



GROUND INVESTIGATION SERVICES (Southern) Ltd

Our Ref: S.6125/G

Your Ref:

15 November 2023

Thinking Buildings
Bloxham Mill Business Centre
Barford Road
Bloxham
Banbury
Oxfordshire
OX15 4FF

FAO Darren Aspinall Esq

Dear Sirs

GROUND GAS ASSESSMENT: ALEXANDRA PARK SCHOOL, BIDWELL GARDENS, LONDON N11 2AZ

Please find enclosed the full set of results for ground gas monitoring in respect of the above. The results must be read in conjunction with Ground Investigation Services (Southern) Ltd Phase II Ground Investigation report: No. S.6125 dated September 2023.

Legislative Framework

There is a complex mix of documentation relating to legislative and regulatory procedures on the issue of ground gas contamination in regard to new development but the principal guidance is published in The Town and Country Planning (General Development Procedure) Order 1995, which requires the planning authority to consult with the Environment Agency before granting planning permission for development on land within 250 metres of land which is being used for deposit of waste, (or has been at any time in the last 30 years) or has been notified to the planning authority for the purposes of that provision.

General

The following assessment relates to the potential for, and the effects of, gases generated by biodegradable matter. The principal ground gases are carbon dioxide (CO₂) and methane (CH₄). The following table provides a summary of the effects of these gases when mixed with air.

TABLE 1. GAS CONCENTRATIONS IN AIR

Gas	By volume	Concentration Consequence
Methane	0.25% 5% 30%	Ventilation required in confined spaces Potentially explosive when mixed in air Asphyxiation
Carbon dioxide	0.5% 1.5% >3-6% >6-22% >22%	8 hour long term exposure limit (LTCL) (HSE Workplace limit) 15 minute short term exposure limit (LTCL) (HSE Workplace limit) Breathing difficulties Headaches, rapid loss of consciousness Death can occur

Following the current Building Regulations Approved Document C1, Section 2 '*Resistance to Contaminates*' (2004 incorporating 2010 and 2013 amendments) a risk assessment approach is required in relation to gaseous contamination based on the source-pathway-receptor conceptual model procedure. We have adopted procedures described in the following reference documents for investigation and assessments of risk of the development being affected by landfill type gases (permanent gases) and if appropriate the identification of mitigation measures.

- BS10175:2011+ A2:2017 '*Investigation of potentially contaminated sites- Code of Practice*'.
- BS8576: 2013 '*Guidance on investigations for ground gas -Permanent gases and Volatile Organic Compounds (VOCs)*'
- BS8485: 2015+A1:2019 '*British Standard Code of practice for the for the design of protective measures for methane and carbon dioxide ground gases for new buildings*
- CIRIA Report C665 '*Assessing risks posed by hazardous ground gases to buildings*' (2007).
- NHBC report No 10627-R01(04) '*Guidance on development proposals on sites where methane and carbon dioxide are present*' (January 2007)

Assessment of source of gases and Ground Gas Risk

Landfill Sources and site soil conditions:

Waste Management Paper 27 (1991) produced by the Department of the Environment '*Control of Landfill Gases*' contains the recommendation to avoid building within 50m of a landfill site actively producing large quantities of landfill type gases and to carry out site investigations within a zone 250m beyond the boundary of a landfill site. No distinction is made between sites of differing ground conditions, but the paper does not advocate the site is safe beyond the 250m zone, dependant, of course, upon the type of landfill and potential for migration of landfill gases.

A Phase I desk study was not commissioned.

The ground investigation report established that the site is underlain by bedrock comprising clay with extensive cappings of made ground extending down to depths between 1.20m and 2.20m. The made ground consists of dark brown clayey sand with much gravel sized constituent of which stone, brick, plastic, metal and china was recorded together with pockets of dark grey carbonised matter.

Conclusion of risks from Results of Phase II Works

The Conceptual Site Model (CSM) illustrated in the Ground Investigation report has indicated that there is a Moderate RISK¹ to the proposed development from elevated PAH within made ground profile. The risk from older made ground (assuming this predates the current school infrastructure) generating methanogenic gas is accorded a Low risk².

In light of this data from the ground investigation and the sensitivity of the site (Moderate sensitivity - School Development) the overall risk from ground gas, emanating from made ground profile affecting receptors (buildings and site users-school staff and pupils) is Low. On the basis of perceived risks an intrusive ground gas investigation was conducted to address this risk.

¹ Risk factors based on initial risk estimation from DETR '*A Guide to Risk Assessment and Risk Management for Environmental Protection*' details of which are included in rear of report and with reference to CIRIA C665

² Table 5.5a CIRIA C665

Ground Gas Monitoring Programme

The ground gas programme was devised from information provided in the original ground investigation report which gave clear and comprehensive geotechnical information across the site.

In terms of ground permeability and the migration of ground gases, the borehole logs illustrate the ground conditions. These are presented in Report No. S.6125. Ground conditions comprise extensive made ground superposing bedrock clay.

The presence of shallow granular strata with typically characteristic high hydraulic conductivity will provide favourable (high permeable) conditions for potential hazardous ground gas migration (lateral and vertical movement). There was direct evidence of the presence of methanogenic sources on site (made ground and organic matter etc) recorded during the site investigation.

On the basis of field records and the nature of proposed development two ground gas wells were installed to 4.00m depths in both boreholes. Site work was undertaken on the 22 and 23 August 2023.

The areal distribution of the boreholes as set out in Table 4.2 (CIRIA 665) in that for a development of Low Sensitivity and Low/Moderate Risk of ground gas there should be a minimum of three wells and the well spacing should be between 50m and 75m apart. The results of the investigation revealed that two wells were installed and the distances between the wells was 30m.

The well installation comprises HDPE 50mm internal diameter slotted and plain pipe installed in the following:

TABLE 2. MONITORING WELL INSTALLATIONS

Borehole No.	Arisings (clean soils) (depth - m)	Lower Seal Bentonite (depth - m)	Slotted Pipe with Filter Medium (depth - m)	Upper Seal Bentonite (depth - m)	Plain Pipe (depth - m)
BH1	4.50-15.00	4.00-4.50	1.00 - 4.00	0.10 -1.00	GL - 1.00
BH2	4.50-8.00	4.00-4.50	1.00 - 4.00	0.10 -1.00	GL - 1.00

The head-works comprised two gas taps, one of which was connected to a rubber bung to draw gas from a point approximately 0.20m below existing ground level and the other tap to an internal tube terminating approximately 0.20m above the base of the borehole well to allow well (or groundwater level - whichever is higher) to allow for re-circulation of air.

Ground Gas Monitoring Results

The monitoring programme comprised six visits over a two and a half-month period between 29 August and 08 November 2023. At each visit the following parameters (Table 3) were measured in the field using a GA5000 Range Gas Analyser and a MiniRAE Lite PID Monitor.

TABLE 3. GAS MONITORING INSTRUMENT SUMMARY

Parameter	Measurement units	Measuring devices
Methane (CH ₄)	Percentage volume-by-volume %v/v	GA5000
Carbon dioxide (CO ₂)	Percentage volume-by-volume %v/v	
Oxygen (O ₂)	Percentage volume-by-volume %v/v	
Gas emission flow rate	Litres per hour (l/hr)	
Barometric Pressure	Millibars (mb)	
Borehole Pressure	Millibars (mb)	
VOCs	Parts per million (ppm)	MiniRAE Lite PID monitor
Hydrogen sulphide	Parts per million (ppm)	
Carbon monoxide	Parts per million (ppm)	
Temperature	Centigrade (C°)	Hand held thermometer
Groundwater level	Metres	Electronic dipmeter

The PID uses an ultra violet light to ionise a gas sample drawn past an ionising source and hence detect its concentration. The light source used was a 10.66eV lamp and the instrument has a resolution of 0.1ppm. The energy required to displace an electron and 'ionise' a compound is called its Ionisation Potential (IP). A 10.66eV lamp would ionise the volatile organic compounds (VOC) that would be found in the anticipated contamination i.e. petroleum hydrocarbons, but not methane.

Carbon dioxide is a non-flammable, toxic gas with long-term and short-term exposure limits of 0.5% and 1.5%, respectively, by volume in air and is approximately one and a half times heavy as normal air.

Methane is a flammable and asphyxiating gas, the flammable range being 5% to 15% under normal atmospheric conditions. If methane, within this range, and atmospheric air are confined and ignited, the gas mixture will explode. Methane is a buoyant gas with a density of approximately two thirds that of atmospheric air.

Other trace gases associated with the generation of methane are carbon monoxide, hydrogen sulphide and volatile organic compounds. Carbon monoxide is a colourless gas which is odourless, explosive in air at concentrations of 12.5-74.2% and is toxic (EH40-2007 *Workplace Exposure Limits* (WEL's)) of 200ppm (short term) and long term – 30ppm. Hydrogen sulphide, is a colourless gas, characterised by 'rotten eggs' odour, and is flammable in air at concentrations of 4.5-45.5% and is toxic (WELs of 10ppm-short term and long term – 5ppm).

Volatile organic compounds may be present in made ground although concentrations are typically low when compared to that of methane and carbon-dioxide, however their presence is indicative of active chemical reactions and their effects on human health should not underestimated. Aside from unpleasant odours, there may be flammable and toxicological risks associated with these compounds. WELs exist for a wide range of VOCs which range from 1ppm (Benzene – short term) and 200ppm (Trichloro-ethane (TCE)-short term).

The six effective monitoring periods were undertaken over a relatively wide range of atmospheric pressures and weather conditions in which the atmospheric pressure ranged between 0991mb and 1017mb. Throughout the period of monitoring there were two periods of 'worst case' conditions (<1000mb).

The results of the monitoring (presented to the rear of this report), indicate Methane was not recorded in any of the borehole wells.

Carbon dioxide was elevated with values (maximum values for each monitoring period) ranging between 1.2%v/v (BH2 - 29.08.23) and 8.5%v/v (BH1 - 12.10.23). Steady state concentrations recorded after a period of ten minutes for each borehole revealed carbon dioxide concentrations generally to either increase or remain static. This trend is replicated over each monitoring period.

Carbon dioxide concentrations were generally higher in BH1 ranging from a low of 3.9% v/v on the 25.10.23 to a high of 8.5% v/v on the 12.10.23. Carbon dioxide concentrations in BH2 in contrast ranged between 1.3% to 4.7%.

The oxygen concentrations were recorded in the range 6.9 %v/v to 20.1 %v/v and the trend in Oxygen levels over the course of monitoring for each borehole over each monitoring period is generally static. Concentrations were generally lower in BH1 compared to BH2.

Other trace gases were generally absent.

The values for hydrogen sulphide, carbon monoxide and VOCs do not exceed the long term Workplace Exposure Limits (WELs).

There was no detectable gas flow in any of the wells. Readings were taken in the range of (0991 - 1017mb) atmospheric pressures with static, rising and falling pressure trends. The results of the monitoring indicate that there does not appear any quantifiable positive correlation between atmospheric pressure and levels of recorded carbon dioxide.

Groundwater was recorded in each borehole well, ranging between 1.36m-2.22m in BH1 and 1.41m-3.95m in BH2. The trend shows a rise in water levels from the first site visit to the second thereafter stabilising between 1.36m-1.89m in BH1 and 1.41m-1.74m in BH2.

GROUND GAS RISK ASSESSMENT

A number of documents are available providing guidance for assessing hazardous ground gases in the context of development of brown-field sites. The available guidance emphasises the importance of developing a robust CSM and employing a risk-based proportionate approach in line with Land contamination Risk Management (LCRM). In addition, the three key guidance documents (produced by NHBC, CIRIA and British Standards) although subtly different in some respects share a common parameter: the calculation of a gas screening value (GSV), referred to as the hazardous gas flow rate (Q_{hg}) in BS8485:2015. The GSV/Q_{hg} is a result of multiplying gas concentrations (%v/v) by borehole gas flow rate (l/hr).

The guidance documents take slightly different approaches in terms of which flow or gas concentrations to use: i.e. steady or peak values. This report calculates GSV's in terms of the highest observed values for both flow rate and gas concentrations (temporal and spatial) in order to ensure a conservative assessment of risk. This approach is deemed appropriate given the proposed development includes new structures for Public Buildings (school) development.

GSV's generated are compared to screening tables set out in the guidance documents.

Two key assessments approaches for assessing ground gas concentrations are:

- 'modified Wilson and Card classification' method set out in CIRIA 665
- BS 8485:2015+A1:2019

Gas Screening Values/Site Hazardous Gas Flow Rates

Based on the above documents the hazardous gas flow rate (Q_{hg}) or GSV should be calculated using:

$$Q_{hg} = (C_{hg}/100) * q$$

Where:

- C_{hg} is the measured hazardous gas concentration in % volume-by-volume (v/v)
- q is the flow rate in litres per hour of combined gases found by direct measurement

If gas borehole flow was not detectable, it should be assumed to be at detection limit of the equipment used, i.e. 0.1 l/hr.

Using the guidance referred to above, which defines risk ranging from very low to very high and categorises these risks as the site Gas Screening Value/Characteristic Gas Situation (1-6) based on the gas screening value (GSV) or site characteristic hazardous gas flow (Q_{hgs}), a maximum concentration of 0.008 L/hr for carbon dioxide was calculated.

Therefore, on this basis the site has been classified as VERY LOW hazard potential and classified as **Characteristic Gas Situation 1 (CS1)**. On this basis according to guidance published by BS 8485:2015 the Required Gas Protection Guidance Value is scored as zero.

Reference to BS8485 and CIRIA C665 cite that for 'Typical Maximum carbon dioxide concentrations' in exceedance of 5%v/v, consideration should be increasing the characteristic gas regime to the next level i.e. CS2. This approach applies to BH1 well where 5%v/v was exceeded on each of the monitoring periods.

Therefore, we advise that a **CS2** rating should be adopted as a minimum requirement. On this basis according to guidance published by BS 8484: the Required Gas Protection Guidance Value is scored as 2.5, i.e. PROTECTION REQUIRED.

Data Quality and sufficiency – Summary

A review was made of the quality of the available data for the site, which can be viewed in Table 4. CIRIA 665 (2007), BS8576 (2013) and BS 8485 (2015+A1:2019) and stress the need for risk assessments to be based on good quality sufficient data and give guidance as to best practice in this respect.

Table 4: Review of Data Quality			
Data Type	Current Situation	UK Practice	Recommendation
Geological and hydro-geological conditions	With regard to landfill gas risk assessment the data from the Phase II comprehensive site investigation with boreholes was very good. Contamination survey also undertaken	CIRIA 665, Wilson and BS 8485:2007 recommend that the geology and hydrogeology to be fully understood	No further action required
Type of installations	Two monitoring wells installed within 97mm/101mm and 150mm diameter bores and 50mm HDPE plastic pipe within made ground and natural ground to allow migration via high permeability soils to wells from potential sources. Two valves installed to allow for recirculation of ground gas	CIRIA 665 and BS8576 recommend boreholes with minimum diameter of 150mm and 50mm plastic pipe with filter surround to match existing and minimum of three wells	No further action required
Monitoring period	The monitoring has been undertaken on a total of six occasions Monitoring has been undertaken over a broad range of weather conditions including worst case atmospheric pressures	CIRIA 665 recommends a minimum of 3 month monitoring over a range of weather conditions (at least two periods of 'worst case conditions) and at least six periods of monitoring. Wilson and Card (1999) recommend that for less than 12 months monitoring the protective measures should be more conservative	No further action required. The wells should be left intact during development in order to allow continued monitoring in accordance with post development verification.
Assessing sufficiency of data	What increase in gas concentration is required to increase the estimated risk and the level of gas protection to be provided. This applies to the absence of a 'worst case' barometric pressure data		Keeping the flow rate constant, the gas concentration would need to increase by a factor of 10 to move to the next risk band (CS3). We consider this to be highly unlikely as the CO ₂ concentrations would have to exceed 50%v/v. THIS IS NOT FFEASIBLE
	Is the increase in flow rate feasible when compared to gas generation?		The flow rate would have to increase by a factor of 8 to move to CS3 classification. THIS IS NOT FEASIBLE
	Decide whether further monitoring is required		Based on the above analysis further gas monitoring is not required

Data Categorisation for Site

Based on the documentation presented in BS8485:2015+A1:2019 the Data Category for the site could be characterised as **Comprehensive** as six ground gas readings have been undertaken over a two and half month period with a range of barometric pressure and weather conditions and a comprehensive Intrusive Site Investigation were carried out for the site.

RECOMMENDATIONS

The proposed development is classified as residential and in consideration of the established CS evaluation and the proposed design incorporating new build and enclosed spaces (subterranean services, ducts etc) the following measures to mitigate the effects of ground gas affecting the development are outlined below:

- Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft) with a minimum of 2000g DPM/reinforced gas membrane
- Beam and block or pre-cast concrete slab and minimum of 2000g DPM/reinforced gas membrane
- All joints and penetration sealed. Minimum 2000g/reinforced gas proof membrane and passively ventilated underfloor sub-space or positively pressurised underfloor sub-space

The BS 8485:2015+A1:2019, Table 4 indicates a score of 2.5 points (Commercial/Public Building – Type C Building). A combination of venting and barrier systems whose scores total at least this number of points is required from the list in Table 5, 6 and 7 of the Standard.

The design of ground gas protection measures should be in accordance with recommended guidance including BRE BR212, BRE 414 and Building Regulations Approved document C Site preparation and resistance to moisture.

Post-Development Verification

Changes in the site's characterisation will occur as a result of the development as noted above. Impacts may also occur due to foundation and soakaway construction etc. Further monitoring to confirm the efficacy of the installed system would be the ideal aim of post-development verification and it would be useful for future work to have records detailing the degree to which current methods of ground gas ingress prevention are effective. Post-development monitoring is a requisite of Environment Agency document Land Contamination Risk Management (LCRM).

Statement with respect to National Planning Policy Framework

Based on investigations completed to date with respect to gaseous contamination, we are of the opinion the proposed development will be safe and suitable for use for the purpose for which it is intended (with provision of ground gas prevention measures) thus meeting the requirements of the National Planning Policy Framework section 120/122, and compliant with the Building Regulations Part C, '*Site preparation and resistance to contaminants and moisture*'.

Should you have any queries with regard to the report, please do not hesitate to contact the undersigned.

For and on behalf of
Ground Investigation Services (Southern) Ltd
Yours faithfully

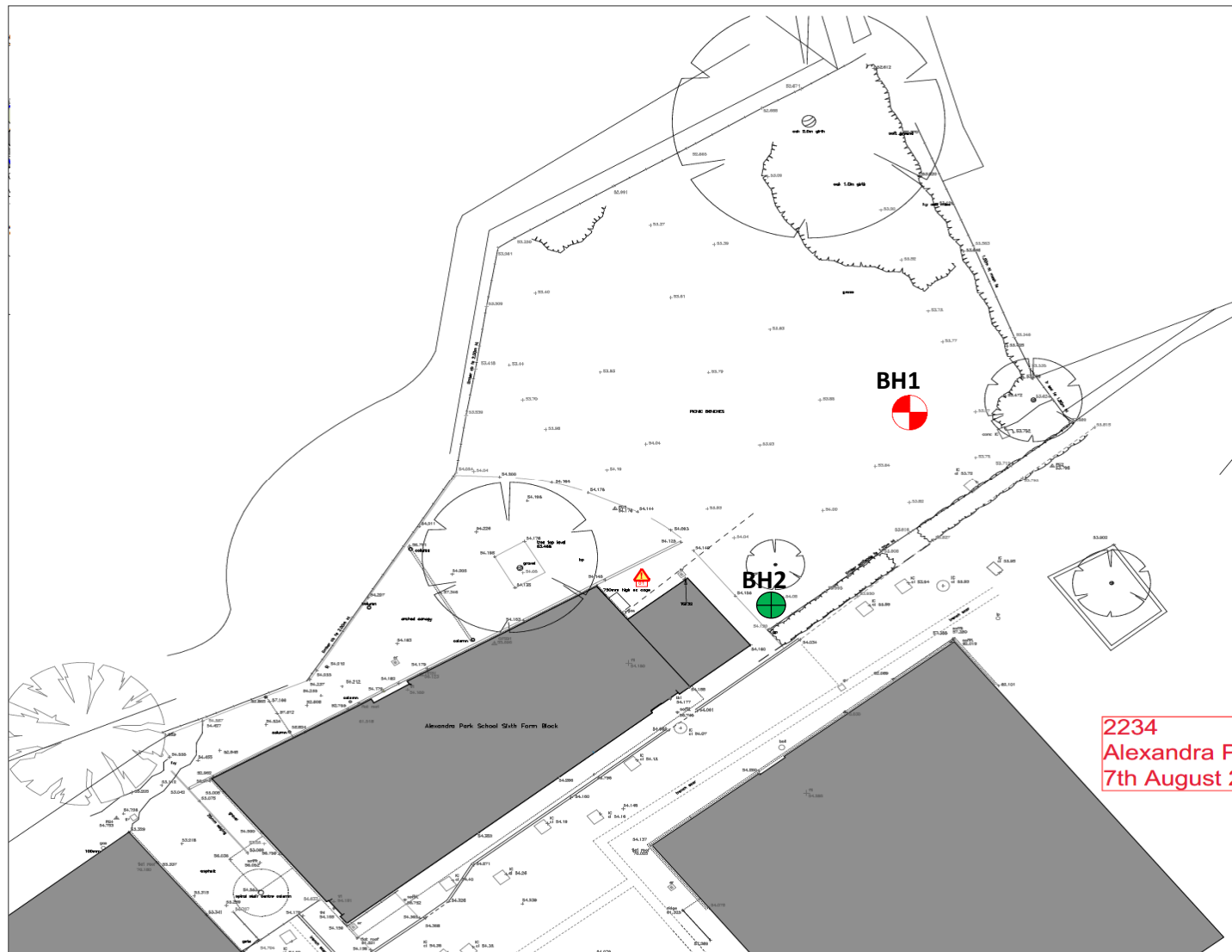


Martyn P Boughton (Director)

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Enc

Borehole Location Plan
Ground Gas Monitoring Results



Client: Thinking Buildings

Site: Alexandra Park School, Bidwell Gardens,
London N11 2AZ

Date: November 2023



Light Cable Percussion Borehole



Windowless Sampling Borehole

Ground Investigation
Services (Southern) Ltd
40 Home Close, Wootton OX13 6DD
Tel 01865 326011

BOREHOLE WELL LOCATION PLAN

Report No.

S.6125/G

Fig

1

Client: Thinking Buildings

Notes:	# minimum detection limit of analyser
Monitoring undertaken for ten minutes	*GSV/Q _{hg} - Gas Screening Value/Hazardous Gas Flow Rate
() Readings in parenthesis represent maximum value (CH ₄ and CO ₂) minimum value (O ₂)	*GSV/Q _{hg} - based on maximum concentration x flow rate x %

Date and time of Testing:	29.08.2023 (10.30hrs)
Monitored by :	Simon Dodd
Atmospheric Pressure (mB) and trend:	1008 (static)
Weather:	Dry warm and sunny
Temperature (between -10° C to +40° C):	19°
Equipment used	GA 5000 Range Gas Analyser Last Calibrated: 22 December 2022 Certificate No. G508095_1/31866 Serial No. G508095

MiniRAE Lite PID Monitor
Last calibrated: 17 October 2022
Certificate No. 72988
Serial No. 595-000946

Visible signs of vegetation stress:	None
Other comments/observations	

Site: Alexandra Park School, Bidwell Gardens, London N11 2AZ

[illegible]

Monitoring undertaken for ten minutes

() Readings in parenthesis represent maximum value (CH₄ and CO₂) minimum value (O₂)

*GSV/Q_{hg} - Gas Screening Value/Hazardous Gas Flow Rate

*GSV/Q_{hg} - based on maximum concentration x flow rate x %

Relevant Information at Time of Monitoring		
Date and time of Testing:	13.09.2023 (10.30hrs)	
Monitored by :	Simon Dodd	
Atmospheric Pressure (mB) and trend:	1017 (falling)	
Weather:	Dry warm and sunny	
Temperature (between -10° C to +40° C):	18°	
Equipment used	GA 5000 Range Gas Analyser Last Calibrated: 22 December 2022 Certificate No. G508095_1/31866 Serial No. G508095	MiniRAE Lite PID Monitor Last calibrated: 17 October 2022 Certificate No. 72988 Serial No. 595-000946
Visible signs of vegetation stress:	None	
Other comments/observations		

Monitored by :	Simon Dodd
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(mB) and trend:	1017 (falling)
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Weather:	Dry warm and sunny
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to +40° C):	18°
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Equipment used	GA
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Last Calibrated: 22 December 2022

Certificate No. G508095 1/31866

Serial No. G508095

NOTE

Other comments/observations

Last calibrated: 17 October 2022

Certificate No. 72988

Serial No. 595-000946

Serial No. 999-0000-40

Client: Thinking Buildings

[illegible]

*GSV/Q_{hg} - based on maximum concentration x flow rate x %

Relevant Information at Time of Monitoring

Date and time of Testing:	26.09.2023 (10.45hrs)	
Monitored by :	Simon Dodd	
Atmospheric Pressure (mB) and trend:	1010 (static)	
Weather:	Dry warm and overcast	
Temperature (between -10° C to +40° C):	19°	
Equipment used	GA 5000 Range Gas Analyser Last Calibrated: 22 December 2022 Certificate No. G508095_1/31866 Serial No. G508095	MiniRAE Lite PID Monitor Last calibrated: 17 October 2022 Certificate No. 72988 Serial No. 595-000946
Visible signs of vegetation stress:	None	
Other comments/observations		

Site: Alexandra Park School, Bidwell Gardens, London N11 2AZ

[illegible]

Monitoring undertaken for ten minutes

() Readings in parenthesis represent maximum value (CH₄ and CO₂) minimum value (O₂)

*GSV/Q_{hg} - Gas Screening Value/Hazardous Gas Flow Rate

*GSV/Q_{hg} - based on maximum concentration x flow rate x %

Relevant Information at Time of Monitoring		
Date and time of Testing:	12.10.2023 (11.00hrs)	
Monitored by :	Simon Dodd	
Atmospheric Pressure (mB) and trend:	1007 (static)	
Weather:	Mild with light rain	
Temperature (between -10° C to +40° C):	13°	
Equipment used	GA 5000 Range Gas Analyser Last Calibrated: 22 December 2022 Certificate No. G508095_1/31866 Serial No. G508095	MiniRAE Lite PID Monitor Last calibrated: 17 October 2022 Certificate No. 72988 Serial No. 595-000946
Visible signs of vegetation stress:	None	
Other comments/observations		

Date and time of Testing:	12.10.2023 (11.00hrs)
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Monitored by :	Simon Dodd
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Atmospheric Pressure (mB) and trend: 1007 (static)

Weather:	Mild with light rain
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Temperature (between -10° C to +40° C):	13°
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Equipment used	GA
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GA 5000 Range Gas Analyser
Last Calibrated: 22 December 2022
Certificate No. G508095_1/31866
Serial No. G508095

MiniRAE Lite PID Monitor
Last calibrated: 17 October 2022
Certificate No. 72988
Serial No. 595-000946

Visible signs of vegetation stress:	None
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Other comments/observations

Site: Alexandra Park School, Bidwell Gardens, London N11 2AZ

Notes:	# minimum detection limit of analyser
Monitoring undertaken for ten minutes	*GSV/Q _{hg} - Gas Screening Value/Hazardous Gas Flow Rate
() Readings in parenthesis represent maximum value (CH ₄ and CO ₂) minimum value (O ₂)	*GSV/Q _{hg} - based on maximum concentration x flow rate x %

Visible signs of vegetation stress:	None
Other comments/observations	

Site: Alexandra Park School, Bidwell Gardens, London N11 2AZ

Relevant Information at Time of Monitoring		
Date and time of Testing:	08.11.2023 (11.00hrs)	
Monitored by :	Simon Dodd	
Atmospheric Pressure (mB) and trend:	997 (falling)	
Weather:	Mild with sunny periods and light rain	
Temperature (between -10° C to +40° C):	13°	
Equipment used	GA 5000 Range Gas Analyser Last Calibrated: 22 December 2022 Certificate No. G508095_1/31866 Serial No. G508095	MiniRAE Lite PID Monitor Last calibrated: 31 October 2023 Certificate No. 78032 Serial No. 595-000946
Visible signs of vegetation stress:	None	
Other comments/observations		