Environmental
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RGS

<ENVIRONMENTAL><GEOTECHNICAL>

Ground Gas

RISK ASSESSMENT

job number	C3224/22/E/4914
date	16.04.24
site address	Land off Barnsley Road Grange Moor Wakfield WF4 4DS
written by	S. Hale
checked by	R.A. Palmer
issued by	R.A. Palmer

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Rogers Geotechnical Services Ltd
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01484 604354 Company No. 5130864

Report on a Ground Gas Risk Assessment

Location:	Barnsley Road Grange Moor, Wakefield, West Yorkshire, WF4 4DS		
For:	PC Specialist Limited		
Report No.	C3224/24/E/6470	Report date:	April 2024

For and on behalf of **Rogers Geotechnical Services Ltd**

Steven Hale BSc FGS Geo-environmental Technician	**Rob Palmer** MSc FGS ACIEH Engineering Director

1. Previous Reporting

1.1 Phase 1 Desk Study

A Phase 1 Desk Study was issued by RGS (Ref: C3224/22/E/9414) in January 2023. This report indicated the presence of a historical quarry within the southern section of the site which was subsequently backfilled and used as a landfill. As such, it was considered that this feature represented a potential source for the emission of hazardous gases and was recommended to be monitored.

1.2 Coal Mining Risk Assessment

A coal mining risk assessment (CMRA) was presented within the phase one desk study. The CMRA included the use of a Consultants Coal Mining Report as provided by the Coal Authority. This risk assessment revealed the presence of past underground coal mining beneath the site, as well as recorded gas incidents/remediation approximately 100m to 320m north and north-east of the site.

1.3 Mine Shaft Investigation

As indicated within the CMRA, a mine shaft was recorded to be present within the boundaries of the site to the south eastern corner. As such, a mine shaft investigation was carried out as part of the Phase 2 Report (Ref: C3224/22/E/4914) to investigate the validity of its presence. No evidence to the presence of the historical mine shaft was found during the course of the investigation.

1.4 Windowless and Rotary Boreholes

A phase 2 geo-environmental and coal mining report was carried out upon completion of the rotary boreholes (Ref: C3224/22/E/4914). The report concluded that there are no shallow coal seams and associated workings beneath the proposed building. However, workings may be present beneath the most southern proposed parking areas. The results of the gas monitoring conducted during the rotary drilling phase suggest that there is a moderate risk of gasses associated with mine workings being present below the proposed development. In view of all the information obtained in this investigation, it is considered that there is a low risk of ground movement as a consequence of coal workings beneath the site, however the presence and migration of mine gases cannot be discounted.

A windowless sample borehole (WS12) and rotary borehole (R12) were undertaken within the backfilled quarry area. The windowless sample borehole revealed that the backfill material at the near surface comprised of clayey sandy gravel of coal and siltstone. These soils are considered to represent quarry spoil, as opposed to say domestic waste sent to landfill. Typically, such materials (quarry spoil) would not represent a significantly generative source of ground gas. The rotary borehole revealed this spoil extended to approximately 9m, whereupon slag and clinker was revealed to 12m depth. Once again, it is not considered that such soils would produce significant concentrations of gas as these materials are typically stable.

1.5 Gas Monitoring

Gas monitoring was carried out as specified within the Phase 1 Desk Study and CMRA. This monitoring was undertaken within six standpipes with 10 visits between 14th February and 22nd May 2023 with the results recorded and documented within the Phase 2 Report. It should be appreciated that methane and carbon dioxide were recorded at levels in excess of 11% and 5%, respectively. Moreover, carbon monoxide and hydrogen sulphide was also detected. The discussion of the results concluded that the site can be fully classified as Characteristic Situation Level 3 when adopting the highest concentrations of ground gas with the highest recorded flow rates. The conceptual site model and site-specific risk assessment applied a high risk rating to the migration of hazardous gases in regards to operatives and end users, with a moderate rating being applied to neighbours. These risk ratings considered that the ground gas was likely an issue with the wider area and that remediation will be required on site in order to either remove the contamination or break pathways.

2. Ground Gas Risk Assessment

Following the previous reporting, a Ground Gas Risk Assessment was required in order to fully appraise and appreciate the correlations between the previously recorded information and site setting. In order to assist with this assessment, a site plan showing the gas monitoring standpipes locations has been included within Appendix 1. This site plan includes the Characteristic Situation Levels for each borehole calculated individually and colour coded for ease of viewing. Additionally, the gas monitoring data can be found within Appendix 2 and will be referenced throughout this report.

This report considers the harmful gases dispersed through the soils from the sources identified, (landfill and mine workings) and accounts for the movements of large volumes of harmful mine gases which could migrate via permeable broken strata or mine entries. In order to produce a ground gas risk assessment, the latest document ‘Good Practice for Risk Assessment for Coal Mine Gas Emissions’ produced by CLAIRE has been given due consideration.

2.1 Assessment of Gas Monitoring Data

As previously mentioned, it is necessary to review the gas monitoring date that was collected in order to provide detailed insights. It should be appreciated that while the Phase 2 report indicates that the site is to be classified as Characteristics Situation Level 3, this is a conservative assessment as it takes the highest recorded concentrations of methane, carbon dioxide and flow rate in order to calculate the gas screening value (GSV). In order to more accurately analyse the results, each borehole and its corresponding results have been taken individually. This action suggests that the Characteristic Situation Level for the site is more accurately represented by a level of 2. Nevertheless, this does not invalidate the Phase 2's conclusion as it takes the most conservative and worst-case scenario approach in order to classify the site as Characteristic Situation Level 3.

2.1.1 Effect of Groundwater Levels, Flow Rates and Atmospheric Pressures on Gas Levels

Variable groundwater levels were measured in the standpipes in boreholes WS01, WS03, WS04 and WS09 with no groundwater recorded within WS10 or WS12. It should be appreciated that these monitoring visits took place in varying weather conditions from sunny to rainy. If we compare a day of relatively high groundwater to a day of relatively low, it can be stated once again that there is no obvious correlation between the gas values and the level of groundwater. An example of this is taken from WS09 when we compare the results measured on the 27th March and 24th April 2023 as the groundwater levels were recorded to be 0.05m and 3.51m depth respectively. Viewing the gas values of methane, found to be 0.0% and 0.1% and carbon dioxide to be 0.2% and 1.6% respectively, between the dates it is suggested that the values are noted to be all low despite the drastic difference in groundwater level. This supports the argument that there is no apparent correlation between gas levels and groundwater levels.

It should be appreciated that only two of the ten monitoring visits occurred during a 'worst case' scenarios of falling atmospheric pressure. When comparing the results on these days it can be stated that there is no apparent correlation between gas values and atmospheric pressure. For example, on 21st February 2024 in WS01 was a day of falling pressure with a reading of 999mb. It can be stated that the gas results during this time when compared to the following visit on the 28th February, a day of steady pressure and a reading of 1011mb, are comparable with both visits having a methane reading of 0.3% and a carbon dioxide reading of 8.2% and 8.6% respectively. Further to this, on the same dates the results taken from WS04 detail pressures of 993mb during falling pressure and 1012 during steady atmospheric pressure. The methane result during these visits were 1.8% and 18.8% with the carbon dioxide levels being 0.5% and 0.9% respectively. These results suggest that gas readings varied across the site independently of the atmospheric pressures.

An alternative correlation can be seen when viewing the publicly recorded atmospheric data when compared to the flow rates recorded during the investigation, this can be seen in the table below:

Table 1: Summary of Atmospheric Pressures Across Gas Monitoring Period

Month	Highest Recorded Pressure mb	Lowest Recorded Pressure mb	Highest Recorded Flow Rate l/h	Lowest Recorded Flow Rate l/h
February	1045	1010	0.2	0.1
March	1030	979	1.5	0.1
April	1031	986	1.7	0.1
May	1034	1009	0.2	0.1

Pressures acquired from weatheronline.co.uk

It can be suggested that there is indeed a correlation between atmospheric pressure and flow rate when viewing the publicly recorded date. As can be seen in the above table the atmospheric pressure was recorded to drop below 1000 mb during March and April while at the same time, the flow rates have their highest recorded values.

In review of the previous discussion it can be stated that while there may be a correlation between lower atmospheric pressures and higher flow rates, there does not appear to be any correlation between high flow rates and higher recorded gas readings. Additionally, the groundwater level also does not appear to impact the gas readings. As such, it is unlikely that any changes to groundwater level or atmospheric pressure will impact the risk ratings applied to the site.

2.2 Assessment of Ground Gas Models

As part of the ground gas risk assessment, diagrammatic conceptual site models were produced of the site that present it in its current site use and in its proposed site use with potential migration pathways and sources annotated; these models can be seen within Appendix 3. It has been assessed in both the Phase 1 and Phase 2 reports that the sources of ground gas constitute the landfill towards the southern end of the site and the potential mine workings beneath the site. However, from reviewing the gas monitoring data and assessing the ground gas models it should be appreciated that the risk of gas produced by the landfill, if any, is low as none of the gas values at WS12 were noted to be of any significance. Additionally, as the development plans do not include any structures to be placed on or close to the landfill it is expected that any ground gas using it as pathway will simply vent to atmosphere.

The remaining source of ground gas on site is expected to originate to mine workings known to be present beneath the surface, as demonstrated with the onsite gas monitoring and also the recorded mine gas emission records demonstrated in the CMRA. This source of gas has been classified as high risk in regards to its pathway to the inside of currently present buildings on site and its potential pathway without remediation to the inside of the large commercial unit that has been proposed to be constructed. As can be seen in the model, outside of the proposed unit the ground gas is classified as low risk as it will simply vent to atmosphere.

3. Conclusion

The datasets suggest that the high levels of ground gas recorded during the phase 2 site investigation are likely sourced from mine workings at depth or off-site. Indeed, mine gases have been recorded in the surrounding areas. It is not anticipated that landfill on-site represents a generative source of ground gas.

In conclusion, the site being classified as Characteristic Situation Level 3 represents the ‘worst case’ scenario in regards to the risks of ground gas migration to the proposed developments. As such, it is considered that the remediation recommendations (i.e. gas membrane) made within the Phase 2 Report will be sufficient to lower the risk and prevent the build-up of harmful gasses.

4. References

- British Standards Institution (2013), BS 8576 Guidance on Investigations for Ground Gas – Permanent Gases and Volatile Organic Compounds.
- British Standards Institution (2015 +A1:2019) BS8485: Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings, B.S.I., London.
- CIRIA Report C665, Assessing risks posed by ground gasses to building.
- Hooker P.J. and Bannon M.P., 1993. Methane: its occurrence and hazards in construction. CIRIA Report 130
- Department of the Environment, 1996. Methane and other gases from disuse coal mines: the planning response technical report. The Stationary Office;
- BS 8576:2013. Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs);
- BS 8485:2015 + A1:2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings;
- CIRIA, 2019. CIRIA Report C758D, Abandoned Mine Workings Manual; and
- Coal Authority, 2019. Guidance on managing the risk of hazardous gases when drilling or piling near coal. The Coal Authority, Health and Safety Executive, British Drilling Association, Federation of Piling Specialists and the Association of Geotechnical and Geo-environmental Specialists. Version 2, April 2019.
- CL:AIRE, 2019. Good Practice for Risk Assessment for Coal Mine Gas Emmissions.

Appendix 1

Site Plan



Notes:

Investigation positions approximated from site operative's notes.

RGS Environmental Geotechnical Specialists

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Client:

Avie Consulting

Job Number:

C3224/24/E/6470

Project Details:

Barnsley Road, Grange Moor

Scale: Not to scale - reference only

Appendix 2

Gas Monitoring Data

Rogers Geotechnical Services Ltd

GAS/WATER MONITORING - SITE RECORD

Client:

Site:

Gas Monitor: Geotech GA5000
Serial No. G503524
Calibration Date: 24.08.2022
Dip Meter: 003

Input by : M. Tuck Checked by : R.A. Palmer

Date : 07.03.2023 Date : 20.02.2024

Borehole No	Date	CH_4 (%)	CO_2 (%)	O_2 (%)	Flow (l/hr)	Barometric Pressure (mb)	Water Level (m)	Standpipe Depth (m)	Depth During Visit	Atmospheric Conditions	COMMENTS
WS01	14.02.2023	0.4	6.4	12.9	0.1	1003	-		1.08	Sunny	Falling pressure, CO 2
	21.02.2023	0.3	8.2	11.6	0.1	999	_		1.08	Cloudy	Falling pressure, CO 4
	28.02.2023	0.3	8.6	12.3	0.1	1011	_		1.08	Cloudy	Steady pressure CO 0
	07.03.2023	0.3	8.3	11.3	0.3	**976**	0.97		1.08	Sunny	Steady pressure CO 1
WS03	14.02.2023	0.2	6.4	9.1	0.1	1003	1.57		2.11	Sunny	Falling pressure, CO 1
	21.02.2023	0.2	8.0	9.2	0.1	993	1.56		2.11	Cloudy	Falling pressure, CO 1
	28.02.2023	0.5	9.9	8.8	0.2	1012	1.61		2.11	Cloudy	Steady pressure CO 0
	07.03.2023	0.4	**10.3**	7.6	0.2	**976**	1.71		2.11	Sunny	Steady pressure CO 0
WS04	14.02.2023	0.2	**0.0**	18.1	0.1	1004	0.86		1.85	Sunny	Falling pressure, CO 90
	21.02.2023	1.8	0.5	18.0	0.2	993	0.89		1.84	Cloudy	Falling pressure, CO 99
	28.02.2023	18.6	0.9	6.0	0.1	1012	1.30		1.84	Cloudy	Steady pressure CO4
	07.03.2023	**18.8**	1.0	**3.5**	**1.5**	977	1.09		1.84	Sunny	Steady pressure CO 3 Peak flow 1.8
WS09	14.02.2023	0.4	2.0	13.9	0.0	1003	3.55		3.78	Sunny	Falling pressure, CO 3
	21.02.2023	0.4	2.9	14.1	0.0	993	3.58		3.78	Cloudy	Falling pressure, CO 0
	28.02.2023	1.4	4.2	12.7	0.0	**1013**	3.63		3.78	Cloudy	Steady pressure CO 3
	07/03/2023	**0.1**	4.3	11.7	0.0	977	3.57		3.77	Sunny	Steady pressure CO 1
WS10	14.02.2023	**0.1**	1.2	20.9	0.0	1003	-		1.52	Sunny	Falling pressure, CO 2
	21.02.2023	**0.1**	1.7	20.4	0.0	991	_		1.54	Cloudy	Falling pressure, CO 0
	28.02.2023	**0.1**	0.9	21.2	0.0	1011	_		1.54	Cloudy	Steady pressure CO 0
	07/01/1900	**0.1**	1.7	19.6	0.0	**976**	_		1.54	Sunny	Steady pressure CO 0
WS12	14.02.2023	**0.1**	2.5	19.3	0.0	1003	-		4.07	Sunny	Falling pressure, CO 9
	21.02.2023	**0.1**	3.6	18.5	0.0	991	_		4.07	Cloudy	Falling pressure, CO 0
	28.02.2023	**0.1**	0.2	**21.7**	0.0	1012	_		4.07	Cloudy	Steady pressure CO 0
	07.03.2023	**0.1**	1.5	21.0	0.0	977	_		4.07	Sunny	Steady pressure CO 0

Rogers Geotechnical Services Ltd

GAS/WATER MONITORING - SITE RECORD

Client:

Site:

Gas Monitor: Geotech GA5000
Serial No. G503524
Calibration Date: 01.02.2023
Dip Meter: 003

Input by : M. Tuck Checked by : R.A. Palmer

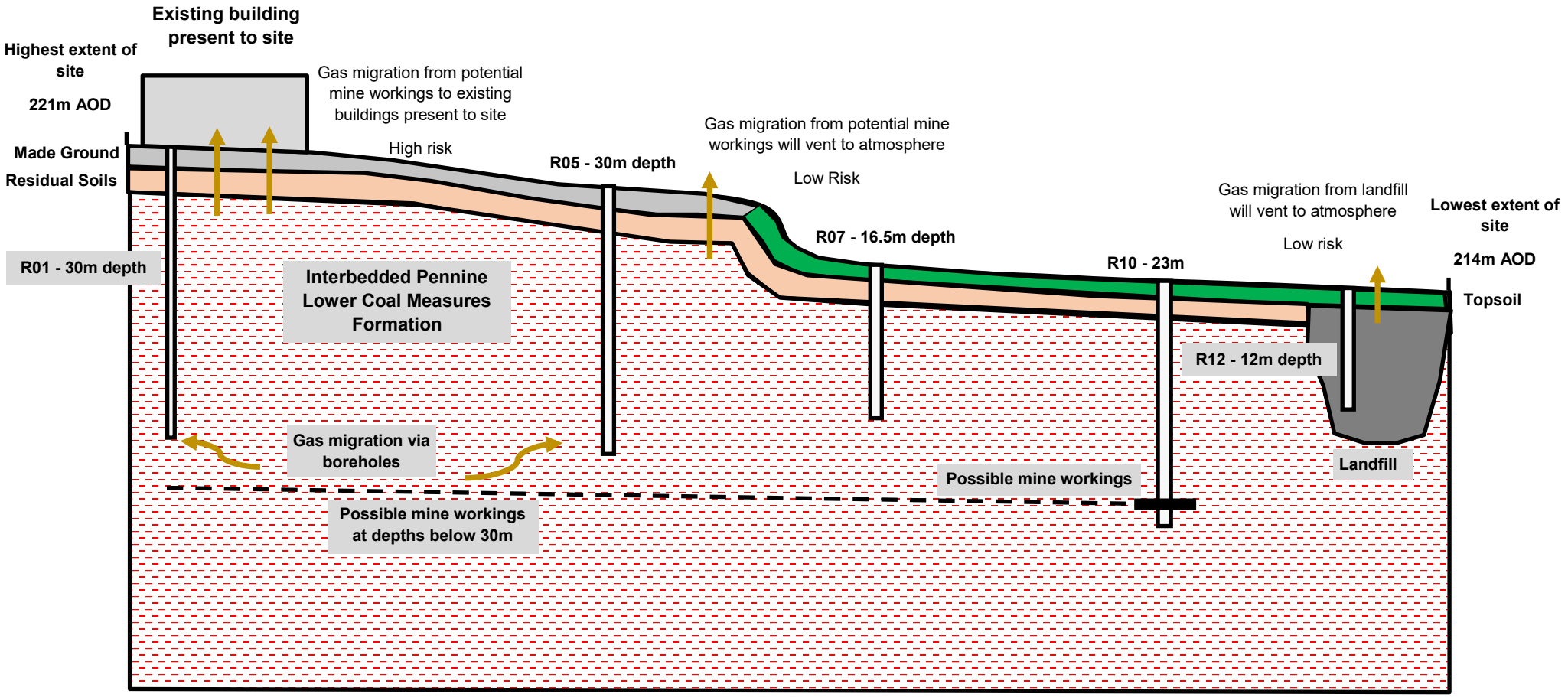
Date : 22.05.23 Date : 20.02.2024

Borehole No	Date	CH_4 (%)	CO_2 (%)	O_2 (%)	Flow (l/hr)	Barometric Pressure (mb)	Water Level (m)	Standpipe Depth (m)	Depth During Visit	Atmospheric Conditions	COMMENTS
1	13.03.2023	1.3	7.6	11.4	1.3	956	0.93		1.08	Drizzle	Steady pressure CO 5
	27.03.2023	0.2	8.1	10.9	0.1	1001	0.88		1.07	Cloudy	Steady pressure, CO 22
	11.04.2023	0.2	8.3	9.5	0.6-0.5	983	0.83		1.07	Sunny	Steady pressure CO 39
	24.04.2023	3.4	0.3	19.3	0.0	981	0.53		1.02	Sunny intervals	Rising pressure CO 18 Tap off standpipe.
	09.05.2023	0.2	9.4	2.8	0.1	985	0.66		0.98	Cloudy	Steady pressure CO 14
	22.05.2023	4.7	**11.4**	2.2	0.1	999	0.57		0.95	Sunny	Steady pressure CO 15 H2S 1
3	13.03.2023	0.1	4.5	8.2	0.4	**955**	1.42		2.11	Drizzle	Steady pressure CO 0
	27.03.23	0.2	3.3	16.0	0.1	1001	1.41		2.11	Cloudy	Steady pressure, CO 17
	11.04.2023	0.1	6.9	1.6	0.0	983	1.62		2.12	Sunny	Steady pressure CO 6
	24.04.2023	**0.0**	6.1	2.3	0.1	987	1.39		2.12	Sunny intervals	Rising pressure CO 3
	09.05.2023	0.7	11.3	**0.6**	0.1	986	1.45		2.11	Cloudy	Steady pressure CO 1
	22.05.2023	0.5	5.1	1.5	0.0	1000	1.44		2.11	Sunny	Steadt pressure CO 2
4	13.03.2023	10.8	0.2	11.7	0.0	957	0.98		1.83	Drizzle	Steady pressure CO 4
	27.03.23	3.3	**0.1**	19.2	0.0	1001	1.08		1.83	Cloudy	Steady pressure, CO 29
	11.04.2023	10.8	0.2	16.3	0.0	983	1.09		1.83	Sunny	Steady pressure CO 20
	24.04.2023	33.9	0.8	6.7	0.4	988	1.26		1.83	Sunny intervals	Rising pressure CO 20
	09.05.2023	43.8	1.1	1.4	0.2	985	1.51		1.85	Cloudy	Steady pressure CO 14
	22.05.2023	**53.8**	1.6	1.5	0.1-0.0	1000	1.50		1.84	Sunny	Steady pressure CO 3
9	13.03.2023	0.2	3.2	12.1	1.5	957	0.47		3.77	Drizzle	Steady pressure CO 0
	27.03.23	**0.0**	0.2	**21.5**	0.0	**1002**	0.05		3.75	Cloudy	y pressure, CO 1, 10 second reading only due to water in stan
	11.04.2023	1.2	0.2	19.3	**1.7**	982	0.62		3.77	Sunny	Steady pressure CO 3
	24.04.2023	0.1	1.6	16.6	0.0	987	3.51		3.77	Sunny intervals	Rising pressure CO 13
	09.05.2023	4.5	3.4	4.4	0.0	985	3.09		3.76	Sunny intervals	Steady pressure CO 2
	22.05.2023	**0.0**	4.6	1.9	0.0	1000	3.48		3.75	Sunny	Steady pressure CO 1
10	13.03.2023	0.1	1.0	19.6	0.0	957	_		1.56	Drizzle	Steady pressure CO 0
	27.03.23	0.1	0.3	21.0	0.0	1001	_		1.55	Cloudy	ssure, CO 0, Tap was removed from standpipe when well was
	11.04.2023	**0.0**	1.8	17.7	0.0	982	_		1.55	Sunny	Steady pressure CO 0
	24.04.2023	**0.0**	1.8	19.9	0.0	987	_		1.55	Sunny intervals	Rising pressure CO 0
	09.05.2023	0.1	1.3	19.5	0.0	985	_		1.53	Sunny intervals	Steady pressure CO 1
	22.05.2023	0.1	2.5	16.8	0.1-0.0	1000	_		1.47	Sunny	Steady pressure CO 1
12	13.03.2023	**0.0**	3.5	18.8	0.0	957	_		4.07	Drizzle	Steady pressure CO 0
	27.03.23	**0.0**	1.2	20.3	0.0	**1002**	_		4.07	Cloudy	Steady pressure, CO 0
	11.04.2023	**0.0**	3.8	17.7	0.1	982	_		4.08	Sunny	Steady pressure CO 1
	24.04.2023,	**0.0**	0.3	21.4	0.0	988	_		4.08	Sunny intervals	Rising pressure CO 0
	09.05.2023	0.1	2.2	18.0	0.0	985	_		4.08	Sunny intervals	Steady pressure CO 1
	22.05.2023	0.1	1.4	19.2	0.0	1000	_		4.08	Sunny	Steady pressure CO 1

Appendix 3

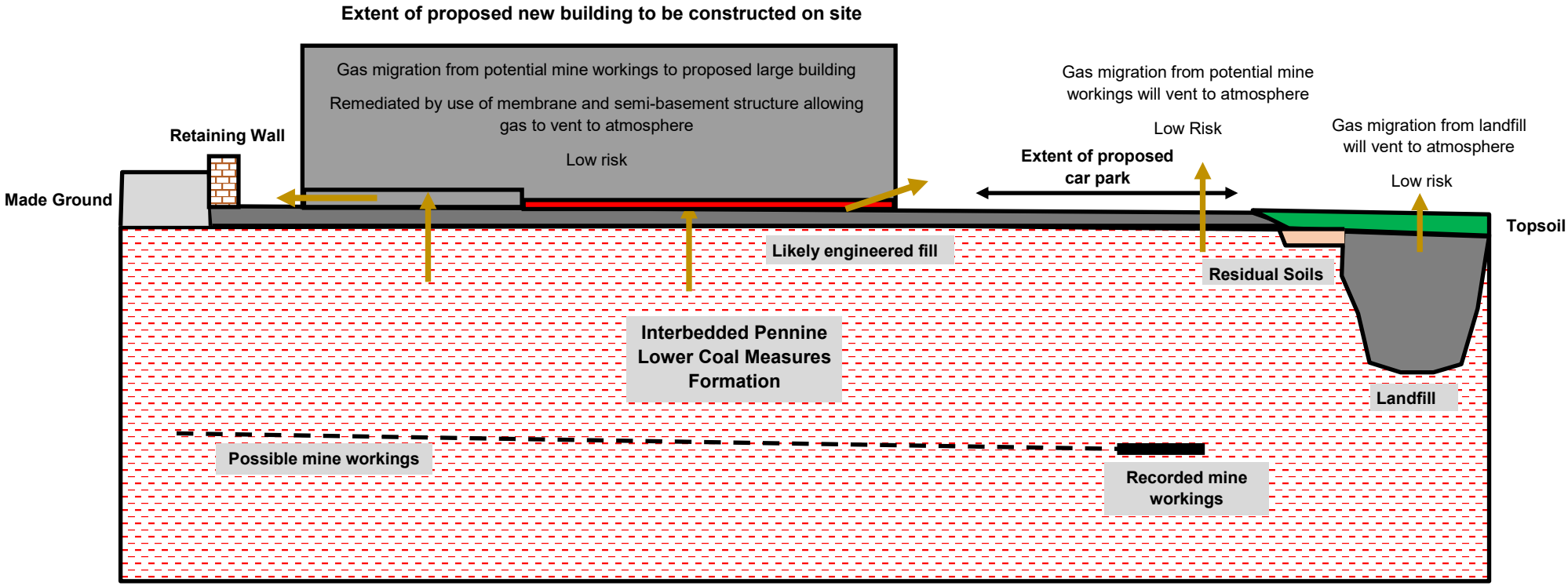
Ground Gas Models

Ground Gas Model for Existing Site Use



The above model considers the migration risks of ground gas from both landfill and potential mine working sources. It is understood that the current site use includes large areas of open fields and storage yards which have been assessed as low risk in regards to ground gas. The buildings that are currently present to the site include a small café, office block and vehicle maintenance workshop.

Ground Gas Model for Proposed Site Use



The above model considers the migration risks of ground gas from both landfill and potential mine working sources. It is understood that a large commercial unit and associated car park are to be constructed on site. It should be understood that as the landfill gases, if present at all, will vent to atmosphere, and thus a low risk has been assigned. A low risk has also been assigned to the new car parking area as it is all open with nowhere for gases to accumulate. The proposed commercial unit has been assigned a low risk in regards to ground gases as it is expected that sufficient remedial measures shall be installed and validated.