SPR item	SPR item present based on desk study (Yes/No)	Comment
R9 – Continuous groundwater in soil	No	No natural superficial deposits are recorded beneath the site. **In the absence of a receptor no further assessment is required.**
R10 – Continuous groundwater in rock	No	The site is indicated to be underlain by low permeability London Clay which is classified as 'unproductive strata'. It is considered likely that an aquifer exists at depth (associated with the groundwater abstraction licences), however this is overlain by low permeability clay which has been proved to the termination depths of boreholes beneath the site at 15.5m. It is considered that the presence of the low permeability London Clay would significantly retard any downward migration of potential contaminants. **It is considered that there is no intact source-pathway-receptor linkage present and no further assessment is necessary with regard to the deeper aquifer.**
Controlled Waters – groundwater dependent terrestrial ecosystem (GDTE or wetland)		
R11 – GDTE/Wetland		No GDTE/Wetland within 250m of the site.

4.2 Methodology for Stage 1 Qualitative Assessment of Risk

Contaminants are likely to be present at the site and ground gases may be being generated, therefore risks posed by the site to receptors have been evaluated in accordance with the methodology given in the guidance document CIRIA C552. This methodology for risk evaluation is a qualitative method of interpreting the available data from the information gathering phase of the assessment. It involves the classification of the:

- magnitude of the probability (likelihood) of the risk occurring.
- magnitude of the potential consequence (severity) of risk occurring

The descriptions of the magnitudes of the consequences and likelihoods of risks occurring given in Tables 6.3 and 6.4 of CIRIA C552 have been used in this assessment.

Once the consequence and probability have been classified, a risk category, ranging from "very high risk" to "very low risk", can be assigned to each possible contaminant linkage. The table below summarises the consequence versus probability matrix with the assigned risk category and the actions corresponding with the classification.

Comparison of Consequences v Probability					
		Consequence			
		Severe	Medium	Mild	Minor
Probability	High likelihood	Very High Risk	High Risk	Moderate Risk	Moderate/ Low risk
	Likely	High Risk	Moderate Risk	Moderate/ Low risk	Low Risk
	Low likelihood	Moderate Risk	Moderate/ Low risk	Low Risk	Very Low Risk
	Unlikely	Moderate/ Low risk	Low Risk	Very Low Risk	Very Low Risk

Estimated Risks	
Very high risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not already undertaken) and remediation are likely to be required.
High risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present substantial liability. Urgent investigation (if not already undertaken) is required, and remedial works may be necessary in the short term and are likely over the longer term.

Moderate risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that harm would be severe, or if any harm were to occur, it is more likely that the harm would be relatively mild. Urgent investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
Low risk	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very low risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

Our research has indicated that the site was formerly occupied by 'research farms' and a veterinary pharmaceutical premises and it is likely, therefore, that chemical contamination will be present on site associated with this land use. The following assessment of risk is based on the redevelopment of the site for residential houses with gardens, and risks posed by the potential contaminant linkages in the developed site.

4.3 Risks to Human Health

Soil Contamination Risks

Made ground is likely to be present at the site and may have elevated contaminant levels. Contact with site soils is likely to be limited to any soft landscaped areas and exposure pathways also limited. However, human site users could be at risk from any potential contaminants present.

Exposure of sensitive residential receptors to contaminants				
Probability of risk being realised		**Consequence of risk being realised**		**Risk classification**
Low Likelihood	Made ground associated with the sites historical land use is likely to be present beneath the site. There is a potential contaminant linkage and circumstances, under which an event could occur are possible. However, it is by no means certain that even over a longer period such an event would take place and is less likely in the shorter term.	**Medium**	Potential for chronic damage to human health likely to result in "significant harm".	**Moderate**

Ground Gas Risks

Limited made ground associated with the sites historical use are anticipated, which is underlain by the London Clay Formation.

Migration of soil gas/vapours to on site properties				
Probability of risk being realised		**Consequence of risk being realised**		**Risk classification**
Low Likelihood	Previous site uses and the site visit indicate the potential for made ground beneath parts of the site, which could contain biodegradable material and could degrade to produce elevated levels of gas. There is a potential contaminant linkage and circumstances, under which an event could occur are possible. However, it is by no means certain that even over a longer period such an event would take place and is less likely in the shorter term.	**Medium**	Potential for chronic damage to human health likely to result in "significant harm".	**Moderate**

Overall, it is considered that a **moderate** risk should be assigned to risks to human health, although it is clear that some uncertainty remains as the presence of contamination and ground gas emissions has not been confirmed.

4.4 Risks to Plant Growth

Based on the desk study information and ICSM made ground may be present at the site surface which, if present, is unlikely to be a suitable medium for healthy plant growth in any soft landscaped areas.

Phytotoxic Risks				
Probability of risk being realised		**Consequence of risk being realised**		**Risk classification**
Low Likelihood	There is a potential contaminant linkage and circumstances, under which an event could occur are possible. However, it is by no means certain that even over a longer period such an event would take place and is less likely in the shorter term.	**Medium**	Affect to Plant Growth	**Moderate**

4.5 Risks to Controlled Waters

Groundwater contamination at the site due to the leaching of contaminants				
Probability of risk being realised		**Consequence of risk being realised**		**Risk classification**
Unlikely	The site is underlain by limited made ground associated with the previous and current site use, which is in turn underlain by the low permeability London Clay Formation, which is classified as unproductive strata.	**Medium**	Pollution of sensitive water environment	**Low**

Surface water contamination at the site due to contaminants migrating to local waters				
Probability of risk being realised		**Consequence of risk being realised**		**Risk classification**
Unlikely	The site is underlain by limited made ground associated with the previous and current site use, which is in turn underlain by low permeability London Clay, which would significantly retard any lateral migration of potential contaminants to surface water receptors. However, potential sources of contamination have been identified on site and further assessment to confirm the underlying ground conditions is required.	**Medium**	Pollution of sensitive water environment.	**Low**

Overall, it is considered that a **low** risk should be assigned to risks to controlled waters, although it is clear that some uncertainty remains as the presence of contamination and contaminant linkages has not been confirmed.

4.6 Risks to the Buildings and Services

Made ground is likely to be present at the site and may have elevated contaminant levels. Contaminants could potentially affect concrete building elements or service pipework including potable water supplies. The potential for ground gases to affect buildings has been discussed above.

Exposure of buildings and services to site contaminants				
Probability of risk being realised		**Consequence of risk being realised**		**Risk classification**
Likely	There is a potential contaminant linkage and circumstances, under which an event could occur are possible.	**Medium**	Damage to integrity of concrete building elements and potable water supplies.	**Moderate**

Exposure of buildings and services to site contaminants				
Probability of risk being realised		**Consequence of risk being realised**		**Risk classification**
	However, it is by no means certain that even over a longer period such an event would take place and is less likely in the shorter term.			

4.7 Objectives of the Site Investigation and Methodology

The initial conceptual site model was used to inform the design of the site investigation. Where chemical analysis data has been obtained for soils and waters, JPB's risk assessment methodology comprises an initial comparison of potential contaminant concentrations with Stage 2 Risk Assessment generic assessment criteria. The concentrations of contaminants exceeding these criteria and contaminants for which authoritative Stage 3 Risk Assessment criteria were not available are assessed in Stage 3 Risk Assessment, a site-specific quantitative risk assessment.

The Stage 3 Risk Assessment comprises a quantitative risk assessment of contaminant concentrations performed using appropriate risk assessment models and tools. These assessments are discussed in more detail in the later sections of this report.

In order to test and develop the initial CSM, the site investigations had the following objectives:

- To identify the extent of any made ground at the site (potential contaminant source)
- To identify the nature, extent, and concentration of contaminants in soil, groundwater and ground gases.
- To determine if contaminants are leachable or otherwise mobile.
- To examine the ground gas regime at the site.
- To determine what threat the site poses to off site water receptors.
- To determine what threat the site contaminants pose to off site human receptors (occupants of adjacent properties).
- To determine what threat the site poses to on site human receptors (workers and occupants).
- To determine geotechnical properties of soils.
- To determine foundation solutions for development.

In order to achieve these objectives, the investigation was designed to include the following: trial pitting, California bearing ratio (CBR) tests, window sampling boreholes with standpipes installed and specialist laboratory testing of recovered soil and samples for geotechnical and chemical characteristics. Monitoring of ground gas concentrations and groundwater levels in standpipes was also undertaken. These investigations are described in more detail in the following section of this report.

PART THREE – SITE INVESTIGATIONS

5.0 SITE INVESTIGATIONS

5.1 Programme of Works and Investigation Rationale

The design and performance of this site investigation takes cognisance of the guidance given in BS 10175 – Investigation of Potentially Contaminated Sites – Code of Practice – BSI 2011 and BS5930. Investigation points were located where access, ground conditions and underground services allowed. It should be noted that soil and rock conditions are highly variable and may differ between sampling points and under current site buildings and this may affect interpolation. Additional features may exist buried at depth and undetected by investigation. The approximate locations of all trial pits and boreholes are shown on JPB Drawing WB307-01/R/F/05.

Work Item	Description	Appendix
Trial pit excavations	**20 trial pits**, to between 1.3m and 3.7m depth, undertaken by a Johnson Poole & Bloomer Geo-environmental Engineer between 4th and 6th April 2022.	Appendix 8
Rationale	To investigate the nature, extent and engineering properties of the soils underlying the site and recover soil samples for chemical analysis. Specific targeted investigations are discussed in below.	
California Bearing Ratio tests	**Undertaken in 18 trial pits** (TP01-TP02, TP04-TP08 and TP10-TP20) by Terra Tek Limited.	Appendix 9
Rationale	To facilitate road and paving design.	
Window Sampling Boreholes	**12 soils boreholes** (WS01 to WS12), to depths of 5m bgl, were sunk by Geospek Limited across the site between 7th and 8th April 2022.	Appendix 10
Rationale	To investigate the nature, extent and engineering properties of the soils underlying the site and recover soil samples for geotechnical and chemical analysis. Specific targeted investigations are discussed below.	
Geotechnical testing	**Geotechnical laboratory** testing of soil samples was performed by i2 Analytical Ltd and included the following: i) Compaction Tests (2.5kg Rammer). ii) Moisture Content and Atterberg Limits. iii) One dimensional consolidation testing. iv) Particle Size Distribution (PSD).	Appendix 11
Rationale	To determine engineering properties of the soils underlying the site.	
Chemical contamination testing	**15 soil samples** (10 made ground and 3 natural) were analysed by i2 Analytical Ltd at our instruction. This included a sample taken from bunded material at the eastern area of the site, as shown on JPB Drawing WB307-01/R/F/05. The soil testing programme comprised the following chemical parameters; **asbestos (presence and type), pH, total sulphate, water soluble sulphate, sulphides, phenols, total cyanide, Total Petroleum Hydrocarbons (TPH), Polyaromatic Hydrocarbons (PAH), arsenic, mercury, selenium, lead, total chromium, hexavalent chromium, cadmium, copper, nickel, zinc, water soluble boron and percentage soil organic matter (SOM)**. All samples were tested for **leachability** where appropriate. Where site observations indicated, samples were scheduled based on the usage and the conditions encountered on the site. Targeted testing for **TPH (aliphatic/aromatic split), VOCs** and **PCBs** was instructed where the Conceptual Site Model/historical research indicated their possible presence. **Three samples** were analysed for **Waste Acceptance Criteria Testing (WAC).** **Three soil samples** from the trial pits were analysed for UKWIR water supply pipe suite. The suite comprised the following parameters; **VOCs plus TIC of compounds at >20µg/kg, SVOCs plus TIC of compounds at >20µg/kg, amines, petroleum hydrocarbons split into following ranges; C5-C10, C11-C20 and C20-C40, pH value, electrical conductivity, redox potential.** In addition to the above, a handheld mini monitor 900 Series Geiger Counter (EP15 1380) was used to screen the soils and take ambient readings to monitor radioactivity during the site works.	Appendix 12
Rationale	To determine concentrations of potential chemical contaminants in the soils underlying the site.	

Work Item	Description	Appendix
Gas and water monitoring	**Gas and water monitoring** at standpipes installed in five of the boreholes (WS01, WS04, WS05, WS08 and WS11) was carried out. Levels of methane, carbon dioxide, oxygen, nitrogen, carbon monoxide, hydrogen sulphide and atmospheric pressure were recorded. Flow rates were also recorded. Following the collection of the gas data the depth to any water present within the standpipes installed in the boreholes was measured using a dipmeter.	Appendix 13
Rationale	To determine the groundwater and ground gas regimes at the site	

In addition to JPB's investigation protocol, the following targeted investigations were carried out.

Targeted Investigation Point	Target	Specific Contamination Analysis (if required)
WS08	Electricity Sub-station and above ground fuel tank	PCBs, TPH and VOCs
Trial Pit TP11 and TP14	Area of former building.	General suite plus asbestos.
WS10	Within area of former septic tank highlighted in the 2012 ERM report.	General suite plus asbestos.
BUND1	Made ground bund material in eastern area of site.	General suite plus asbestos.

PART FOUR – GEOTECHNICAL

6.0 SITE GEOLOGY

6.1 General

The general geological conditions beneath the site were assessed from the available information including a review of geological maps and boreholes. This provided an indication of the general thickness of the superficial cover.

The recent investigations appear to confirm the anticipated geological conditions with made ground overlying the London Clay Formation.

6.2 Made Ground

Limited made ground was encountered in 25 of the 32 exploratory holes which were sunk/excavated down to between 0.3m and 1.5m bgl. The made ground typically comprised topsoil/tarmac/concrete over sand and gravels including flint, brick fragments, concrete, rare plastic and ceramic, as well as reworked natural soft to firm sandy gravelly clay.

6.3 Natural Superficial Deposits

No natural superficial deposits were proven beneath the site.

6.4 Solid Geology

The exploratory holes encountered the London Clay Formation at between 0.3m and 1.5m bgl down to the maximum termination depths (maximum 5.0m bgl). This generally comprised firm slightly silty sandy clay with chalk and flint gravels, which becomes stiff to very stiff with depth. Some horizons of very clayey sand were encountered within this strata (WS01, WS03 and WS08), however these did not appear to be continuous across the site and were likely localised pockets/horizons within the clay.

6.5 Groundwater

No groundwater was encountered in any of the borehole or trial pits during drilling/excavation, with the exception of a slight groundwater seepage recorded at 0.65m within the made ground at TP06.

The standpipes installed during the investigation were subsequently monitored and the results are summarised in the following table.

BH	Surface level (mAOD)	Response Zone	Response Materials	Water Depths Recorded (m) [Water level] (mAOD)					
				21/04/22	06/05/22	20/05/22	01/06/22	14/06/22	30/06/22
WS01	49.26	1m to 5m	London Clay	1.68 [47.58]	1.96 [47.30]	2.06 [47.20]	2.05 [47.21]	2.14 [47.12]	2.23 [47.03]
WS04	52.55	1m to 5m	London Clay	3.83 [48.72]	4.05 [48.5.0]	4.10 [48.45]	4.17 [48.38]	4.27 [48.28]	4.43 [48.12]
WS05	50.26	1m to 5m	London Clay	2.17 [48.09]	2.43 [47.83]	2.40 [47.86]	2.30 [47.96]	2.36 [47.90]	2.23 [48.03]
WS08	52.35	1m to 5m	London Clay	3.25 [49.10]	3.59 [48.76]	3.64 [48.71]	3.63 [48.72]	3.67 [48.68]	3.71 [48.64]
WS11	57.61	1m to 5m	London Clay	2.22 [55.39]	2.06 [55.55]	1.88 [55.73]	1.88 [55.73]	1.86 [55.75]	1.95 [55.66]

Groundwater levels were recorded within the London Clay on six occasions from the standpipes within boreholes on the 21st April and 30th June 2022. A review of the recorded groundwater values over this period indicates that groundwater lies at between 1.68m and 4.43m bgl (47.03m to 55.75mAOD). Based on this information, a laterally continuous groundwater table is not present beneath the site. The groundwater encountered is likely perched groundwater within the London Clay, which is confined to thin sandy horizons within the strata.

7.0 ENGINEERING CHARACTERISTICS OF THE SUPERFICIAL MATERIALS

7.1 General

The results of the in situ and laboratory geotechnical testing of the samples recovered during the recent investigations are included in Appendix 11. The soil parameters from the in situ and laboratory testing of samples are summarised in the following table.

7.2 Made Ground

Due to the shallow depths within the boreholes (maximum depth of 1.1m bgl) no standard penetration tests were carried out within the made ground deposits.

Reworked Natural

Material Type	Cohesive Reworked Natural Clay
Range of consistency	Soft to firm
Soil Density (Mg/m^3)	1.59 – 1.69 Mg/m^3
Hand Vane tests results	33.33 – 96 kPa
Average Shear Strength	53.67 kPa
Undrained Shear Strength Classification	Low to medium
California Bearing Ratio (CBR) value (%)	1.2 – 4.6%

7.3 Solid Geology

Cohesive

Material Type	London Clay
Natural Moisture Content (%)	8.4-33
Plastic Limit (%)	20-28
Liquid Limit (%)	44-80
Plasticity Index (%)	22-53
Soil type based on plasticity chart	Medium to very high
Soil descriptions from PSD	Slightly sandy to very sandy CLAY
Range of consistency	Soft to very stiff
Soil Density (Mg/m^3)	1.56 - 1.7 Mg/m^3
Hand Vane tests results	23 – 135 kPa
Average Shear Strength	65.08 kPa
Undrained Shear Strength Classification	Low to high
Standard Penetration Test (SPT) N values	4 - 41
Mass Shear Strength (c) based on SPT value using Stroud Correlation	18.4 – 176.3 kPa
Modulus of volume compressibility (m_v) based on SPT value (Stroud)	0.05 – 0.53 m^2/MN
California Bearing Ratio (CBR) value (%)	1.7 – 2.4%

Granular

Material Type	Granular bands within the London Clay
Standard Penetration Test (SPT) N values	16

8.0 FOUNDATION DESIGN CONSIDERATIONS

8.1 General

Based upon the engineering properties of the soils as discussed in previous sections of this report, we would offer the following comments regarding suitable founding horizons. The wall loadings for the proposed development are unknown at present but are assumed to be in the range of 120 kN/m to 150 kN/m for the warehouse structures.

8.2 Made Ground

The investigation has indicated the site to be overlain by limited made ground (encountered in 25 of the 32 exploratory holes). Due to the inherent variability of this material it is considered that this horizon would not be very suitable as a founding horizon in its present condition.

The site is currently occupied by buildings and it is known that there were former buildings in the central and western areas, and therefore foundations will to be encountered. These concrete obstructions would be a constraint to any of the foundation solutions advised in the following sections and would require to be removed during any demolition operations.

8.3 Solid Geology (London Clay)

Pad Foundations

Cohesive London Clay was recorded beneath the made ground/topsoil across the site, and allowable bearing pressures for various sized pad foundations within this strata was calculated using a conservative shear strength of 60kN/m^2. The top of London Clay strata appeared to be soft in places, most likely due to weathering, therefore it is recommended that the pads are founded within firm London Clay at 2m depth. It is assumed that these are placed at a minimum of 2m depth in the natural ground or at 0.5m penetration into cohesive London Clay where made ground is present at 1.5m depth. All settlements are within acceptable limits less than 25mm. The allowable bearing pressures are summarised in the following table:

Width (m)	Allowable Bearing Pressure (kN/m^2)	Maximum Column Loading (kN/m)
1.0m x 1.0m	124	124
1.5m x 1.5m	114	256
2.0m x 2.0m	85	340

8.4 General Comments

pH values and sulphate levels were recorded above laboratory reporting limits therefore an assessment was carried out in accordance with BRE Special Digest 1. The ground conditions indicate design sulphate class DS-4 and ACEC class AC-4. **Therefore, concrete specifications should be such as to be protective of buildings exposed to these conditions.**

During site works, should any localised softening of the soils be encountered then these materials should be removed and replaced with well compacted hardcore. In addition, it is imperative that the foundation excavations are kept dry to ensure the integrity of the London Clay as this material is very sensitive to wetting. All excavations should be examined to ensure that the material is consistent with that used in the assessment.

Groundwater was not encountered during the excavation/drilling of the exploratory holes, except for a slight seepage recorded at TP06. However some perched groundwater was observed in borehole installations during subsequent monitoring visits. During the design of any excavations at the site due consideration should be given to the control of surface water and possible ground inflow and sidewall stability, with all necessary precautions being taken to ensure safe working conditions. This should be carried out in accordance with Health & Safety and CDM Guidance.

9.0 ROAD CONSTRUCTION

The investigation has indicated that the site is underlain by limited made ground over the London Clay Formation.

Prior to the construction of any adoptable roads CBR testing would be required at 25m centres along the route of these in order to ascertain the requirements for a capping layer. It should be noted, however, that any road built on areas of made ground or any upfilled areas would require a full capping layer.

Any material beneath the road will require to be placed in accordance with the Specification of Highway Works Series 600 and appropriate testing carried out to confirm the acceptability of the material.

Eighteen CBR tests were carried out along the proposed road service yard paving areas, and these indicated CBR values in the range of 1.2% to 4.6%. As natural soils with a CBR value with less than 2% were encountered together with made ground deposits, a full capping layer will be required.

Eleven of the recorded CBR values were below 2.5%, and therefore the material is a soft sub-grade as per Interim Advice Note 73/06 Revision 1 (2009) Design Guidance for Road Pavement Foundations (Draft Hd25) then the measures outlined in that document should be undertaken to address these issues. The guidance is as follows

The minimum permitted Design CBR is 2.5% CBR. Where a subgrade has a lower CBR it is considered unsuitable support for a pavement foundation. It must therefore be permanently improved using one of the options given in the following paragraphs.

The material at the surface can be removed and replaced by a more suitable material. If the depth of relatively soft material is small, it can be replaced in its entirety, although it may only be necessary to replace the top layer. The thickness removed will typically be between 0.5 and 1.0m.

Although the new material may be of better quality, the new Design CBR should be assumed to be equivalent to 2.5%, in order to allow for effects of any softer underlying material and the potential reduction in the strength of the replacement material to its long-term CBR value.

If the soil is cohesive, a lime (or similar) treatment may be appropriate, subject to soil suitability being demonstrated. Details of various soil treatments are given in HA44 (DRAB 4.1.1). The new Design CBR should again be assumed to be equivalent to 2.5% unless agreed otherwise under Departure from Standard approval. HA 74 (DMRB 4.1.6) contains further advice on stabilisation.

Site Operatives During Construction of the Development

No elevated contaminants were recorded from the soil laboratory test results, however, localised Chrysotile asbestos cement type material was detected within the shallow made ground at WS05 (0.3m-0.5m bgl), therefore is potential for significant harm to future workers from the effects of the inhalation of asbestos. The Construction Industry Research and Information Association (CIRIA) have published a Report132 entitled “A Guide for Safe Working on Contaminated Sites 1996”. The recommendations within this publication should be followed during works, particularly with reference to the control measures and personal protective equipment (PPE) and respiratory protective equipment (RPE) required when handling asbestos containing materials and other contaminants. It is considered that the risk to future workers can be sufficiently mitigated by site workers using appropriate PPE/RPE.

Roads Maintenance Workers in the Completed Development

Risks have been identified due to the presence of localised Chrysotile asbestos cement type material locally within the shallow made ground at WS05 (0.3m-0.5m). However, services are to be placed in oversized trenches and backfilled with clean materials. In addition, the use of appropriate PPE/RPE will serve to mitigate the risk to workers from asbestos containing materials and other unknown contaminants.

General

As with any construction or maintenance activity, risks to workers should be managed by appropriate health and safety risk assessments/COSHH undertaken in the normal manner by the employer prior to works being undertaken as required by health and safety legislation.

PART FIVE – CHEMICAL CONTAMINATION AND GAS EMISSIONS ASSESSMENT

10.0 STAGE 2 GENERIC QUANTITATIVE RISK ASSESSMENT - CHEMICAL CONTAMINATION

10.1 Introduction

The Stage 2 generic quantitative assessment of risk to human health, property, ecology, surface water and ground water considers the potential for exposure based on comparison of the results to conservative generic criteria. JPB's risk assessment methodology is discussed in detail in Appendix 7 and is summarised in the flow chart presented in that appendix.

In terms of human health, the guideline concentration appropriate to the proposed end use of the site is used in the interpretation of the results. The site is proposed for development as a commercial premises, therefore, the most relevant criteria, those for a commercial development have been adopted. At Stage 2 all soil contaminant concentrations are compared with GACs. If necessary, at Stage 3 representative soil contaminant concentrations are calculated and used for comparison with assessment criteria.

It is understood that the site previously undertook work in relation to radioisotopes, and was registered for the use and storage of radioactive substances. It is understood that work with radioactive isotopes ceased in 1994, and a full radiological survey and decontamination programme was undertaken by external consultants in the late 1990s. Since this time, no radioactive substances have been stored or used at the site.

During the present investigation, a handheld mini monitor 900 Series Geiger Counter (EP15 1380) was used to monitor background radiation and screen the soils for signs of radioactive contamination whilst working. No radioactivity above the normal background levels were recorded at any time during the investigation. It should be noted that the monitor was only used in areas accessed during the investigation (external areas), and no internal monitoring of the buildings was undertaken.

10.2 Risk Assessment

The following tables summarise the results of the Stage 2 assessment. For C4SLs, S4ULs and EIC/AGS/CL:AIRE values derived using 1% soil organic matter have been adopted where available. JPB derived GAC have been derived conservatively assuming site soils have 1% soil organic matter.

Human Health - Chemical Contamination

Parameter	Concentration range (mg/kg)	Concentration range exceeding JPB GAC (mg/kg)	JPB GAC Commercial/ Industrial (mg/kg)	Source of GAC	No. and location of exceedances
Arsenic	0.5-19	None	640	C4SL	None
Boron	0.4-18	None	240000	S4UL	None
Cadmium	Below Detectable Limits	None	410	C4SL	None
Chromium (III)	23-50	None	8600	S4UL	None
Hexavalent Chromium (Chromium (VI))	Below Detectable Limits	None	170	C4SL	None
Copper	15-71	None	68000	S4UL	None
Lead	16-180	None	2300	C4SL	None
Mercury (Inorganic mercury)	Below Detectable Limits	None	1100	S4UL	None
Nickel	13-43	None	980	S4UL	None
Selenium	Below Detectable Limits	None	12000	S4UL	None
Zinc	37-230	None	730000	S4UL	None
Cyanides	Below Detectable Limits	None	175	JPB GAC	None
Toluene	Below Detectable Limits	None	56000	S4UL	None
Ethylbenzene	Below Detectable Limits	None	5700	S4UL	None
Benzene	Below Detectable Limits	None	98	C4SL	None
o - xylene	Below Detectable Limits	None	6600	S4UL	None
m - xylene	Below Detectable Limits	None	6200	S4UL	None

Parameter	Concentration range (mg/kg)	Concentration range exceeding JPB GAC (mg/kg)	JPB GAC Commercial/ Industrial (mg/kg)	Source of GAC	No. and location of exceedances
p – xylene	Below Detectable Limits	None	5900	S4UL	None
Phenols	Below Detectable Limits	None	440	S4UL	None
Aliphatic TPH >EC_6 –EC_8	Below Detectable Limits	None	7800	S4UL	None
Aliphatic TPH >EC_8 –EC_{10}	Below Detectable Limits	None	2000	S4UL	None
Aliphatic TPH >EC_{10} –EC_{12}	Below Detectable Limits	None	9700	S4UL	None
Aliphatic TPH >EC_{12} –EC_{16}	Below Detectable Limits - 17	None	59000	S4UL	None
Aliphatic TPH >EC_{16} –EC_{35}	Below Detectable Limits - 290	None	>100%	S4UL	None
Aromatic TPH >EC_6 –EC_8	Below Detectable Limits	None	56000	S4UL	None
Aromatic TPH >EC_8–EC_{10}	Below Detectable Limits	None	3500	S4UL	None
Aromatic TPH >EC_{10} –EC_{12}	Below Detectable Limits – 3.7	None	16000	S4UL	None
Aromatic TPH >EC_{12} –EC_{16}	Below Detectable Limits - 22	None	36000	S4UL	None
Aromatic TPH >EC_{16} –EC_{21}	Below Detectable Limits - 110	None	28000	S4UL	None
Aromatic TPH >EC_{21} –EC_{35}	Below Detectable Limits - 150	None	28000	S4UL	None
Naphthalene	Below Detectable Limits – 2.7	None	190	S4UL	None
Acenaphthylene	Below Detectable Limits	None	83000	S4UL	None
Acenaphthene	Below Detectable Limits – 3.8	None	84000	S4UL	None
Fluorene	Below Detectable Limits – 6.5	None	63000	S4UL	None
Phenanthrene	Below Detectable Limits 35	None	22000	S4UL	None
Anthracene	Below Detectable Limits – 8.4	None	520000	S4UL	None
Fluoranthene	Below Detectable Limits - 26	None	23000	S4UL	None
Pyrene	Below Detectable Limits – 16	None	54000	S4UL	None
Benz(a)anthracene	*	*	*	*	*
Chrysene	*	*	*	*	*
Benzo(b)fluoranthene	*	*	*	*	*
Benzo(k)fluoranthene	*	*	*	*	*
Benzo(a)pyrene	Below Detectable Limits - 5.9	None	77	C4SL	None
Indeno (1,2,3-CD) pyrene	*	*	*	*	*
Dibenzo(a,h)anthracene	*	*	*	*	*
Benzo(g,h,i)perylene	*	*	*	*	*
PCBs (non dioxin-like) Sum of seven congeners	Below Detectable Limits	None	9.5	JPB GAC	None
Chlorobenzene	Below Detectable Limits	None	56	S4UL	None
1,2-dichlorobenzene	Below Detectable Limits	None	2000	S4UL	None
1,3-dichlorobenzene	Below Detectable Limits	None	30	S4UL	None
1,4-dichlorobenzene	Below Detectable Limits	None	4400	S4UL	None
1,2,3-trichlorobenzene	Below Detectable Limits	None	102	S4UL	None
1,2,4-trichlorobenzene	Below Detectable Limits	None	220	S4UL	None

Parameter	Concentration range (mg/kg)	Concentration range exceeding JPB GAC (mg/kg)	JPB GAC Commercial/ Industrial (mg/kg)	Source of GAC	No. and location of exceedances
Other chlorophenols	Below Detectable Limits	None	3500	S4UL	None
Hexachlorobutadiene	Below Detectable Limits	None	31	S4UL	None
Hexachlorobenzene	Below Detectable Limits	None	110	S4UL	None
1,1,2,2-Tetrachloroethane	Below Detectable Limits	None	270	S4UL	None
1,1,1,2-Tetrachloroethane	Below Detectable Limits	None	110	S4UL	None
Tetrachloroethene (PCE)	Below Detectable Limits	None	24	C4SL (CL:AIRE)	None
Trichloroethene (TCE)	Below Detectable Limits	None	0.73	C4SL (CL:AIRE)	None
Trichloromethane	Below Detectable Limits	None	99	S4UL	None
Tetrachloromethane	Below Detectable Limits	None	2.9	S4UL	None
Vinyl chloride	Below Detectable Limits	None	1.1	C4SL (CL:AIRE)	None
1,1-dichloroethane	Below Detectable Limits	None	280	EIC/AGS/ CL:AIRE	None
1,1-Dichloroethene	Below Detectable Limits	None	26	EIC/AGS/ CL:AIRE	None
1,2,4-Trimethylbenzene	Below Detectable Limits	None	42	EIC/AGS/ CL:AIRE	None
1,2-Dichloropropane	Below Detectable Limits	None	3.3	EIC/AGS/ CL:AIRE	None
2,4-Dimethylphenol	Below Detectable Limits	None	16000	EIC/AGS/ CL:AIRE	None
2,4-Dinitrotoluene	Below Detectable Limits	None	3700	EIC/AGS/ CL:AIRE	None
2,6-Dinitrotoluene	Below Detectable Limits	None	1900	EIC/AGS/ CL:AIRE	None
2-Chloronaphthalene	Below Detectable Limits	None	39.	EIC/AGS/ CL:AIRE	None
Sum of 2-Methylphenol 3-Methylphenol 4-Methylphenol	Below Detectable Limits	None	160000	EIC/AGS/ CL:AIRE	None
Bromobenzene	Below Detectable Limits	None	97	EIC/AGS/ CL:AIRE	None
Bromodichloromethane	Below Detectable Limits	None	2.1	EIC/AGS/ CL:AIRE	None
Butyl benzyl phthalate	Below Detectable Limits	None	940000	EIC/AGS/ CL:AIRE	None
Chloroethane	Below Detectable Limits	None	960	EIC/AGS/ CL:AIRE	None
Chloromethane	Below Detectable Limits	None	1.0	EIC/AGS/ CL:AIRE	None
Cis 1,2 Dichloroethene	Below Detectable Limits	None	14	EIC/AGS/ CL:AIRE	None
Diethyl Phthalate	Below Detectable Limits	None	150000	EIC/AGS/ CL:AIRE	None
Hexachloroethane	Below Detectable Limits	None	22	EIC/AGS/ CL:AIRE	None
Propylbenzene	Below Detectable Limits	None	4100	EIC/AGS/ CL:AIRE	None
Styrene	Below Detectable Limits	None	3300	EIC/AGS/ CL:AIRE	None

* Parameter assessed using the benzo(a)pyrene surrogate marker approach.
PAH ratios have not been calculated as all samples had low or no appreciable PAH contents.

Human Health - Asbestos

Fifteen soil samples were scheduled for laboratory testing for the presence of asbestos. **Chrysotile** cement type material was detected to be present in a made ground soil sample from WS05 at 0.3m-0.5m. Further quantification by polarising light and dispersion staining was undertaken on this sample and determined the quantity of asbestos to be 1.19% (by weight). Asbestos was not identified within the fourteen other samples scheduled for analysis.

Phytotoxicity – Soils

Parameter	Concentration range (mg/kg)	Concentrations exceeding GAC (mg/kg)	GAC (mg/kg)	Source of GAC	No. and location of exceedances
Copper	15-71	None	pH 6.0-7.0 = 135 pH >7.0 =200	MAFF Guidance	None
Zinc	37-230	None	pH 6.0-7.0 =200 pH >7.0 =300	MAFF Guidance	None
Nickel	13-43	None	pH 6.0-7.0 = 75 pH >7.0 =110	MAFF Guidance	None
Cadmium	Below Detectable Limits	None	3	MAFF Guidance	None
Lead	16-180	None	300	MAFF Guidance	None
Mercury	Below Detectable Limits	None	1	MAFF Guidance	None
Chromium	23-50	None	400	MAFF Guidance	None
Selenium	Below Detectable Limits	None	3	MAFF Guidance	None
Arsenic	0.5-19	None	50	MAFF Guidance	None

Buildings and Services

Buildings and Services – Soils Effect on Concrete

Parameter	Concentration Range	SSAC BRESD1/BRE PBMCL
pH	6.7 – 11.0	<5 or >8
Total Sulphate	210 – 5,400 mg/kg as SO_4	Not Applicable
Water soluble sulphate	10.1 – 3,350 mg/L as SO_4	Not Applicable

Buildings and Services – Soils Effect on Water Supply Pipes

Parameter Group*	Parameter	Sum of Maximum Concentrations or maximum (mg/kg)	PE GAC (mg/kg)	Exceeded Yes/No	PVC GAC (mg/kg)	Exceeded Yes/No
1	Extended VOCs suite by purge and trap or headspace and GC-MS with TIC (but not including group 1a)	Below Detectable Limits	0.5	No	0.125	No
1a	BTEX + Propylbenzene +MTBE	Below Detectable Limits	0.1	No	0.03	No
2	SVOCs (including TIC, but not groups 2e or 2f)	Below Detectable Limits	2	No	1.4	No
2e	Phenols	Below Detectable Limits **– 2.1**	2	**Yes**	0.4	**Yes**
2f	Cresols and chlorinated phenols	Below Detectable Limits	2	No	0.04	No
3	Mineral oil C11-C20	Below Detectable	10	No	-	No
4	Mineral oil C21-C40	Below Detectable Limits - 25	500	No	-	No
5	Conductivity	110 - 510	-	-	-	-
	pH value	7.1 – 8.3	-	-	-	-
	Redox potential	25.6 – 256.6	-	-	-	-
2a**	Ethers	Below Detectable Limits	0.5	No	1	No
2b**	Nitrobenzene	Below Detectable Limits	0.5	No	0.4	No

Parameter Group*	Parameter	Sum of Maximum Concentrations or maximum (mg/kg)	PE GAC (mg/kg)	Exceeded Yes/No	PVC GAC (mg/kg)	Exceeded Yes/No
2c**	Ketones	Below Detectable Limits	0.5	No	0.02	No
2d**	Aldehydes	Below Detectable Limits	0.5	No	0.02	No
6	Amines	Below Detectable Limits	MRL		-	-

* Specific compounds included within groups are listed in Table G1 of the UKWIR guidance. Group 2f includes chlorinated phenols, not just those listed in Table G1.
** No specific compounds included within groups listed in Table G1 of the UKWIR guidance were recorded in VOC or SVOC TICs.

Controlled Waters

Leachates

Parameter	Concentration Range (µg/L unless stated otherwise)	Groundwater Receptors		Surface Water receptors	
		RPV/DWS (source) (µg/L unless stated otherwise)	No. and location of exceedances	EQS/MRL (Source) (µg/L unless stated otherwise)	No. and location of exceedances
Arsenic	Below Detection Limits – 6.1	10	-	50	-
Cadmium	Below Detection Limits	5	-	40.71 – 239.33	-
Chromium	Below Detection Limits – 120	50	WS05 at 0.3m-0.5m	4.7	
Copper	7-36	2000	-	1	All tested samples (16) TP11 at 0.3m, TP02 at 0.2m, TP14 at 0.3m, TP17 at 0.3m, TP07 at 0.2m, WS01 at 0.2m, WS02 at 0.9-1.0m, WS05 at 0.3-0.5m, WS03 at 0.4-0.5m, WS04 at 0.2 – 0.4m, WS06 at 0.9-1.0m, WS08 at 0.2-0.3m, WS09 at 0.2m-0.3m, WS12 at 0.4-0.5m, WS10 at 0.4-0.5m and BUND1
Lead	2.7-90	10	TP02 at 0.2m and TP14 at 0.3m	1.2	
Mercury	Below Detection Limits	1 (MRL)	-	0.07	-
Nickel	3.7-11	20	-	4	TP11 at 0.3m, TP02 at 0.2m, TP14 at 0.3m, TP17 at 0.3m, TP07 at 0.2m, WS01 at 0.2m, WS03 at 0.4-0.5m, WS04 at 0.2 – 0.4m, WS06 at 0.9-1.0m, WS08 at 0.2-0.3m, WS09 at 0.2m-0.3m, WS12 at 0.4-0.5m, WS10 at 0.4-0.5m and BUND1
Selenium	Below Detection Limits – 14	10	WS06 at 0.9m-1.0m	10	
Zinc	4.6-43	5000 (*)	-	11.9	TP11 at 0.3m, TP02 at 0.2m, TP14 at 0.3m, TP17 at 0.3m,

Parameter	Concentration Range (µg/L unless stated otherwise)	Groundwater Receptors		Surface Water receptors	
		RPV/DWS (source) (µg/L unless stated otherwise)	No. and location of exceedances	EQS/MRL (Source) (µg/L unless stated otherwise)	No. and location of exceedances
					TP07 at 0.2m, WS01 at 0.2m, WS03 at 0.4-0.5m, WS04 at 0.2 – 0.4m, WS08 at 0.2-0.3m, WS10 at 0.4-0.5m and BUND1
Cyanide	Below Detection Limits	50	-	1 (free cyanide)	-
Sulphate	4-123	250mg/L	-	400mg/L	-
Sulphide	Below Detection Limits	5 (MRL)	-	(MRL)	-
Phenol	Below Detection Limits – 2.5	0.5 (*)	WS06 at 0.9m-1.0m, TP11 at 0.3m, TP02 at 0.2m, TP14 at 0.3m, TP17 at 0.3m and TP07 at 0.2m.	7.7	-

* - indicates a parameter where no maximum concentration is given in the Water Supply (Water Quality) EA 2001 and as such the value from the Water Supply (Water Quality) EA 1990 has been used.

1. Groundwater Resource Receptors

A review of the potential controlled water receptors at the site was undertaken in the light of the information gained during the site investigation.

The site has been shown to be underlain by limited made ground on top of low permeability London Clay, which is classified as unproductive strata by the EA. Water monitoring at standpipes has confirmed variable groundwater levels across the site at between 1.68m and 4.05m bgl (47.30m to 55.55mAOD), which indicates an absence of a laterally continuous water table beneath the site. It is considered that the groundwater encountered represents perched groundwater accumulations within the London Clay (possibly confined within localised sandy horizons). On the basis of this information groundwater resource receptors are considered to be absent from the site and no further assessment of groundwater quality at the site is required.

2. Surface Water Receptors

The nearest surface water feature is the four small ponds and the River Pinn located 50m north-west and 110m south-east of the site, respectively. The present site investigation has indicated there to be limited Made Ground or a soil contamination source beneath the site. In addition, the site is underlain by low permeability London Clay, which would inhibit the migration of any potential contaminants beneath the site to the surface water receptors. On the basis of this information it is considered that no significant intact SPR linkage between the site and the surface water features are present, and therefore no requirement for a controlled waters assessment in relation to surface water receptors is considered necessary.

Conclusion

The soil laboratory test results indicate an absence of a source of contamination beneath the site. In addition, the site is underlain by limited made ground on top of low permeability London Clay, which is classified as 'unproductive strata' by the EA. The presence of this strata would serve to inhibit vertical and lateral migration of any potential contaminants beneath the site. On the basis of this information, it is considered that no significant intact SPR linkage between the site and controlled waters are present, and therefore no further assessment is considered necessary.

10.3 Summary

Human Health

No soil concentrations of tested determinants exceeded their relevant human health GACs. However, asbestos (hard cement type material) was identified in one sample of the shallow made ground at WS05 (0.3m-0.5m). Further quantification by polarising light and dispersion staining determined the quantity of the asbestos to be 1.19% (by weight). Asbestos was not identified within the other fourteen tested samples, therefore it is considered to be localised and not a site wide occurrence. It is understood that soft landscaping is proposed in the vicinity of WS05. On the basis of this information, **remedial measures are required to protect human health**.

Phytotoxicity

No soil concentrations exceeded phytotoxicity GACs, therefore, **no remedial measures are required to protect healthy plant growth.**

Controlled Waters

On the basis of the findings of the investigation and the above assessment, it is considered that there are no significant intact contaminant linkages to groundwater or surface water receptors at the site. It is therefore concluded that no further assessment with regards to the controlled waters is considered necessary at the site.

Buildings and Services

pH values and sulphate concentrations indicated that the ground conditions fall within design sulphate class DS-4 and ACEC class AC-4 as defined in BRE Special Digest 1.

The requirements for water supply pipes are outlined in the Water Supply Pipes section of this report.

11.0 WATER SUPPLY PIPES

In accordance with UK Water Industry Research (UKWIR) document, "Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites", UKWIR report reference 10/WM/03/21, 2010 a site investigation has been carried out and a Site Assessment Report has been incorporated into this report. The findings of the comparison of chemical test results with UKWIR threshold values is presented as follows.

Soils –Water Supply Pipes

Parameter Group*	Parameter	Sum of Maximum Concentrations or maximum (mg/kg)	PE GAC (mg/kg)	Exceeded Yes/No	PVC GAC (mg/kg)	Exceeded Yes/No
1	Extended VOCs suite by purge and trap or headspace and GC-MS with TIC (but not including group 1a)	None Detected	0.5	No	0.125	No
1a	BTEX + Propylbenzene +MTBE	Below Detectable Limits	0.1	No	0.03	No
2	SVOCs (including TIC, but not groups 2e or 2f)	Below Detectable Limits	2	No	1.4	No
2e	Phenols	Below Detectable Limits **– 2.1**	2	**Yes**	0.4	**Yes**
2f	Cresols and chlorinated phenols	Below Detectable Limits	2	No	0.04	No
3	Mineral oil C11-C20	Below Detectable	10	No	-	No
4	Mineral oil C21-C40	Below Detectable Limits - 25	500	No	-	No
5	Conductivity	110 – 510 µS/cm	-	-	-	-
	pH value	7.1 – 8.3	-	-	-	-
	Redox potential	25.6 – 256.6 mV	-	-	-	-
2a**	Ethers	Below Detectable Limits	0.5	No	1	No
2b**	Nitrobenzene	Below Detectable	0.5	No	0.4	No
2c**	Ketones	Below Detectable	0.5	No	0.02	No
2d**	Aldehydes	Below Detectable Limits	0.5	No	0.02	No
6	Amines	Below Detectable Limits	MRL		-	-

* Specific compounds included within groups are listed in Table G1 of the UKWIR guidance. Group 2f includes chlorinated phenols, not just those listed in Table G1.

** No specific compounds included within groups listed in Table G1 of the UKWIR guidance were recorded in VOC or SVOC TICs.

** As phenol concentrations recorded exceed PE and PVC pipe GACs, the use of these pipe types is precluded and the absence of some specific suites of analysis use to determine whether these pipes are suitable for use is irrelevant in this case. Reference to Table 3.1 of the UKWIR guidance indicates that the remaining pipe types, barrier pipe, wrapped steel and wrapped ductile iron are not affected by the remaining organic chemicals in other groups not tested for.

The suitability of various pipe materials for use at the site is summarised in the table below.

Parameter Group*	Parameter	PE	PVC	Barrier pipe	Wrapped Steel	Wrapped Ductile Iron	Copper
1	Extended VOCs suite by purge and trap or headspace and GC-MS with TIC (but not including group 1a)	Pass	Pass	Pass	Pass	Pass	Pass
1a	BTEX + Propylbenzene +MTBE	Pass	Pass	Pass	Pass	Pass	Pass
2	SVOCs (including TIC, but not groups 2e or 2f)	Pass	Pass	Pass	Pass	Pass	Pass
2e	Phenols	**Fail**	**Fail**	Pass	Pass	Pass	Pass
2f	Cresols and chlorinated phenols	Pass	Pass	Pass	Pass	Pass	Pass

Parameter Group*	Parameter	PE	PVC	Barrier pipe	Wrapped Steel	Wrapped Ductile Iron	Copper
3	Mineral oil C11-C20	Pass	Pass	Pass	Pass	Pass	Pass
4	Mineral oil C21-C40	Pass	Pass	Pass	Pass	Pass	Pass
5	Conductivity	Pass	Pass	Pass	Fail	**Fail**	-
	pH value	Pass	Pass	Pass	Pass	Pass	**Fail**
	Redox potential	Pass	Pass	Pass	-	Pass	Pass
2a	Ethers	Pass	Pass	Pass	Pass	Pass	Pass
2b	Nitrobenzene	Pass	Pass	Pass	Pass	Pass	Pass
2c	Ketones	Pass	Pass	Pass	Pass	Pass	Pass
2d	Aldehydes	Pass	Pass	Pass	Pass	Pass	Pass
6	Amines	Pass	Pass	Pass	Pass	Pass	Pass
Materials overall pass or fail		**Fail**	**Fail**	Pass	**Fail**	**Fail**	**Fail**

Given the presence of phenols, PE and PVC are not considered appropriate for use at the site. In addition, due to the conductivity and pH values of the soil, wrapped steel, wrapped ductile iron and copper pipes are not considered to be suitable. The assessment in the table above suggests that barrier pipe would be suitable for the proposed development.

Further recommendations on standards and specifications for water supply pipes and fittings and installation requirements for various pipe materials are given in Part 4 of the UKWIR guidance report reference 10/WM/03/21.

In addition, due to the presence of localised asbestos in the made ground at WS05 we would recommend that services must be placed within **oversized** trenches lined with coloured Terram and backfilled with clean/inert material to ensure that all future maintenance personnel will only be in contact with clean material at this location.

Backfill Materials

We would recommend that clean backfill is used around the pipes as this will both protect the pipes from contaminants in the surrounding soil and also reduce the risk of contamination to personnel making any repairs to the pipes in the future.

Health and safety

The Environment Agency indicated that consideration should be given to the health and safety of any workers working during installation and on the pipe in the future.

Health and Safety Risk Assessments and COSHH Assessments should be carried out by the designated engineer or manager. As contamination is known to be present on the site, appropriate PPE and safety equipment, as determined by the Risk and COSHH assessments should be made available. This may include but is not limited to;

- Dust: Dust protection measures including dust suppression and where required respiratory protection (such as dust masks) must be used.
- Gas Testing: The use of suitable air quality monitoring equipment is advised at all times. Carbon Dioxide, Hydrocarbons, Methane and Sulphide should be considered as part of any test suite.
- Skin Protection: Skin barriers including suitable gloves, clothing and footwear must be worn at all times.

Site personnel should maintain vigilance to detect any unpleasant odours, strangely coloured made ground, made ground other than generally observed during this investigation, fibrous materials or chemical residues in order that they can be assessed by suitably qualified personnel.

The risk to personnel from contaminated soil during the repair of the water pipes in the future should be low as the use of clean backfill around the pipes has been recommended.

Potential contamination to the proposed mains services should a burst occur

The Environment Agency indicated that consideration should be given to potential contamination to the proposed mains services should a burst occur.

As detailed above, we have recommended that clean backfill is used around the water pipes.

12.0 GAS EMISSIONS RISKS

12.1 General

Due to the presence of made ground at the site, gas monitoring was undertaken at standpipes installed in 5 of the recent boreholes; WS01, WS04, WS05, WS08 and WS11, and the results are included in Appendix 13.

The assessment of ground gas as a potential constraint to development has been the subject of a great deal of research and published guidance. Ground gas can be a concern for several reasons; flammable gases may cause an explosion, accumulation of gases within poorly ventilated areas may lead to asphyxia or toxic gases may cause harm to those exposed to them. Some physical properties of ground gases are tabulated below.

Gas	Explosive Range	Density at 20ºC	Toxicity (% by volume in air)*
Methane	5-15% by volume	0.72 kg/m^3	30 (low)
Carbon dioxide	N/A	1.98kg/m^3	0.5 (high)
Carbon monoxide	12.5-74.2% by volume	1.25kg/m^3	0.02 (high)
Hydrogen sulphide	4.2-46% by volume	1.54kg/m^3	0.001 (high)

* short term occupational exposure limits. The long term occupational exposure limit for carbon monoxide is 30ppm and for hydrogen sulphide is 5ppm.

Gas Emissions Sources

The desk based information and initial CSM identified the following potential gas generation sources at the site;

- Mineral made ground – typically a low generation potential source.
- Natural mineral soils, sands, gravels and clays – normally a low generation potential source. The London Clay is considered to be a very low gas generation material, and would not normally be considered to be a significant gas generation source.

These sources are discussed further below, in the light of data obtained during intrusive investigations and monitoring.

12.2 Analysis of Results

Gas measurements recorded at borehole standpipes are summarised in the table below.