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Development at 19 Burnside Road

Phase II Interpretative Report

December 2023

Document Control

Project:	Development at 19 Burnside Close Phase II Intrusive Investigation
Client:	Mr T. Dunford
Job Number:	RBG326

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DISCLAIMER

This report was produced by RB Geotechnical for Mr T. Dunford (The client), for the specific purposes of a Phase II Intrusive Investigation and Interpretative Report, for the proposed residential development at land to the North of 19 Burnside Close in Batley, West Yorkshire. This report may not be used by anyone else other than the client without their express permission. In any event, RB Geotechnical accepts no liability for any costs, liabilities or losses arising from the use of reliance upon the contents of this report by anyone other than the client.

1.0 INTRODUCTION

1.1 Brief and Scope

RB Geotechnical was commissioned by the client, to carry out a Phase II Intrusive Site Investigation at 19 Burnside Close in Batley, West Yorkshire. The site is intended to have two new semi-detached residential properties constructed.

RB Geotechnical undertook an intrusive ground investigation on 13th December 2022 and 30th November 2023, to gain the necessary information required to assess the underlying ground conditions and to allow for ground gas monitoring standpipe to be installed . This assessment was designed to assess for possible ground gas risks.

This report discusses the findings of this ground investigation and provides an analysis which includes a series of conclusions and recommendations relating to the potential risks and constraints of the proposed development.

1.2 Terms and Conditions

This report has been prepared for Mr T. Dunford, for the purpose of assessing for soil contamination and the ground gas risks on site.

1.3 Scope and Objectives of Report

The purpose of this report is to provide factual and interpretative information required to comply with the requirements of a Phase II Intrusive Site Investigation and land contamination assessment. The scope of the report is as follows:

- To provide general information on the site such as location and description;
- To summarise the environmental and historical setting of the site; e.g., landfills, permits, sensitive land uses and historical land uses;
- To summarise the ground investigation and its findings;
- Provide factual information and descriptions of ground conditions;
- To assess geotechnical parameters of the site;
- To provide a quantitative risk assessment for the proposed end use of the site; and

- To provide recommendations for further works where necessary.

1.4 Constraints and Limitations

This report is intended for the client for assisting them in assessing the site for possible ground gas and soil contamination risks.

RB Geotechnical has endeavoured to assess all information provided to them. The report includes summaries of information from external sources and cannot offer any guarantees or warranties for the completeness or accuracy of information relied upon.

The conclusions resulting from this study are not necessarily indicative of future conditions or operating practices at or adjacent to the site.

It should be noted that although every effort has been made to ensure the accuracy of the data obtained from the investigation, the possibility exists for variations in ground and groundwater conditions between and around the borehole locations. In addition, groundwater levels will vary seasonally and with changes in weather conditions.

1.5 Sources of information

Environmental information has been obtained following a review of the Phase I Desk Study, along with the findings of the intrusive ground investigation.

The sources of information used for this report are:

- RB Geotechnical, Development at 19 Burnside Close, Phase I Desk Study Report, RBG326, December 2022;
- Mugen Windowless Sample Borehole Logs, December 2022;
- RB Geotechnical, Hand Dug Trial Pit Logs, December 2023; and
- Envirolab Job No. 23/12008, 18th December 2023.

Although every effort has been made to ensure the accuracy of the information contained herein, no checks have been carried out to ensure the accuracy of information obtained from third parties and no liability can be accepted for any errors or misinterpretation of the third-party information where it has been incorporated into this report.

2.0 SITE DETAILS

2.1 Site Location and Description

The 0.04ha sized site is located at 19 Burnside Close in Batley, West Yorkshire. The development site is currently occupied by an area of grassland, with trees along the boundary. The existing house of 19 Burnside Close is situated to the South of the site, separated by a wooden fence.

The National Grid Reference for the centre of the site is 423208, 426231.

2.2 Proposed Development

Two new semi-detached houses are to be built to in the current Northern garden of 19 Burnside Close. These houses are to include private gardens and driveways. The proposed development and exploratory hole location plan is included as Appendix A.

3.0 EXISTING INFORMATION

3.1 Site History

Historical maps show the site to be open farmland until the 1960s, when a small building is shown in the North East corner, associated with the house of number 19. The site remains unchanged beyond the 1960s.

3.2 Geology, Hydrology and Hydrogeology

3.2.1 Geology

According to the published geological maps the site is underlain by bedrock of the Pennine Lower Coal Measures Formation of Mudstone, Siltstone and Sandstone.

Two coal seams are mapped outcropping close to the site, the Flockton Thick and the Flockton Thin.

3.2.2 Hydrology and Hydrogeology

The underlying bedrock is classified as being a Secondary A Aquifer. There are no water networks within 250m of the site boundary and the site is at Very Low flood risk from rivers and sea.

3.3 Coal Mining Risk Assessment/Intrusive Investigation

A desk-based Coal Mining Risk Assessment was carried out by RGS in 2020 and concluded that two coal seams are anticipated to be present within 30m of the ground surface. Historic mining activity is evident in the local area, and therefore the site was deemed to be at risk of potential unrecorded mine workings.

Therefore, Rotary Open Hole drilling was carried out on the site in July 2021, comprising 3 boreholes. Upon carrying out this drilling, voids were encountered in two of the three boreholes (from 6.0m/8.0m depth to at least 20m depth). These voids indicate the likely presence of unrecorded mine workings.

The presence of these mine workings indicates that the site will require grouting prior to construction of the new houses, in order to stabilise the underlying voids. The presence of these voids also poses a risk of potential ground gases. It was therefore recommended that an additional Intrusive Investigation was carried out to allow for installation of ground gas monitoring standpipe and for a ground gas assessment.

4.0 INTRUSIVE INVESTIGATION

4.1 Design

The Ground Investigation was designed by RB Geotechnical to allow for installation of ground gas monitoring standpipe to allow for a ground gas assessment to be carried out and for hand dug trial pits to obtain shallow soil samples for contamination testing.

4.2 Ground Investigation Activities

The Ground Investigation was undertaken in general accordance with:

- BS 5930 (1999). Code of Practice for Ground Investigation;
- BS1377. Methods of test for Soils for Civil Engineering Purposes; and
- BS 10175:2011 (2011). Investigation of Potentially Contaminated Sites – Code of Practice.

The Ground Investigation comprised the following:

- Three Windowless Sample Boreholes to install ground gas monitoring standpipe; and
- Four Hand Dug Trial Pits to obtain shallow soil samples for contamination testing.

This Ground Investigation was undertaken on 13th December 2022 and 30th November 2023. The exploratory holes were logged and sampled by a qualified engineer.

An exploratory hole location plan is shown in Appendix A.

4.3 Sampling and In-Situ Testing

Small, disturbed samples were recovered from the boreholes and stored in plastic pots and jars placed into a cool box.

4.4 Laboratory Testing

All chemical (contamination) laboratory testing was scheduled by RB Geotechnical and was intended to provide contamination data for the specific areas sampled. The scope of the testing was designed to enable comments regarding characterisation of potential contamination on site.

A total of six soil samples were sent to Envirolab, which is a registered UKAS Testing laboratory. Table 4.1 summaries the Laboratory Testing carried out. Full chemical laboratory testing results are shown in Appendix D.

Table 4.1 Summary of Chemical Laboratory Testing

Analysis	Total number of Samples
Heavy Metals	4
Cyanide	4
Speciated PAH	4
Total TPH	4
Asbestos	4

4.5 Ground Gas Monitoring Standpipe

Ground gas monitoring standpipe was installed in all three Windowless Sample Boreholes (WS01, WS02 and WS03), with the construction details as follows:

- WS01: 0.5m plain pipe and 1.50m slotted, with bentonite seal to 0.50m and pea gravel from 0.50m to 2.0m;
- WS02: 0.5m plain pipe and 1.50m slotted, with bentonite seal to 0.50m and pea gravel from 0.50m to 2.0m; and

- WS03: 0.5m plain pipe and 1.50m slotted, with bentonite seal to 0.50m and pea gravel from 0.50m to 2.0m;

In-situ gas monitoring carried out in each of these Boreholes, using a portable gas meter which measures Oxygen, Methane, Carbon Dioxide and air pressure.

5.0 INTRUSIVE GROUND INVESTIGATION FINDINGS

The exploratory hole location plan is shown in Appendix A and full exploratory hole logs are included as Appendix B .

5.1 Ground Conditions Encountered

5.1.1 Topsoil

Turf over a dark grey, brown slightly gravelly CLAY TOPSOIL was encountered in all three exploratory holes from ground level, extending to depths of 0.20mbgl (metres below ground level) to 0.30mbgl.

5.1.2 Highly Weathered Bedrock (Gravelly Clay)

A firm becoming stiff dark grey/pale yellow, slightly gravelly CLAY, with gravels of Sandstone and Ironstone, was encountered beneath the Topsoil in all three boreholes, at depths from 0.20mbgl to 0.30mbgl and extending to the base of the boreholes at 2.0mbgl. Intact weathered Mudstone was encountered beyond this depth.

Standard Penetration Testing (SPTs) were carried out within this stratum in all three boreholes, with SPT N values found to range from 15 to 34, generally increasing with depth as the stratum becomes less weathered and more of an intact bedrock.

5.2 Ground Gas Risk Assessment

The risks associated with ground gases have been considered in accordance with British Standard BS 8485:2015+A1:2019 “Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings” and CIRIA Report C665 “Assessing Risks Posed by Hazardous Gases to Buildings”.

Ground Gas Monitoring was carried out on six separate occasions following the intrusive Ground Investigation on the following dates: 19th December 2022, 29th December 2022, 3rd January 2023, 12th January 2023, 18th January 2023 and 25th January 2023, allowing for a range of atmospheric pressures and pressure patterns in order to obtain characteristic and worst-case scenarios. Full gas monitoring results are shown in Appendix C.

The methodology used to carry out a semi-quantitative estimate of the risks from ground gas at the site is that described in BS8485:2015+A1:2019 and CIRIA Report C665 which recommends following the classification system proposed by Wilson and Card in CIRIA Report 149.

Gas Screening Values (GSV) for the site was calculated using the highest gas values (using both Methane and Carbon Dioxide) and flow rate. The highest measured gas value on this site was Carbon Dioxide of 3.70%, with a Flow Rate of 0.10l/hr. The GSV for the site can therefore been calculated as 0.037 x 0.10 = to be 0.0037 l/hr.

Using Table 2 from BS8485:2015+A1:2019, the site GSV of 0.159l/hr classifies it as having a 'Very Low' Hazard Potential, with a CS value of CS1.

Using Table 3 from BS8485:2015+A1:2019, the site can be defined as being building type 'Type A', which is defined as being a private building, with conventional building constructing.

Using Table 4 from BS8485:2015+A1:2019, the gas protection score by CS and type of building, for this site is: 0, which means no gas protective measures are necessary.

Therefore, it can be concluded that although mine workings are present beneath the site, they do not pose any source of ground gases which could affect the proposed development. No further remedial measures are therefore deemed necessary related to ground gases.

Groundwater monitoring was also carried out during gas monitoring and on all occasions, no groundwater was encountered.

6.0 GROUND CONTAMINATION – GENERIC QUANTITATIVE RISK ASSESSMENT

The following assessment was performed in the context of the planning regime and in line with current UK guidelines which follows the procedures set out in the Environmental Agency 'Land Contamination Risk Management' (LCRM) web pages which are accessible via the government website. LCRM provides the technical framework for structured decision making about land contamination and builds on previous work carried out under the Contaminated Land Research Programme of the former Department of the Environment. LCRM has adopted and refined the methodology and terminology that has been used in contaminated land risk assessment for a number of years.

This is used to determine if unacceptable risks to humans, vegetation or to specific parts of the wider environment are present on the site. The risk assessment follows the source, pathway, receptor methodology, as described in Contaminated Land Report (CLR) 11, which is used to build a conceptual site model to determine the presence of any pollutant linkages at the site. Should pollutant linkages exist at the site it is deemed necessary to further develop the risk assessment by comparing contamination test results with generic or site-specific assessment criteria in order to determine if an unacceptable level of risk is present at the site. If legislation or guidance changes, or the proposed end use is modified, then it will be necessary to reassess the risks which may require further sampling and testing.

We understand our brief to comprise the following items related to the contamination aspects of this investigation.

- Compare laboratory test results with generic assessment criteria;
- Determine a conceptual site model and identify any pollutant linkages at the site;
- Determine the level of risk posed by environmental hazards on site to human health, vegetation, controlled waters and structures; and
- Make recommendations for further work or remediation strategies.

Soil samples were recovered in accordance with current industry practice and were sent to Envirolab to be analysed for the determinants listed in section 4.4 of this report.

The results of these analyses are included in Appendix D of this report.

6.1 Human Health Assessment

UK guidance recommends that a risk-based approach is taken for the assessment of contaminated land and as such, DEFRA have introduced the CLEA methodology, SGV's and Category 4 Screening Values (C4SL). The CLEA methodology is a deterministic risk assessment model that estimates the long-term exposure to contaminants in the soil for children and adults and predicts the amount of contaminant to which a person might be exposed based on a given soil concentration. By comparison with relevant health criteria on tolerable or acceptable intakes of various contaminants the model was used by DEFRA and the Environment Agency to generate SGV's and C4SL's.

At the time of writing this report the DEFRA and Environment Agency has not published SGV's/C4SL using the CLEA 1.071 software for all anthropogenic toxic substances with C4SL's for further contaminants due to be produced at some point in the future. As such, it was necessary to use other methods to generate target concentrations for contaminants of concern on site.

In order to generate generic assessment criteria which are protective of human health, for use in human health risk assessment, where CLEA SGV's and C4SL's are not available the Environment Agency recommends the use of the CLEA 1.071 software in conjunction with advice found on the GOV.UK CLEA web pages. Accordingly, the Chartered Institute of Environmental Health (CIEH) in partnership with Land Quality Management (LQM) derived a set of Generic Assessment Criteria Values following the approach set out in the DEFRA research project SP1010, C4SL. The GAC for missing contaminants of concern were calculated using the CLEA 1.06 software released in July 2009 and termed Suitable 4 Use Levels (S4UL's). The input parameters used for calculating each S4UL value are listed in the substance specific chapters of the reference document associated with the S4UL's, namely 'The LQM/CIEH S4ULs for Human Health Risk Assessment (Land Quality Press, 2015). Where published UK guidance values are not available (I.e., for TPH), the results have been determined in-house using published toxicological data and UK government endorsed risk models.

The current view of the Environment Agency is that the C4SL's are considered to be a trigger value at which an exceedance may cause concern for human health and generally requiring further investigation and/or assessment.

The DEFRA C4SL and LQM/CIEH S4UL's for a residential with gardens land use has been selected as this matches the proposed future land use.

6.2 Vegetation Assessment

As the CLEA methodology only takes account of the risks to human health, a different approach is required to determine the risks to vegetation. In order to determine if levels of phyto-toxic contaminants in soil, not normally considered to be harmful to humans, are suitable to maintain growth of vegetation the published reference values produced by the Ministry of Agriculture, Fisheries and Food (MAFF) have been used in this assessment.

7.0 DISCUSSION OF RESULTS

7.1 Human Health Hazards

The results shown in Table 7.1, confirm that very slightly elevated levels of Arsenic were encountered in the location of HP04 which is situated in the proposed back garden area of one of the properties in the South West corner of the site. Additionally, a very slight elevation of TPH was encountered in exploratory hole HP02 (located in the proposed back garden of the other property in the North West corner of the site). Due to the presence of these slightly elevated levels of contamination, remedial measures will be required in the form of excavating the contaminated soils and replacement with a clean imported subsoil and topsoil.

Table 7.1 Comparison of Soil Test Results with Residential with Gardens C4Sl/S4UL

Determinant	Assessment Criteria (mg/kg)		Recorded Concentrations Across The Site (mg/kg)	
	C4SL Screening Levels	S4UL Generic Assessment Criteria/RB Geotechnical Generic Assessment Criteria	Highest Recorded Value	Location of Highest Recorded Value and other Exceedances
Metals, semi- metals and non-metals				
Arsenic	37	37	41	HP04
Cadmium	17	11	2.0	HP03/HP04
Copper	NC	2400	67	HP03
Chromium Total	NC	910	114	HP03
Lead	210	NC	103	HP03
Mercury (elemental)	NC	1.2	0.51	HP03
Nickel	NC	130	37	HP01/HP04
Selenium	NC	250	<1	All
Zinc	NC	3700	143	HP03
PAH (total)	NC	NC	74.4	WS02
TPH (total)	NC	150-550$_{(4)}$	155	HP02
Naphthalene	NC	1.5	0.95	HP04
Acenaphthylene	NC	170	0.02	HP04
Acenaphthene	NC	210	0.33	HP04
Fluorene	NC	170	0.10	HP03
Phenanthrene	NC	95	2.73	HP04

Determinant	Assessment Criteria (mg/kg)		Recorded Concentrations Across The Site (mg/kg)	
	C4SL Screening Levels	S4UL Generic Assessment Criteria/RB Geotechnical Generic Assessment Criteria	Highest Recorded Value	Location of Highest Recorded Value and other Exceedances
Anthracene	NC	2400	0.63	HP04
Fluoranthene	NC	280	2.73	HP04
Pyrene	NC	620	2.21	HP04
Benzo(a)anthracene	NC	7.2	0.93	HP04
Chrysene	NC	15	0.93	HP04
Benzo(b)fluoranthene	NC	2.6	0.83	HP04
Benzo(k)fluoranthene	NC	77	0.32	HP04
Benzo(a)pyrene	3.2	2.2	0.55	HP04
Indeno(1,2,3-c,d)Pyrene	NC	2.3	0.31	HP04
Dibenzo(a,h)anthracene	NC	0.24	0.05	HP04
Benzo(g,h,i)perylene	NC	320	0.27	HP04
Others				
Cyanide (total)*	NC	5	<1	All
Asbestos	NC	NC	Not Detected	All

NOTES:
(1) C4SL/LQM S4UL 2015 for Residential with gardens land use scenario at 1% organic matter content
(2) *= Dutch Target value used as screening value for cyanide.
(3) NC = No criterion.
(4) Limit based on CCME sum of C10-C34 (for most conservative screening value). Includes $C_{10} - C_{16}$ limit = 150mg/kg (worst case minimum value) and $C_{16} - C_{34}$ = 400mg/kg. Only for use as preliminary screening value, where hydrocarbons not suspected. If TPH>150mg/kg the value will be assessed in addition to levels of other related inorganics from the same sample, to establish if further assessment is necessary.

7.2 Vegetation Hazards

The concentrations of the various phytotoxic contaminants encountered in the shallow soils indicate that no elevated levels of Heavy Metals were measured across the site.

Table 7.2 Soil Test Results Vs Phyto-Toxic Chemical Assessment Criteria

Determinant	MAFF Reference Value (mg/kg)		Recorded Concentrations Across Sampled Area (mg/kg)	
	Maximum Permissible Concentration		Highest Recorded Value	Location of Highest Recorded Value
	pH 5.0-5.5	pH >7		
Metals and semi- metals				
Arsenic	50	NL	41	HP02
Copper	80	200	67	HP03
Nickel	50	110	37	HP01/HP04
Zinc	200	300	143	HP03
Cadmium	3	NL	2.0	HP03/HP04
Lead	300	NL	103	HP03
Selenium	3	NL	<1	All

NOTES: (1) NL = indicates that no level has been set

8.0 CONCEPTUAL SITE MODEL

8.1 Introduction

The information obtained from this investigation has been collated and evaluated to develop a refined Conceptual Model for the site.

The site has been assessed in line with current UK guidelines, namely the Contaminated Land (England) Regulations 2000 and Part IIA of the Environmental Protection Act 1990 and follows the procedures set out in the Environmental Agency 'Model Procedures for the Management of Land Contamination – Contamination Land Report (CLR).11'.

CLR.11 provides the technical framework for structured decision making about land contamination and builds on previous work carried out under the Contaminated Land Research Programme of the former Department of the Environment. CLR 11 has adopted and refined the methodology and terminology that has been used in contaminated land risk assessment for a number of years.

CLR.11 defines the three essential elements to any risk:

- A contaminant **source** - a substance that is in, on or under land and has the potential to cause harm or to cause pollution of controlled waters;
- A **receptor** – in general terms, something that could be adversely affected by a contaminant, such as people, an ecological system, property or a water body; and
- A **pathway** - a route or means by which a receptor can be exposed to or affected by a contaminant.

Each of these elements can exist independently, but they create a risk only where they are linked together, so that a particular contaminant affects a particular receptor through a particular pathway. This kind of linked combination of source-pathway-receptor is described as a **pollutant linkage**.

This report presents a Phase 2 Conceptual Model and Quantitative Risk Assessments for the site, based on the proposed conservative end use of residential with home grown vegetables.

8.2 Hazard Identification

8.2.1 Potential Contamination Sources

Mine workings have been encountered beneath the site, and therefore a risk of ground gases was identified. Due to historical demolition of buildings across the site it was also established that possible contaminants could exist in the shallow soils as a result of this.

A summary of potentially significant sources of contamination encountered are presented in Table 8.1.

Table 8.1 Summary of Contaminant Sources & Contaminants

Structure / Process	Contaminants Present on Site
Historical Demolition of Buildings	Elevated levels of Arsenic and Total Petroleum Hydrocarbons
Mine Workings	No elevated levels of ground gases were measured during the ground gas monitoring assessment.

8.2.2 Potential Receptors

The following are considered as potential receptors in relation to the current and proposed use of the site.

- **Future Residential users** – Female child aged 0-6 years using communal gardens;
- **Utility / Construction / Demolition / Site Investigation workers** – Workers undertaking routine / non-routine work involving ground disturbance works and maintenance of below ground services (assuming workers are only wearing standard construction / utility worker PPE);
- Underlying **Secondary A Aquifer** – Underlying bedrock
- **New potable water supply pipes**
- **Ingress of ground gases into structures**

8.2.3 Potential Contamination Pathways

The following are considered plausible contamination pathways given the nature of the site and the potential contaminative sources identified, and assuming a continued current use.

- Risk from ground gases, asphyxiation or explosion.

8.2.4 Quantitative Risk Assessment

By considering the sources, pathways and receptors, an assessment of the environmental risks is made with reference to the significance and degree of the risk. This assessment is based on consideration of whether the source contamination can reach a receptor and hence whether it is of major or minor significance.

An initial conceptual model of the source-pathway-receptor linkages has been developed based on the information derived from the Phase I Desk Study and this intrusive investigation. The Conceptual Site Model has been used to identify Relevant Pollutant Linkages for the current and proposed end uses which have been assessed quantitatively and qualitatively using CIRIA 552 guidance, as described in Table 8.2 and Table 8.3.

Table 8.2 Methodology for Assessing Consequence of Harm

Consequence	Criteria
Severe	Short term (acute) risk to Human Health likely to result in "significant harm" as defined by the Environmental Protection Act 1990, Part IIa. Short term risk of pollution of sensitive water resource. Catastrophic damage to buildings / property
Moderate	Chronic damage to Human Health likely, over a long term, to result in "significant harm" as defined by the Environmental Protection Act 1990, Part IIa. Pollution of sensitive water resources
Mild	Health effects to Human Health that are unlikely to result in "significant harm" as defined by the Environmental Protection Act 1990, Part IIa. Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services. Damage to sensitive buildings / structures / services or the environment
Negligible	Non-permanent health effects to Human Health that are unlikely to result in "significant harm" as defined by the Environmental Protection Act 1990, Part IIa. Those that are easily prevented by means such as personal protective clothing. Harm, although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve.

Table 8.3 Methodology for Assessing Likelihood of Consequence Occurring

Probability	Criteria
Almost Certain	Circumstances are such that an event either appears very likely in the short term and almost inevitable over the long term or there is evidence of currently harm occurring
Likely	Circumstances are such that an event, whilst not inevitable, is possible in the short term and is likely to occur over the long term
Unlikely	Circumstances are such that it is possible an event could occur, but it is by no means certain to occur even over a longer period, and it is less likely in the shorter term
Very Unlikely	Pollutant linkage may be present, but the circumstances under which harm would occur are improbable even in the medium to long term
Extremely Unlikely	Pollutant linkage may be present, but the circumstances under which harm would occur are highly improbable even in the long term

The risk assessment table and apportioned scores presented in Table 8.4 are in general accordance with CIRIA 552. The main exception is that irreversible risks to human health are considered to have a severe consequence irrespective of whether the effects are chronic or acute in nature.

Table 8.4 Comparison of Consequence and Likelihood

Consequence / Probability	Severe	Moderate	Mild	Negligible
Almost Certain	Very High Risk	High Risk	Moderate Risk	Low Risk
Likely	High Risk	Moderate Risk	Moderate/ Low Risk	Low Risk
Unlikely	Moderate Risk	Moderate/ Low Risk	Low Risk	Very Low Risk
Very Unlikely	Low Risk	Low Risk	Very Low Risk	Very Low Risk
Extremely Unlikely	Very Low Risk	Very Low Risk	Very Low Risk	Very Low Risk

The categories of risk are defined as follows:

Very High Risk: There is a probability that severe harm is almost certain to arise to a designated receptor from an identified source, or there is evidence that severe harm to a designated receptor is currently occurring.

High Risk: There is a probability that severe harm is likely to arise to a designated receptor from an identified source, or there is a probability that moderate harm is almost certain to arise.

Low Risk: There is a possibility that harm could arise to a designated receptor from an identified source, but it is likely that this harm, if realised, would be mild at worst.

Very Low Risk: There is a very low possibility that harm could arise to the receptor, but it is likely that this harm, if realised, would be mild at worst.

In accordance with CLR11, professional judgement has been employed to evaluate the risk on a qualitative basis using available information.

A summary of the pollution linkages is provided in Table 8.5

Table 8.5 Conceptual Site Model

Source	Receptor	Pathway	Risk	Pollutants Encountered/Chemicals of Concern	Remedial Option(s)/Next Steps
On Site: Contaminants present due to historical building demolition Mine workings resulting in Ground Gases **Off Site:** None	Residential Homeowners	• Dermal contact or ingestion contaminants in soil-derived dust and entrained surface water run-off from areas where soil is exposed at the surface or where excavation takes place and in shallow groundwater in the natural strata if excavation takes place below the water table. • Inhalation of contaminants in soil derived dust from areas where soil is exposed at the surface of where excavation takes place. • Inhalation of soil and water derived vapours and ground gas outdoors • Inhalation of soil derived, and water derived vapours and ground gas indoors where it may have accumulated in buildings and enclosed spaces.	Moderate/Low	Elevated Levels of Arsenic and Total Petroleum Hydrocarbons	Elevated levels of Arsenic and Total Petroleum Hydrocarbons were identified within the shallow soils of the proposed back garden areas. These contaminants may be present due to the recent use of heavy machinery in these areas during the grouting process for stabilising the ground. Remedial measures will therefore be necessary in the proposed soft landscaped garden areas, in the form of excavating the currently existing topsoil and replacement with clean imported topsoil.
	Construction Workers		Low	No elevated levels of ground gases were monitored during ground gas assessment	No elevated levels of ground gases were encountered and therefore no remedial measures will be necessary for ground gases.
	Groundwater within the underlying superficial soils and bedrock	• Leaching of contaminants and/or migration of free phase contaminants from the unsaturated zone soils to groundwater in the natural strata • Vertical migration of contaminants in shallow groundwater to deeper strata and aquifer.	Low	No Further Assessment Required	
	Surface Water	• Lateral migration of contaminants and/or migration of free phase contaminants present in the Made Ground via groundwater to surface water discharge • Lateral migration of contaminants and/or migration of free phase contaminants present in the Made Ground and entrained in surface water	Low	No Further Assessment Required	

		runoff		
	Building	• Accumulation of soil and water derived vapours/and or ground gas in enclosed spaces	Low	No Further Assessment Required related to ground gases.
	Potable Water Supply Routes	• Migration of contaminants into newly placed potable water supply routes	Low	No Further Assessment Required

8.3 Discussion of Risks

The risk assessment presented in the above sections and summarised within the CSM presented in Table 8.5 shows that Contaminant Linkages have been identified at the site in the form of elevated levels of Arsenic and Total Petroleum Hydrocarbons. The following sections provide a discussion of the environmental risks based on the ground investigation, soil contamination test results and the gas monitoring assessment.

8.3.1 Human Health

Proposed residential property users

The ground investigation and gas monitoring assessment showed that no elevated levels of ground gases were measures during the ground gas assessment. No further remedial measures are therefore deemed necessary in terms of ground gas protective measures.

However, elevated levels of Arsenic and Total Petroleum Hydrocarbons were measured in the proposed back garden areas. Remedial Measures will therefore be necessary in these areas.

Therefore, the current risks to human health has currently been assessed to be **MODERATE/LOW**

Utility / Construction / Demolition / Site Investigation (i.e. Ground Disturbance) Workers

The probability of contact with contaminated soils increases for workers involved with ground excavation (e.g. during development, site investigation or maintenance works). However, due to the exposure time to contaminants on site and the assumption that appropriate PPE will be worn the risks to site operatives is considered **LOW**.

8.3.2 Aquifer

The risks to the underlying aquifer has been assessed to be **LOW.**

8.3.3 Surface Water

The risk of contaminants to controlled waters is considered to be **LOW**.

8.3.4 Potable Water Supply Pipes

The current risk to proposed new utility routes is **LOW**.

8.3.5 Buildings

Ground gas monitoring did not identify any elevated levels. This risk of ground gases into the new building are therefore currently considered to be **LOW**.

8.4 Proposed Remedial Measures

Due to the presence of elevated levels of Arsenic and Total Petroleum Hydrocarbons in the proposed back garden areas of the new houses, remedial measures will be required. The elevated levels of contamination were identified within the shallow Topsoil at depths up to 0.30m below ground level. The following remedial measures will therefore be required:

- Excavation of all soils in proposed garden areas to the top of the underlying superficial deposits (Gravelly Clay Highly Weathered Bedrock), at a depth of around 0.20m to 0.30m;
- Removal of all contaminated soils from site and transported to appropriate disposal facility, ensuring all relevant waste transfer notes and tickets are obtained;
- Import clean topsoil to the site from approved provider, ensuring necessary testing certificates are provided with the soil; and
- Placement of minimum 0.30m of the clean topsoil across the proposed garden areas, taking photographs throughout the process to confirm it has been carried out correctly.

All remedial measures in the proposed soft landscaped areas can be carried out after construction of the main buildings is complete. But these remedial measures must be completed before the properties can be deemed safe for use.

9.0 CONCLUSIONS

Potential on-site sources of contamination were identified as possible ground gases due to the presence of mine workings beneath the site and possible soil contaminants.

An intrusive investigation was therefore carried out across the site comprising three Windowless Sample Boreholes, to allow for installation of ground gas monitoring standpipe and a ground gas risk assessment and excavation of four hand dug trial pits to allow for collection of soil samples for soil contamination testing.

Ground conditions were found to comprise Topsoil to depths of 0.20mbgl to 0.30mbgl, underlain by a highly weathered bedrock of gravelly clays to 2.0mbgl. Intact bedrock was encountered at 2.0mbgl.

A total of six rounds of ground gas monitoring were carried out following the intrusive investigation, over a range of barometric pressures. Upon carrying out this assessment no elevated levels of Carbon Dioxide or Methane were recorded, and therefore no further remedial measures are necessary in terms of ground gas protective measures.

A total of four soil samples were collected and tested for a range of contaminants, with elevated levels of Arsenic and Total Petroleum Hydrocarbons encountered in two of the exploratory holes situated in proposed back garden areas. Remedial measures will therefore be required in these areas in the form of excavating the contaminated soils and replacement with a clean imported topsoil.

10.0 REFERENCES

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