To confirm that the recommended remedial measures are valid for the entire site.
- For health and safety purposes during construction.
- To better classify soils for disposal purposes.
- To confirm foundation and infrastructure design.

Once the site has been cleared and inspections have been carried out during demolition and clearance (as outlined above), the following additional works should be undertaken:

- A series of trial pits (probably by backhoe excavator) to allow observation of soils and sampling and testing for geotechnical properties and chemical contaminants. Provisionally, it is estimated that around 20 additional trial pits would increase the density of coverage to more acceptable 25m x 25m grid.
- Chemical testing of soil samples should include for Waste Assessment Criteria (WAC) as well as for the range of contaminants tested already and reported upon here.
- If significant degradable materials are found that cannot be removed or deep made ground is identified that extends beyond trial hole depth then additional boreholes would be recommended with standpipes as necessary.
- Proposed formations for roads and hardstandings should be tested by CBR or similar to determine the required depth of construction.

10.0 REFERENCES

9.1 British Geological Survey Sheet 256 (North London, 1:50,000), 1994.

9.2 British Research Establishment Report 211, 1999, 'Radon: Guidance on Protective Measures for New Dwellings'.

9.3 British Standard 5930:1999, 'Code of Practice for Site Investigations'.

9.4 British Standard 1377:1990, Part 9, 'Methods of Test for Soils for Civil Engineering Purposes'.

9.5 National House Building Council Standards - Chapter 4.2 'Building near trees'.

9.6 The Management of Health and Safety at Work Regulations, 1999.

9.7 The Construction (Design and Management) Regulations, 2007.

9.8 The Confined Space Regulations, 1997.

9.9 Construction Site Safety Guidance – E5, 'Working in and around Excavations'. CITB, January 2007.

9.10 Building Research Establishment, BRE Special Digest 1:2005 3rd edition, 'Concrete in Aggressive Ground'.

9.11 Defra & Environment Agency, 'The Model Procedures for the Management of Land Contamination' (CLR11)(2004)

9.12 Environment Agency/DEFRA, 2009, Contaminated Land Exposure Assessment.

9.13 Chartered Institute of Environmental Health and Land Quality Management of Nottingham University 2009, Generic Assessment Criteria 2nd Edition.

9.14 Building Research Establishment, BRE Report 465 'Cover systems for land regeneration: thickness of cover systems for contaminated land'

9.15 Health and Safety Executive, Health and Safety Guideline (HSG) Documents

9.16 Dept of Transport, 'Specification for Highway Works', 2004 and revisions.

9.17 British Standards, BS 8485 'Code of practice for the characterization and remediation from ground gas of affected development', 2007

ANNEX A
DRAWINGS & FIGURES

- Site Location Plan
- Preliminary Development Layout

ROLTON GROUP
ENGINEERING THE FUTURE

Rolton Group

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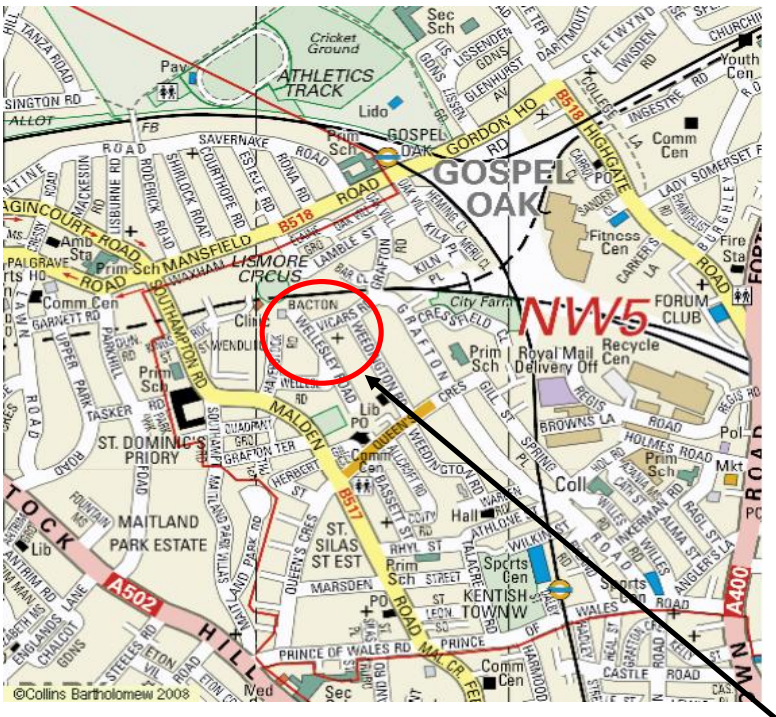
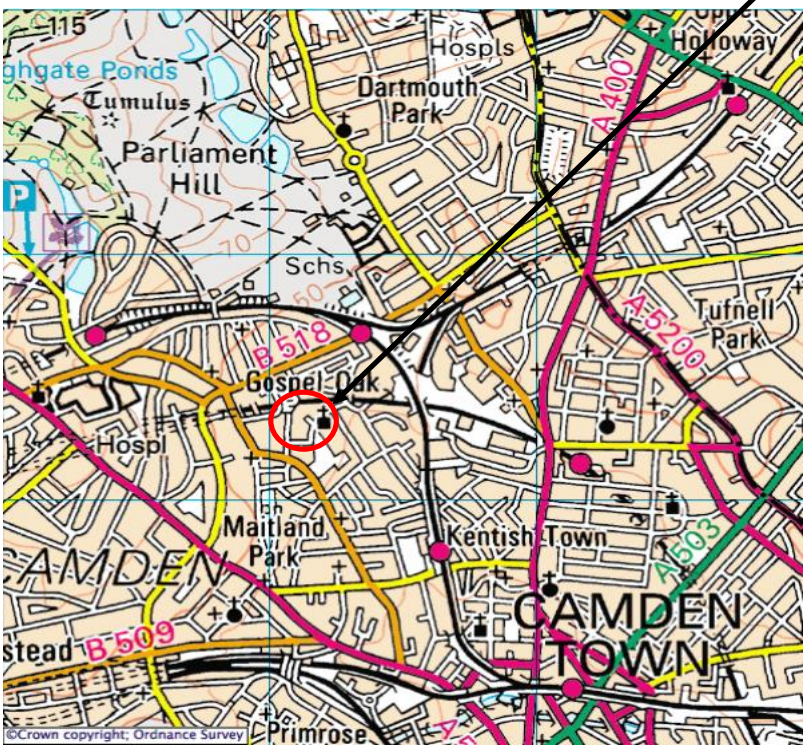
Project No.	**Bacton Low Rise**
Figure Title	**Site Location Plan**
Date	**May**
Figure Number	**1**
Scale	**N.T.S.**
Prepared by	**TEM**



SITE

nearest postcode **NW5 4PT**
approx grid reference **528089 / 185250**



MASTERPLAN VIEW - PREFERRED OPTION

Mixed tenure housing

New landscaped street enhances the setting of St. Martin's Church, giving it a sense of place in the new townscape.

Apartments in rented / shared ownership building

Family houses and family maisonettes for rented / shared ownership

Apartments in private sale / shared ownership building