



Your Environment

INTERIM PHASE 2: SITE INVESTIGATION REPORT AT THE QUAD, 11 ARKWRIGHT ROAD, READING, BERKSHIRE, RG2 0LU

For Headoffice 3

Your Environment

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For and on behalf of YourEnvironment				

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1.0 Introduction

YourEnvironment (YE) was instructed by Headoffice 3 (Quote No: Q4841, Dated: May 23rd 2018) for the provision of a Phase 2: Site Investigation Report for a site located at The Quad, 11 Arkwright Road, Reading, Berkshire, RG2 0LU.

The purpose of this investigation was to provide a factual and interpretative report on our findings in respect to works completed at the site by YE which comprised four (4no.) windowless sampler boreholes (WS01-WS04) with associated contamination laboratory testing. Additionally, all four of these windowless sampler borehole positions were installed with standpipes to allow for future gas and groundwater monitoring to be undertaken.

This SI was completed subsequent to a previously published Phase 1: Desktop Study and Preliminary Risk Assessment Report, issued by YE (Report reference: YE4555 dated: May 2018), to which this report should be read in conjunction with. As such this report seeks to address the potential pollutant linkages identified within the Preliminary Conceptual Model contained within the Phase 1: Desktop Study and Preliminary Risk Assessment Report.

The purpose of this report is to accompany other documentation for the aim of acquiring planning permission from Reading Borough Council.

This report presents a full factual record of all site works carried out, the results of *insitu* testing and subsequent laboratory testing of selected samples obtained during these works. The report has been formulated in accordance with BS10175:2015 '*Investigation into Potentially Contaminated Sites – Code of Practice*' and CLR11 – '*Model Procedures for the Management of Land Contamination*' and from the National Planning Policy Framework.

YE take no responsibility for conditions which have not been revealed by the windowless sampler boreholes, or which occur between windowless sampler boreholes. Whilst every effort has been made to interpret the conditions between investigation locations, such information is only indicative, and liability cannot be accepted for its accuracy.

The information contained in this report is intended for the use of the named client (or their approved contractors). Should any part of this report be relied on by a third party, that party does so wholly at its own risk and YE disclaim any liability to such parties. Should the purposes for which the report is used, or the proposed use of the site change, this report may no longer be valid and further use or reliance upon the report in those circumstances shall be at the client's sole and own risk. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. YE should in all such altered circumstances be commissioned to review and update this report accordingly.

2.0 Proposed Development

We understand current plans for the redevelopment of the site include:

- The conversion of the current office buildings to form forty-five (45no.) residential units.

The proposed redevelopment plans for the site can be reviewed within **Appendix A.**

3.0 Previous reports

As previously outlined, an earlier Phase 1: Desktop Study and Preliminary Risk Assessment Report has been completed for the study site, issued by YE.

A summary of the Stage 1: Desktop Study Report's findings can be found in Section 4.0.

4.0 Physical Setting

4.1 Site Information

Access

The site was accessible from Arkwright Road, with an electric metal gate which can be opened to provide vehicle access onto site.

Topography

The site sloped from south to north with varying sizes of local undulations throughout. The site looked to have been made into the side of a hill with the properties located south of the site on a higher level of ground with a retaining wall separating them.

Vegetation

The site was not heavily vegetated but did have some areas as follows:

Located on the sites northern boundary next to the access point were two trees, one either side of the gate, approximately ten to fifteen metres high, located upon soft permeable landscaping with lower level bushes within.

North of the building were various areas of ornamental bushes and shrubbery.

Some household waste is located throughout the site which looks to have been blown into the area by the weather.

Buildings and Structures / Floor Covering

There was one building located on the site, a three storey brick constructed building with metal cladding on the upper half with a metal sheeted pitched roofing and concrete floor covering. The building looked to be used as offices and storage although it was at the time empty.

Located on the sites southern boundary was a large brick retaining wall approximately three to five metres high depending on the area of the boundary.

The parking area located on the north, east and west of the building is currently used for car storage.

Surface Permeability / Ground Covering

It was estimated that 95% of the site was impermeable concrete with 5% comprising soft permeable landscaping.

Drainage Features

North, east and west of the building located on site had a number of manholes and surface water drains located within.

Other Services

It was evident that the site had access to water and electric.

Surrounds

The site was located within a commercial and industrial estate with various commercial properties surrounding the site on all flanks.

4.2 Geology

The relevant British Geological Survey (BGS) online mapping indicates that there are no superficial ground deposits on site and the bedrock/solid geology is comprised of Lambeth Group (clay, silt and sand).

4.3 Hydrogeology

The Environment Agency designate aquifers in accordance with the Water Framework Directive. These designations reflect not only the importance of aquifers in terms of groundwater as a resource (drinking water supply) but also their role in supporting surface water flows and wetlands ecosystems. The aquifer designation data is based on geological mapping provided by the British Geological Survey.

As a result of the bedrock geology on site, the aquifer is designated as being a Secondary (A) Aquifer. This is defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as Minor Aquifers.

4.4 Hydrology

Groundwater Abstraction Licences

There are ten active groundwater abstraction licences within 2000m, the closest of which is 656m north for a potable water supply - direct. The remaining records are over 770m from the study site.

Surface Water Abstraction Licences

There are two active surface water abstraction licence within 2000m, the closest of which is 1308m west for a potable water supply - direct. The remaining record is 1764m north from the site.

Potable Water Abstraction Licences

There are ten active potable abstraction licences within 2000m, the closest of which is 656m west. The remaining entries are over 770m from the site.

Groundwater Vulnerability and Soil Leaching Potential

The on site soil vulnerability category is listed as being 'HU', this is defined as soil information for urban areas and restored mineral workings. These soils are therefore assumed to be highly permeable in the absence of site-specific information.

Source Protection Zones

The study site is not located within a Source Protection Zone.

Ordnance Survey Water Network

There are thirty-six records within 500m of the study site, the closest two of which are 271m north for inland rivers. The remaining results are over 280m from the study site.

Surface Water Features

There are no records within 250m of the study site.

4.5 Summary of Possible Contamination Sources

On Site Sources

The following possible on site sources were identified from the previous historical study:

- Unspecified pit;
- Electrical warehouse.

The following on site sources were identified from the previous site walkover:

- None identified.

The following possible on site sources were identified from the previous EnviroInsight and GeoInsight:

- Unspecified ground workings;
- Sand pit;
- Landfill;
- Unspecified pit;
- Contractor's yard;
- Unspecified depot;
- Unspecified tank.

The following contaminants are potentially associated with these sources:

- Heavy Metals;
- TPH and PAH;
- Potential asbestos;
- Ground gas – methane and carbon dioxide, from decomposition of organic carbon in Made Ground and infilled material associated with potential considerable depth of Made Ground and landfill on site.

In practice, a broad contaminant screen should be analysed for to ensure that potential contaminants are not omitted.

Off Site Sources

The following off site sources were identified from the previous historical study:

- Brick and tile works (200m west);
- Unspecified pits (immediately north and east and 250m south);
- Kilns (150m north);
- Tanks (immediately east, 70m east, 90m north, 90m south and 180m north);
- Bus depot (20m south);
- Contractor's yard (50m southwest);

- Garage (150m east);
- Display factory (10m west);
- Tractor factory (immediately north);
- Fencing factory (10m east);
- Engineering works (20m northeast);
- Electrical works (40m north);
- Plastic works (50m northeast);
- Electricity substation (50m north).

There are further entries present but these are considered far enough from the site to pose no risk.

The following off site sources were identified from the previous site walkover:

- Industrial/ commercial properties surrounding the site on all flanks.

The following off site sources were identified from the previous GeoInsight and EnviroInsight:

- Sewage discharges (48m south);
- Waste oil and recovered oil site (37m west);
- Petrol vapour recovery process (58m south);
- NIHHS site (94m south);
- Unspecified ground working (57m north);
- Sand pit (26-28m east);
- Refuse heap (80m north);
- Landfill (99m southwest);
- Waste transfer station (113m north);
- Unspecified works (4m west, 22-36m north and 30m east);
- Kilns (76m north);
- Unspecified tanks (61-80m east, 83-87m north and 83-84m south);
- Electricity substations (47-50m north);
- Motor mower works (22-23m north);
- Vehicle repair, testing and servicing site (10m south and 37m west);
- Consumer products (26m south);
- Industrial products (38m west).

The following contaminants are potentially associated with these sources.

- Heavy Metals;
- PAH and TPH;
- Asbestos;
- PCBs;
- VOCs and SVOCs;
- Ground gas – from the variety of infilled land and activities in the area that could have led to methane and carbon dioxide generation from decomposition of organic carbon in Made Ground/infilled material and hydrocarbon spillages which could volatilise in the subsurface of the site.

5.0 Preliminary Conceptual Site Model and Risk Assessment

This presented Conceptual Site Model has been re-issued from the earlier issued Phase 1: Desktop Study to provide information regarding the possible **sources** of contamination on site, the **pathway** in which the contamination can migrate and a vulnerable **receptor** to the contamination, all of which need to be present for there to be a risk. Given the proposed end use of the site the generic land use of 'residential with homegrown produce' has been applied. Consequently, the following Source – Pathway – Receptor relationships have been identified.

Contaminant Source	Pathways	Receptor	Potential Severity	Probability of Risk	Level of Risk	Justification
On Site: Made Ground soils on site possibly containing elevated metals, other inorganics such as TPH, PAH, phenols, VOC and SVOCs.	Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Low Likelihood	Moderate	A moderate risk is assessed due to the variety of potentially contaminative land uses on site, with an emphasis on the landfill. Although there is limited risk of direct contact with the soil due to the lack of soft landscaping areas, there is a risk from vapour intrusion.
		Construction Workers	Medium	Likely	Moderate	Construction workers are likely to come into direct contact with soils during groundworks. Safe working practices should be implemented and appropriate personal protective equipment (PPE) should be used to mitigate any potential risk from contact with soils and shallow/perched groundwater.
	Leaching through soils and migration via groundwater or soil pore moisture	Controlled Waters	Medium	Low Likelihood	Moderate	A moderate risk is assessed due to the variety of potentially contaminative sources on site and the presence of a Secondary (A) Aquifer within the bedrock underlying the site. The nearest groundwater and potable water abstraction licence is 656m north. The nearest surface water abstraction licence is 1308m west for a potable water supply. In addition, there are no surface water features within 250m and the nearest river networks are 271m north for inland rivers. The site is not within a source protection zone.
	Permeation of water pipes	Construction materials, future end users and site visitors	Medium	Likely	Moderate	Hydrocarbons, especially aromatics are known to permeate plastic pipes. Provision of water supply pipes and connectors formed from proprietary "barrier pipe" materials (eg polyethylene-aluminium-polyethylene) may be required by the water supply company.
On Site: Asbestos at/near ground surface in Made Ground soils.	Inhalation of fibres in airborne dust	Plant and Wildlife	Mild	Low Likelihood	Low	A low risk is assessed as there are no indicated areas of soft landscaping on the proposed site plans.
		Future end users and site visitors	High	Low Likelihood	Low/Moderate	Likelihood is considered to be low/moderate as although the site walkover did not identify any potential asbestos containing materials (ACMs), the commercial history of the site creates potential for asbestos contamination.
		Construction Workers	High	Low Likelihood	Low/Moderate	Despite the lack of identified ACMs during the walkover, safe working practices should be implemented and appropriate personal protective

						equipment (PPE) should be used to mitigate any potential risk from asbestos in soils.
On Site: Ground Gases (CH ₄ , CO ₂) from on site Made Ground.	Gas migration and build up within buildings (explosion/asphyxiation risk)	Future end users and building structures.	High	Low Likelihood	Moderate	A moderate risk is given due to the landfill and extensive infilled land on site. Current guidance indicates that Made Ground is generally classified as low risk in terms of potential for gas generation.
Off Site: Historical land uses and activities, Made Ground/infilled material possibly containing elevated metals, other inorganics, TPH, PAH, PCBs, phenols, VOC and SVOCs.	Leaching through soils and migration via groundwater or soil pore moisture	Future end users and site visitors	Mild	Low Likelihood	Moderate	Given the variable permeability of the underlying geology and hydrogeology, there is a moderate risk for the leaching of contaminants. This combined with the variety of potentially contaminative activities in the surrounding area create a risk for contamination on site.
	Inhalation of vapours	Future end users and site visitors	Medium	Low Likelihood	Moderate	A moderate level of risk is assessed due to the potentially contaminative land uses/activities within proximity to the site that could pose a potential risk to the site.
Off Site: Ground Gases (CH ₄ , CO ₂ , H ₂ S) from off site Made Ground historical land uses/activities.	Gas migration and build up within buildings (explosion/asphyxiation risk)	Future end users and building structures.	High	Low Likelihood	Moderate	The potentially contaminative land uses/activities and infilled land proximal to the site create a potential for ground gas generation. Current guidance indicates that Made Ground is generally classified as low risk in terms of potential for gas generation.

Table 1: Preliminary Conceptual Site Model

6.0 Fieldworks

6.1 Site Investigation

The following SI works were completed on May 26th 2018 under the supervision of a Geo-Environmental Engineer from YE. In summary, the investigation included:

- A two-man team ascertained the routes of any below ground services in close proximity to the proposed exploratory hole positions, using a CAT scan and lifting up of any man hole covers. Following the CAT scan, hand dug starter pits were completed to a depth of 1.20 metres below ground level (mbgl).
- Four (4no.) windowless sampler boreholes (WS01-WS04) were completed, by means of an Archway rig, to a maximum depth of 3.00mbgl. The locations of exploratory positions were selected relative to the historic land use and current proposed redevelopment plans for the site whilst providing a broad coverage of the site as feasibly as possible.
- The windowless sampler boreholes were logged with any groundwater conditions noted and representative soil samples removed in accordance with current guidelines.
- Soil samples were removed from shallow sub surface locations, with further samples taken at depth every 1.00mbgl or when the underlying stratum changed. Samples were subsequently placed in suitable containers including 1kg tubs and 250ml glass jars and placed in cool boxes with cool packs prior to storage within our *in-house* laboratory fridges and then subsequent forwarding to our designated laboratory for analysis.
- All four (4no.) of the boreholes (WS01-WS04) were installed with a standpipe comprising of 50mm pipework to a maximum depth of 3.00mbgl to enable future gas and groundwater monitoring to be undertaken. This was completed with a lockable cover, flush with the ground, to protect the installation.
- Upon completion, all exploratory holes were back filled, compacted and made good to existing levels and finishes, with any surplus spoil bagged up and removed from site.

The positions of exploratory holes in relation to the existing site layout can be reviewed within **Appendix B**. Exploratory windowless sampler logs located in **Appendix C**.

6.2 Ground Gas and Groundwater Monitoring

At the time of issuing this interim report, two rounds of gas and groundwater monitoring have currently been completed, dated May 30th and June 6th 2018 using the standpipe installations of exploratory hole locations WS01-WS04. Details of the following ground gas and groundwater monitoring rounds will be issued within the final report.

7.0 Geology & Ground Conditions

The following ground conditions were encountered during the SI;

Made Ground – Encountered in all exploratory holes to a maximum depth of 1.80mbgl, and generally comprised a red/grey mottled black sandy gravel. Asphalt was encountered in WS01, WS03 and WS04 to a maximum depth of 0.20mbgl. Orange sandy, gravelly CLAY was encountered in WS04 to a maximum depth of 1.20mbgl. Gravel is fine to medium of mixed lithology, flint, coal and brick.

Lambeth Group – This was encountered in WS01, WS03 and WS04 at depths ranging from 0.50m to the maximum excavated depth of 3.45mbgl and consisted of an orange mottled yellow sandy gravelly CLAY, which became very sandy with depth in WS03. A yellow mottled grey SAND was encountered in WS01 at a depth of 0.50mbgl. Sand is fine. Gravel is fine of mixed lithology. We consider this to be representative of the Lambeth Group.

8.0 Groundwater Conditions

Groundwater was not encountered in any of the exploratory holes during the site works completed. At the time of issuing this interim report, only two rounds of gas and groundwater monitoring have been completed; groundwater has not been encountered during either of these monitoring rounds. The groundwater conditions encountered during the following monitoring rounds will be issued within the final report.

It should be noted that groundwater levels are dependent upon seasonal variations and can change after periods of prolonged rainfall or drought.

9.0 Visual and Olfactory Observations

With the exception of general anthropogenic material identified, no visual and/or olfactory evidence of potential contamination was noted within any soils encountered during the drilling of exploratory holes.

10.0 Contamination

10.1 Soil Testing

A total of seven (7no.) samples from the Made Ground and underlying natural soils have been analysed by Messrs QTS Environmental Ltd in their UKAS and MCERTS accredited laboratory-testing facility in accordance with laboratory protocol.

The testing completed comprised of a focused suite of heavy metals, speciated Total Petroleum Hydrocarbons (TPH CWG Aromatic/aliphatic split) and speciated Polycyclic Aromatic Hydrocarbons (PAH) including the more carcinogenic benzo(a)pyrene (BaP) and naphthalene, BTEX, MTBE, phenols, VOCs and SVOCs, soil organic matter (SOM) content, cyanides, pH and sulphates. Samples of Made Ground were additionally screened for asbestos.

The results of this laboratory testing have been compared to the Soil Guideline Values (SGVs) as well as the CIEH 'LQM' guideline values for inorganic and organic contaminants in soils. The proposed development of the site is intended to comprise of residential with limited, raised areas of discrete soft landscaping and therefore screening has been made against the generic land use of 'residential without homegrown produce'.

10.2 Selection of Screening Criteria

The on-site receptors for the site are considered to be:

- Construction workers (during redevelopment of the site only);
- Future maintenance workers (following redevelopment);
- Future residents and visitors (following redevelopment); and
- Trespassers (during redevelopment).

The off-site receptors for the site are considered to be:

- Residents/visitors to the nearby residential dwellings and workers/visitors to the nearby commercial buildings in the immediate vicinity of the site.

Risks to construction workers during the redevelopment process will be mitigated by adhering to appropriate health and safety legislation, and the wearing of appropriate personal protective equipment (PPE). During redevelopment, the site will be securely fenced to prevent trespassers from accessing the site, and good site management practices will be implemented to mitigate exposure to off-site receptors.

The potential pathways for contaminants within the soil to human health receptors following redevelopment are considered to be:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside.

Potential risks via permeation of drinking pipes, and risks to concrete from attack by aggressive ground conditions should be considered at design stage.

The potential pathways for contaminants within the soil to off-site human health receptors following redevelopment are considered to be:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside if contamination within soil is able to migrate across the site boundary within.

In the first instance, the results of this laboratory testing have been compared to generic assessment criteria (GAC) for the residential with consumption of homegrown produce land use scenario. These incorporate the following pathways:

- Direct ingestion of soil and soil derived dust;
- Dermal contact with soil outside and soil derived dust inside;
- Inhalation of soil derived dust inside and outside; and
- Inhalation of soil derived vapours inside and outside.

Given that these incorporate a number of pathways that will not be relevant to the site following redevelopment, this is a highly conservative approach and exceedances will be discussed in this light.

Contaminants have been screened against revised LQM/CIEH S4UL criteria¹ where available. These GAC have been designed for use under planning, using Health Criteria Values based on minimal risk, and updated exposure parameters. The S4UL are intended to replace the previous LQM/CIEH GAC. The S4UL are based on the assumption of a sandy loam soil the 1% soil organic matter (SOM) criteria have been used, where available and appropriate, in the first instance. All soil samples were analysed for %SOM, the range was from 0.3%-1.8%, and so this conservative approach is considered appropriate for initial screening.

Where no S4UL are available, the EIC/ AGS/ CL:AIRE/ GAC² have been used. The toxicological criteria within these are also based on minimal risk. It is recognised that these criteria have not recently been updated, and in particular, do not incorporate the slightly higher inhalation rates that have been used within the S4UL. However, given that they incorporate additional pathways, they are considered suitable for an initial screen. The EIC/ AGS/ CL:AIRE/ GAC are also based on a sandy loam soil and the 1% SOM criteria have been used in the first instance.

There is neither an S4UL nor a EIC/ AGS/ CL:AIRE/ GAC available for lead. In the absence of a GAC based on minimal risk, the C4SL for lead has been used. It is recognised that this is based on a “low level of toxicological concern” rather than on a minimal risk level. However, it is considered appropriate for use under planning, especially for a site where there will effectively be no pathways for inorganic metals following redevelopment.

All the GAC are based on a sandy loam soil. This is considered appropriate for use for initial screening. Although it is apparent from the laboratory soil descriptions, that the Made Ground is heterogeneous, and often has a significant sand/gravel component, especially at shallow depths, it is noted that many of the soil descriptions have a significant clay component.

All of the GAC assume unsaturated soils. However, the use of the GAC are considered to be conservative, because they assume a certain air-filled porosity and water-filled porosity. The GAC also assume that no free phase product is present, and are not intended for use in this instance. No free product was observed within soils during the site investigation.

10.3 Soil Testing Results & Screening

All metals, PAHs, BTEX compounds and TPH CWG analytes are presented in the following tables. Other potential contaminants of concern are only shown where there is at least one result exceeding the limit of detection. All of the laboratory analytical results are presented within **Appendix D**. It should be noted that in respect of returned concentrations in µg/kg these GACs have been multiplied by a factor of 1000, as these are in mg/kg.

Metalloids

Determinant	Min	Max	GAC	Number of exceedances
Arsenic	2	18	40*	0
Cadmium	<0.2	<0.2	85*	0
Chromium (III)	11	29	910*	0

¹ Nathanail et al. (2015) The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, 2015. Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3495

² CL:AIRE (2010) The EIC/AGS/CL:AIRE Generic Assessment Criteria for Human Health Risk Assessment

Chromium (VI)	<2	<2	6*	0
Copper	<4	14	7100*	0
Lead	6	25	310*	0
Mercury	<1	<1	56 ^a	0
Nickel	4	22	180 ^b	0
Selenium	<3	<3	430*	0
Zinc	11	57	40000*	0
Total Phenols	<2	<2	750*	0

Table 2: Metalloids Soil Exceedances

*LQM/CIEH GAC for Residential without homegrown produce land use scenario based on a sandy loam soil and 1% SOM.

#EIC/AGS/CL:AIRE GAC for Residential without homegrown produce land use scenario and 1% SOM+ C4SL
Residential without homegrown produce land use scenario based on a sandy loam soil.

+C4SL for Residential without homegrown produce land use scenario based on a sandy loam soil.

- Based on the inorganic mercury GAC as the conceptual site model does not suggest that other forms of mercury are likely to be present on site.
- LQM issued an update to the nickel S4ULs in August 2015 and this has been taken into account.

➤ There were no exceedances for the metalloids screened.

Organics

Determinant	Min	Max	GAC	Number of exceedances
Naphthalene	<0.1	5.17	2.3*	1
Acenaphthylene	<0.1	<0.1	2900*	0
Acenaphthene	<0.1	<0.1	3000*	0
Fluorene	<0.1	<0.1	2800*	0
Phenanthrene	<0.1	0.25	1300*	0
Anthracene	<0.1	<0.1	31000*	0
Fluoranthene	<0.1	0.28	1500*	0
Pyrene	<0.1	0.25	3700*	0
Benzo(a)anthracene	<0.1	<0.1	11*	0
Chrysene	<0.1	0.14	30*	0
Benzo(b)fluoranthene	<0.1	0.17	3.9*	0
Benzo(k)fluoranthene	<0.1	<0.1	110*	0
Benzo(a)pyrene	<0.1	0.11	3.2*	0
Indeno(1,2,3-cd)pyrene	<0.1	<0.1	45*	0
Dibenz(a,h)anthracene	<0.1	<0.1	0.31*	0
Benzo(ghi)perylene	<0.1	<0.1	360*	0

Table 3: PAH Soil Exceedances

- There was one exceedance for the PAH congeners screened for naphthalene, which was in the Made Ground of WS02 at a depth of 0.50mbgl.

Determinant	Min	Max	GAC	Number of exceedances
Aliphatic >C5 - C6	<0.01	<0.01	42*	0
Aliphatic >C6 - C8	<0.05	<0.05	100*	0
Aliphatic >C8 - C10	<2	3	27*	0
Aliphatic >C10 - C12	<2	<2	130*	0
Aliphatic >C12 - C16	<3	<3	1100*	0
Aliphatic >C16 - C21	<3	<3	65000*	0
Aliphatic >C21 - C34	<10	52	65000*	0
Aromatic >C5 - C7	<0.01	<0.01	370*	0
Aromatic >C7 - C8	<0.05	<0.05	860*	0
Aromatic >C8 - C10	<2	<2	47*	0
Aromatic >C10 - C12	<2	10	250*	0
Aromatic >C12 - C16	<2	<2	1800*	0
Aromatic >C16 - C21	<3	36	1900*	0
Aromatic >C21 - C35	<10	196	1900*	0

Table 4: TPH CWG Aliphatic/Aromatic Soil Exceedances

* LQM/CIEH GAC for Residential without homegrown produce land use scenario based on a sandy loam soil and 1% SOM.

It is noted that the LQM/CIEH S4UL guidance recommends an additive approach for the TPH fraction, so that a hazard index approach is used. Based on a preliminary conservative comparison of maximum concentrations to S4ULs, no forward modelling is necessary to prove that this would still result in no exceedances at the site.

- There were no exceedances for the TPH CWG congeners screened.
- There were no exceedances for BTEX/MTBE congeners, all of which were below the level of detection (LoD).
- The results for the VOC and SVOC congeners were at or below the LoD.
- Asbestos was detected in the form of chrysotile fibre bundles in soil in the Made Ground of WS02 at a depth of 0.50mbgl.

The soil contamination laboratory certificates can be reviewed within **Appendix D**.

10.4 Gas Monitoring Results

The gas monitoring results included below are based on the first two rounds of gas monitoring completed May 30th and June 6th 2018. Details of the following ground gas monitoring rounds will be issued within the final report, it should be noted that the outcomes of this gas monitoring may be subject to change based on these results.

Gas monitoring was carried out on two separate occasions using a Gas monitor (GA5000). Readings were taken from the installed window sampler boreholes of WS01-WS04.

The standpipes were tested for the presence of methane, oxygen, carbon dioxide and hydrogen sulphide. The flow rates of the gas and barometric pressure were also recorded.

The ground conditions were noted to be moist during the first monitoring round with calm wind conditions and dry during the second monitoring round with light wind conditions. The first round of monitoring was completed during rising pressure conditions and the second monitoring round was completed during steady pressure conditions.

Methane was recorded at a maximum peak concentration of 0.6% volume from all installs monitored during the course of monitoring round 1. Oxygen concentrations ranged from a minimum of 8.5% obtained from WS02 during monitoring round 2 to a maximum of 20.3% obtained from WS1 during monitoring round 1. The maximum peak concentration of carbon dioxide of 10.2% was obtained from WS02 during monitoring round 2.

Flow rates were recorded during each round of monitoring from all installations, ranging from a minimum of -0.3l/hr during monitoring round 1 to a maximum of 0.6l/hr during monitoring round 2. Concentrations of hydrogen sulphide were returned as 0.0ppm from both monitoring rounds undertaken. Concentrations of carbon monoxide were recorded from a minimum steady concentration of 0ppmv from WS02 during monitoring round 2 to a maximum steady concentration of 3ppmv from WS03 during monitoring round 1, with a maximum peak concentration of 10ppmv recorded from WS01 during monitoring round 1.

Barometric pressure ranged from a low of 1010mBars during both monitoring rounds to a high of 1011mBars attained during monitoring round 1.

The recorded concentrations of methane and carbon dioxide have been used to calculate a Gas Screening Value (GSV) for the gassing regime at this site. This value has been subsequently compared against CIRIA values supplied within CIRIA Document C665 *Assessing risks posed by hazardous ground gases to buildings* (2007) using Situation B for carbon dioxide and methane.

The values used represent the worst case CO₂ and CH₄ concentrations across all installations.

The maximum flow rate was 0.6l/hr taken during monitoring round 2.

The GSV is calculated as:

(Worst case CO₂ and CH₄ concentration / 100) x worst case flow rate = GSV

Peak Flow Rate (l/hr)	Worst Case CO ₂	CO ₂ GSV	Worst Case CH ₄	CH ₄ GSV
0.6	10.2l/hr CO ₂	0.0612l/hr CO ₂	0.6l/hr CH ₄	0.0036l/hr CH ₄

Table 5: Calculated GSV's

This GSV is a conservative estimate based on the maximum concentrations and flow rate. This approach has been taken at this stage based upon the three monitoring visits that have been undertaken.

Based on the maximum calculated GSV of 0.0612l/hr, Characteristic Situation 1 would normally apply. However, given the peak carbon dioxide levels encountered above 5.0% in WS02 during monitoring round 2 (10.2%), the site can be characterised by CIRIA C665 for situation B, characteristic situation 2 and as 'low risk'. Based on this data, the indication is that there is a gas regime identified and as a consequence, gas protection measures are considered necessary to be incorporated into the proposed development and are included below:

- Due to the levels of CO₂ and in accordance to Table 8.6, Typical scope of gas protection measures, of CIRIA report C665, two levels of protection are considered necessary and should include:

- a) Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200g DPM and underfloor venting;
 - b) Beam and block or pre cast concrete slab and 2000g DPM / reinforced gas membrane and underfloor venting;
 - Possible underfloor venting or pressurisation in combination with a) and b) depending on use;
- Note: All joints and penetrations must be sealed.

The interim monitoring sheets can be viewed in **Appendix E**.

11.0 Site Investigation Findings

It should be noted that at the time of issuing this interim report, there is not enough information present to accurately formulate a full risk assessment or recommendations for the site, as the ground gas and groundwater monitoring has not currently been completed. A full report including all monitoring and laboratory testing results will be issued at a later date.

The information contained below is based upon the soil contamination results currently received and may therefore be subject to change based on the results of the following ground gas and groundwater monitoring rounds.

11.1 Risks to Human Health

With the exception of the limited depth of Made Ground identified, no visual and/or olfactory evidence of potential contamination was noted within any soils encountered during the SI works undertaken.

Overall, one individual soil exceedance from the selected soil samples from the SI which were submitted for a range of inorganic and organic testing was returned with an exceedance, which was for naphthalene (GAC of 2.3mg/kg) in the Made Ground of WS02 at a depth of 0.50mbgl at 5.17mg/kg.

The remaining samples returned a value below the available SGVs and LQM guidance values for each determinand which were adopted as Generic Assessment Criteria (GAC) within YE's risk assessment for the site.

A review of the borehole logs indicate that natural soils are present across the site from approximately 0.50mbgl – 1.80mbgl, it would therefore be reasonable to conclude that these forms of contamination would cease at these depths.

We believe the contamination to be localised to the centre of the site judging by the lack of exceedances identified in the laboratory results of the soil samples tested from the remaining boreholes.

Given the extensive hardstanding across the site, the risk of contact between future residents/visitors and the shallow subsoil is considered to be low, however, if groundworks are to take place, there would be an appreciable risk of contact with groundworkers in respect of ingestion, dermal contact and inhalation pathways. Safe working practices should be implemented and appropriate personal protective equipment (PPE) should be used to mitigate any potential risk from contact with soils and shallow/perched groundwater.

11.2 Risks to Controlled Waters

At the time of issuing this interim report, groundwater monitoring has not yet been completed. Details of the following groundwater monitoring rounds will be issued within the final report.

11.3 Risks to Plants and Wildlife

A low risk has been attributed given the concentrations of phytotoxic contaminants below elevated concentrations.

11.4 Risks to Site Workers

Due to the exceedance of naphthalene, precautions should be taken to minimise exposure of site workers during ground works through the implementation of site safety procedures and the use of suitable personal protective equipment (PPE). Such precautions should include, but not be limited to:

- Personal hygiene, washing and changing procedures;
- Availability of site welfare;
- Provision of PPE appropriate to the task; and
- Daily safety briefings and tool box talks.

All site works will be undertaken in accordance with the guidelines prepared by the Health and Safety Executive (1991) and all work will be carried out in accordance with the Principal Contractor's Health and Safety Plan.

12.0 Conceptual Site Model and Risk Assessment

The Conceptual Site Model has been formulated based upon the interim results from the SI in accordance with BS10175:2015. It aims to provide information regarding the sources of contamination and the pathways in which contamination can migrate to a vulnerable receptor, all of which need to be present for there to be a risk. This is in relation to the proposed end use being classified as ‘residential without homegrown produce’. The following linkages have been identified, please note that these be subject to change based on the results of the following ground gas and groundwater monitoring rounds:

Contaminant Source	Pathways	Receptor	Potential Severity	Probability of Risk	Level of Risk	Justification
On Site: Made Ground soils on site possibly containing elevated metals, other inorganics, TPH and PAH.	Ingestion, dermal contact, inhalation of dusts/vapours	Future end users and site visitors	Medium	Likely	Low	A low risk is considered despite the overall context of returned laboratory results showing one exceedance, which was for naphthalene in the Made Ground of WS02 at a depth of 0.50mbgl, as contact is unlikely between future residential occupiers/visitors and contaminants in the shallow soil or via vapour intrusion.
		Construction Workers	Medium	Likely	Moderate	Construction workers are likely to come into direct contact with soils during groundworks; safe working practices should still be implemented and appropriate personal protective equipment (PPE) should be used to mitigate any potential risk from contact with soils and shallow/perched groundwater.
	Leaching through soils and migration via groundwater or soil pore moisture	Controlled Waters	Medium	Low Likelihood	Low	Based on the interim results, a low risk has been assessed given that the soil exceedance identified from the laboratory results was limited to the Made Ground at a depth of 0.50mbgl and groundwater was not encountered during the site investigation or subsequent monitoring rounds. The aquifer within the bedrock geology is recorded as being a Secondary (A) Aquifer. A full report including all monitoring and laboratory testing results will be issued at a later date.
	Permeation of water pipes	Construction materials, future end users and site visitors	Medium	Likely	Low/ Moderate	A low to moderate risk is assessed as a result of the returned laboratory results and subsequent screening which showed one hydrocarbon exceedance in the form of the PAH congener naphthalene in the Made Ground of WS02 at a depth of 0.50mbgl. Hydrocarbons, especially aromatics and chlorinated solvents, are known to permeate plastic pipes. Provision of water supply pipes and connectors formed from proprietary “barrier pipe” materials (eg. polyethylene-aluminium-polyethylene) may be required by the water supply company particularly as Made Ground has been identified on site.
	Uptake	Plant and Wildlife	Mild	Low Likelihood	Low	As a result of the returned laboratory results which shows an absence of phytotoxic contaminants and the lack of proposed soft landscaping areas on site, the risk is considered to be low.

On Site: Asbestos at/near ground surface in Made Ground soils.	Inhalation of fibres in airborne dust	Future end users and site visitors	High	Low Likelihood	Low	The results of screening indicate that asbestos was detected in the form of Chrysotile in fibre bundles in soil in the Made Ground of WS02 at a depth of 0.50mbgl. A specialist Asbestos Consultant should be contacted to complete further testing of the area and a watching brief should be adopted with regards to the site for the potential of finding any Asbestos Containing Materials (ACMs).
		Construction Workers	High	Low Likelihood	Low	The results of screening indicate that asbestos was detected in the form of Chrysotile in fibre bundles in soil in the Made Ground of WS02 at a depth of 0.50mbgl. A specialist Asbestos Consultant should be contacted to complete further testing of the area and a watching brief should be adopted with regards to the site for the potential of finding any ACMs.
On Site: Ground Gases (CH ₄ , CO ₂) from on site Made Ground.	Gas migration and build up within buildings (explosion/ asphyxiation risk)	Future end users and building structures	High	Low Likelihood	Moderate	Based on the interim results, a moderate risk has been assessed given the results of gas monitoring undertaken to date and subsequently calculated GSV which demonstrates that gas protection measures are necessary (see section 10.4). A full report including all monitoring and laboratory testing results will be issued at a later date.
Off Site: Made Ground soils possibly containing elevated metals, other inorganics, TPH and PAH.	Leaching through soils and migration via groundwater or soil pore moisture	Future end users and site visitors	Mild	Low Likelihood	Low	From the interim results, little risk has been assessed as a result of off site historical/current land uses and activities in proximity to the study site, as the exceedance identified is considered to be localised. Additionally, contaminants present in Made Ground off site are considered unlikely to exhibit significant leachability. A full report including all monitoring and laboratory testing results will be issued at a later date.
	Inhalation of vapours	Future end users and site visitors	Medium	Low Likelihood	Low	A low risk has been assessed as despite the PAH exceedance encountered in WS02, this exceedance is considered to be localised and contaminants present in Made Ground off site are considered unlikely to exhibit significant leachability.
Off Site: Ground Gases (CH ₄ , CO ₂ , H ₂ S) from off site Made Ground.	Gas migration and build up within buildings (explosion/ asphyxiation risk)	Future end users and building structures	High	Low Likelihood	Moderate	Based on the interim results, a moderate risk has been assessed given the results of gas monitoring undertaken to date and subsequently calculated GSV which demonstrates that gas protection measures are necessary (see section 10.4). A full report including all monitoring and laboratory testing results will be issued at a later date.

Table 6: Updated Conceptual Site Model

13.0 Recommendations

It should be noted that at the time of issuing this interim report, there is not enough information present to accurately formulate a complete risk assessment or recommendations for the site, as the full ground gas and groundwater monitoring has not currently been completed. A report including all monitoring and laboratory testing results will be issued at a later date. The following recommendations are based on the results of chemical laboratory testing and the two rounds of ground gas and groundwater monitoring completed to date, and may therefore be subject to change based on the results of the following ground gas and groundwater monitoring rounds.

13.1 Management of Asbestos in Soils

Asbestos screening/identification analysis was completed on soil samples taken as part of the SI's completed, and identified Chrysotile fibre bundles in soil in the Made Ground of WS02 at a depth of 0.50mbgl.

As the current proposals are to convert the existing office buildings to form forty-five (45no.) residential units, the Made Ground material is unlikely to be removed and floor slab is unlikely to be broken, therefore the risk of contact is considered to be low.

However, if the floor slab is to be broken as part of any groundworks, a Specialist Asbestos Consultant should be contacted to complete further testing of the area. If asbestos fibres are present, quantification analysis will be required to ensure that material is correctly classified for waste disposal purposes. However, we envisage that the following procedure should be implemented, once testing has been completed, and approved by a specialist Asbestos Consultant in advance of ground works commencing:

- Precautions should be taken during groundworks to minimise the risk of fibre release, and cemented asbestos should be hand picked where possible to prevent it being broken up by machine excavators;
- It will be necessary to wet the sides/bases of the excavations, particularly in dry weather conditions, to reduce risk of fibre release;
- Ground workers should employ the use of appropriate PPE to prevent potential exposure to asbestos;
- The cemented asbestos should be double bagged, marked and sealed prior to disposal to a covered skip;
- Off-site transport and disposal of cemented asbestos should be completed by a licensed contractor.

A watching brief should be maintained in accordance with the recommendations in Section 13.3. If additional areas of cemented asbestos are encountered, they can be managed in accordance with the above procedure. If further asbestos fibres are suspected, or friable Asbestos Containing Materials are encountered then works should stop, the area should be damped down and a specialist Asbestos Consultant contacted.

13.2 Soils

Overall, one individual soil exceedance from the selected soil samples from the SI which were submitted for a range of inorganic and organic testing was returned with an exceedance, which was for naphthalene in the Made Ground of WS02 at a depth of 0.50mbgl.

A review of the borehole logs indicate that natural soils were not encountered in WS02, but were present across the site from approximately 0.50mbgl – 1.80mbgl, it would therefore be reasonable to conclude that these forms of contamination would cease at these depths.

Given the extensive hardstanding across the site, the risk of contact between future residents/visitors and the shallow subsoil/vapour intrusion is considered to be low, however, there is an appreciable risk of contact with groundworkers in respect of ingestion, dermal contact and inhalation pathways. Safe working practices should be implemented and appropriate personal protective equipment (PPE) should be used to mitigate any potential risk from contact with soils and shallow/perched groundwater.

13.3 Watching Brief and Discovery Strategy

As the current proposals are to convert the existing office buildings to form forty-five (45no.) residential units, the Made Ground material is unlikely to be removed and floor slab is unlikely to be broken, therefore the risk of contact is considered to be low.

However, if the floor slab is to be broken as part of any groundworks, a watching brief should be maintained by the Main Contractor at all times during groundworks. Should any unforeseen contamination, such as oils or soils/groundwater with an unusual colour or odour be encountered during groundworks then the following procedure should be implemented:

- Work to cease in that area to prevent exposure to ground workers and potential contaminants being spread around;
- Notify a Geo-Environmental Consultant to attend site and sample material;
- Notify the Environmental Health Department / Contaminated Land Officer(s) of Reading Borough Council.

If the nature and extent of the contamination is unmanageable under the procedure set out above, then a suitable management, mitigation or remediation procedure will be agreed with the CLO. However, this is considered unlikely at this particular site.

13.4 Services

If new services, in particular potable water supply pipework, are to be required as part of the redevelopment of the site, it is recommended that the local water board are contacted to determine their specifications for the type of pipework which should be used on this site, by providing them a copy of this report and accompanying appendices which contains the results of laboratory testing undertaken on soil samples taken from the site.

All services and in particular potable water supply pipework should comprise of material that is resistant to attack and degradation to chemical attack.

Further information can be found within the published guidance for the '*Selection of Water Supply Pipes to be used in Brownfield Sites*', issued in January 2011 by the UK Water Industry Research (UKWIR), this supersedes the Water Regulations Advisory Scheme (WRAS) Information and Guidance Note – '*Laying Pipes in Contaminated Land*' which has been withdrawn.

13.5 Surface Water

It should be noted that the Environment Agency does not recommend that soakaways be placed within Made Ground, potentially contaminative land or in ground previously identified as contaminated.

14.0 Limitations

YE have prepared this report with all reasonable skill, care and diligence. The work undertaken to provide the basis of this report comprised a study of available documented information from a variety of sources.

The opinions given in this report have been dictated by the finite data on which they are based and are relevant only to the purpose for which the report was commissioned.

Information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data with respect to site conditions. Should additional information become available which may influence the opinion expressed in this report, YE reserves the right to review such information and, if warranted, to alter the opinions accordingly.

It should be noted that any risks identified in this report are perceived risks based on the information reviewed.

The recommendations contained in this report represent our professional opinions. These opinions were arrived at in accordance with currently accepted industry practices at this time and as such is not a guarantee that the study site is free of hazardous conditions.

This report has been prepared solely for the use of the named client, and may not be relied upon by other parties without written consent from YE. YE disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.