

ALDI BARDON RDC GAS PROTECTION STRATEGY

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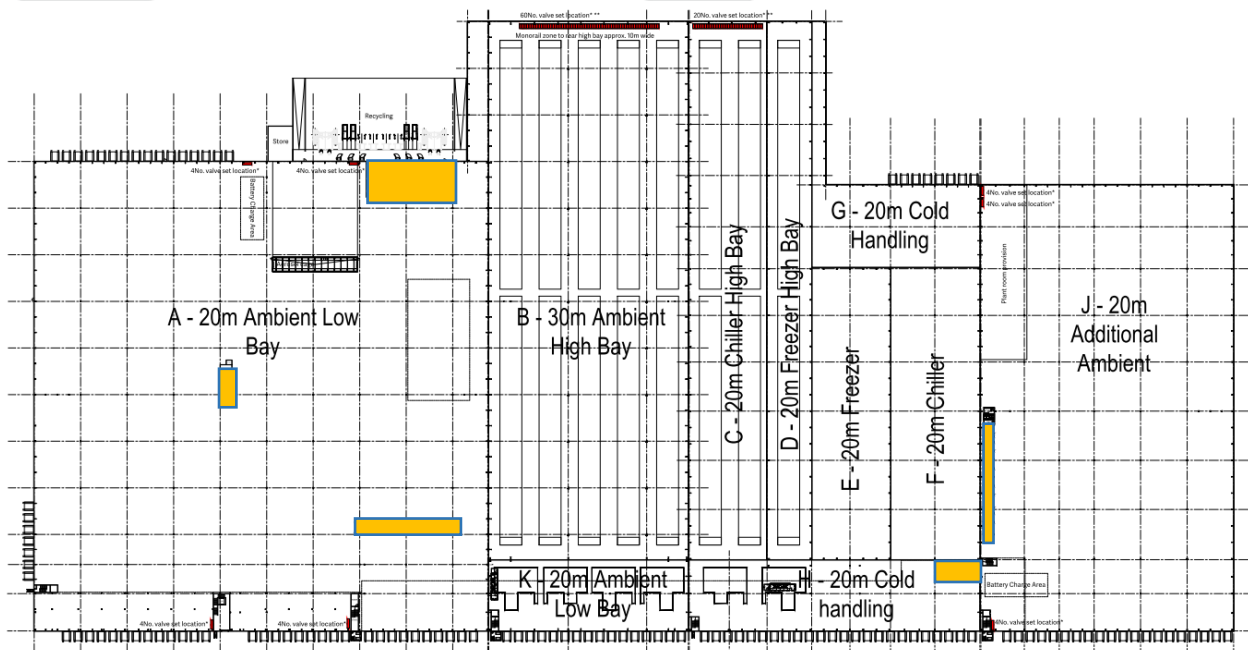
Suitability	Revision	Date	Notes	Author	Checked	Approved
S1	P01	10.12.20	PRELIMINARY ISSUE	AST	HJ	CSD
S1	P02	02.02.21	PLANNING ISSUE	AST	HJ	CSD
S1	P03	19.01.26	UPDATED TESTING (1.3c, 1.5, 1.6, 1.9, 1.11, 1.13 edited and Appendix C added,	AST	CSD	CSD

1. INTRODUCTION

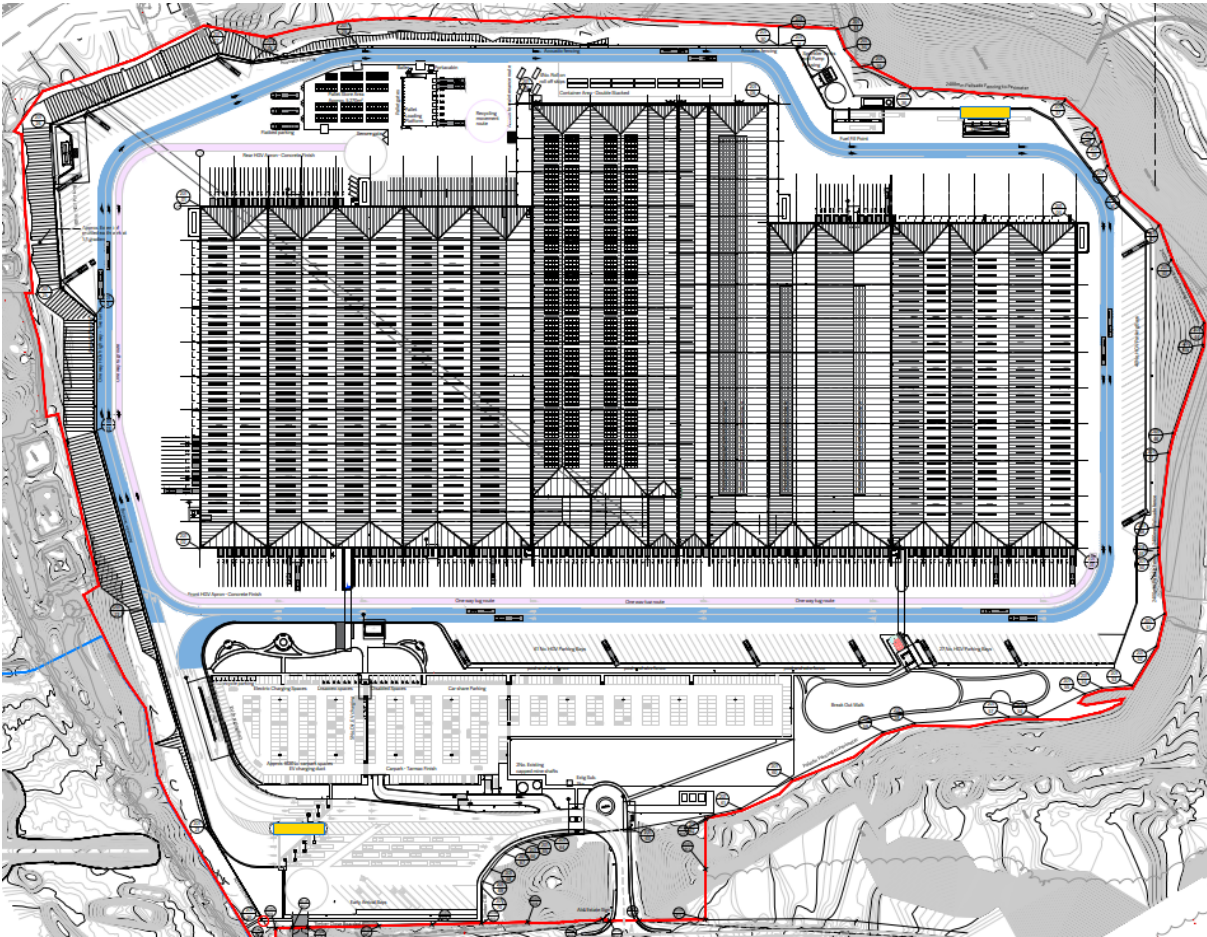
- 1.1. **Purpose:** This document has been produced to address the issue of ground gas for the proposed RDC development. Specifically to address Planning Condition 9 of 20-00224-FUL.
- 1.2. **Site history:** Historically, the site was an active colliery between 1860 and 1960. After its closure in 1960 the site was revisited a number of times to extract additional minerals from spoil mounds and lagoons left behind from the mining works. In 2018 works began to recondition the site and surrounding lagoons to facilitate sale and development. These works consisted of a regime of treating the soil and re profiling the wider site to suit anticipated developer needs. These works were undertaken by the site vendor and were complete in 2020.
- 1.3. **Testing to date:** Multiple site investigations have been undertaken on site over the last decade. Primarily the two reports which address ground gas hazards are summarised below. The basis of the historic site investigation reports were to evaluate the colliery for any residual effects on the ground along with identify the implications on proposed developments, specifically with industrial units in consideration.
 - (a) **ERM Report (2010).** This phase of investigation included installation of 11 No. gas monitoring wells. Results of this investigation concluded that the site was at low risk in regard to naturally occurring radon gas. In addition to this, it was confirmed that the site did not require any special protecting measures to safeguard against ground gases, classifying the site as CS1. Further gas testing was recommended, in accordance with CIRIA C665 (2007) prior to redevelopment, to confirm that no additional gas hot spots were uncovered as part of the redevelopment works.
 - (b) **Capita Report 070745-GEO001 (2015).** A further 22 boreholes were installed and monitored over July, August and September of 2015 by Capita in direct response to the recommendation of the previous ERM report for additional monitoring. 12 of the 22 results classified the site as gas characteristic situation CS2. This was primarily due to the peak flows recorded on site marginally exceeding the limitations set for CS1. The CS2 rating was specifically related to a capped slurry mound which was identified as needing to be remediated. Clause 12.2.13 of the Capita 2015 report stated "it is proposed to excavate the capped lagoon slurry which may remove the source of the gas"
 - (c) **Earth Environmental & Geotechnical Report R5322/26/rev1.** Following the site wide remediation and stabilisation strategy undertaken for the site a revised set of gas monitoring tests were undertaken to confirm that the sites gas issues have been remediated. The testing was situated in proximity to the areas under consideration externally to the primary building footprint. A suite of 9 additional test locations were undertaken and all results classified the site as gas characteristic situation CS1. This

resulted in a more practical classification of the site instead of the slightly heightened CS2 reading recorded in the Capita Report mentioned above. It would appear that actioning clause 12.2.13 of the Capita report has in fact addressed the heightened readings.

- 1.4. **Site remediation:** In recent years, as noted in 1.2 above, the developer Curtis Hall undertook a significant earthworks exercise on site. This exercise was informed by all previous site investigation reports and the recommendations of Bradbrook Consulting (in connection with the Capita report of 2015) in relation to contamination and site wide remediation. These works were completed in the summer of 2020. In June 2020 Bradbrook Consulting released a report outlining the site wide remediation works undertaken for this site. This report confirmed that it is not likely that any significant additional remediation will be required
- 1.5. **Classification:** Additional testing was undertaken by Earth Environmental in 2025 which showed that the site should be classified as CS1, which addresses the concerns of the previously conservative classification of CS2 from the Capita report. However as this testing was not undertaken within the primary building footprint we have kept the recommendations of CS2 characteristic for the primary warehouse. No further gas testing was undertaken post the Capita 2015 regime. As such the site is currently (conservatively) classified as gas characteristic situation CS2 'low risk'. It is probable that site remediation outlined above will have addressed the capped slurry lagoon and thus a reduction from CS2 is likely, however at this time CS2 will be assumed in the absence of further testing. This is considered to represent a worst case conservative scenario.
- 1.6. **Strategy:** Gas protection strategy will be in accordance with BS 8485:2015 – Code of practice for the characterization and remediation from ground gas in affected developments. A CS1 rating will be applied for the ancillary structures and a CS2 rating will be used for the warehouse footprint.
- 1.7. **Building use:** As can be seen on the image below the primary use of the building is, industrial, primarily high bay warehousing space. The building is generally steel framed with jointless concrete floor construction. Within the warehouse space there are a number of dedicated office and welfare areas at ground floor level. These areas are generally constructed over the primary slab, which continues unbroken beneath (thus providing slab on slab arrangements). Ancillary offices and welfare areas are shown by the highlighted (orange) blocks below. Also included within the site, but external to the building footprint, is a gatehouse and a vehicle maintenance unit (VMU), both of which have dedicated office spaces associated with them.



Also included within the site, but external to the building footprint, is a gatehouse and a vehicle maintenance unit (VMU), both of which have dedicated office spaces associated with them and have been classified in accordance with this report as CS1.



- 1.8. **Building Type:** In accordance with BS8485:2015 the warehouse and office areas fall into two distinct categories for assessment for protection against ground gasses. The office spaces will fall into building type C 'Commercial Building' and the warehouse spaces fall into building type D 'Industrial Building'.
- 1.9. **Level of protection:** In accordance with table 4 of BS 8485:2015 (shown below) the following solution scores will be required. Type C (office spaces, within warehouse) 2.5 and building Type D (warehouse space) 1.5. Ancillary office buildings Type C CS1 0 points required.

Table 4 Gas protection score by CS and type of building

CS	Minimum gas protection score (points)			
	High risk	Medium risk		Low risk
	Type A building	Type B building	Type C building	Type D building
1	0	0	0	0
2	3.5	3.5	2.5	1.5
3	4.5	4	3	2.5
4	6.5 ^{A)}	5.5 ^{A)}	4.5	3.5
5	— B)	6.5 ^{A)}	5.5	4.5
6	— B)	— B)	7.5	6.5

^{A)} Residential buildings should not be built on CS4 or higher sites unless the type of construction or site

- 1.10. **Method of protection:** Four varying methods of protection are available to meet the required solution score and are outlined in BS 8485 as follows.
- Barriers
 - Ventilation Measures
 - Membranes
 - In-ground pathway intervention

- (a) **Solution score, building Type C (within warehouse footprint):** As outlined above a solution score of 2.5 is required to suitably protect these areas against ground gasses, this will be achieved as follows. Barriers – These office spaces will be constructed on top of the large bay warehouse floor slab. This floor slab is reinforced with steel fibres to limit crack widths. The joints will be minimal and at an increased spacing to minimise openings within the slab. This form of construction in accordance with BS8485 will achieve a point score of 1.5.
 - (b) Ventilation measures – None provided.
 - (c) Membranes – A proprietary gas membrane will be supplied which conforms with the requirements of BS 8485. This membrane will be independently installed and validated. This will achieve a point score of 2.
 - (d) Pathway intervention – None provided.
 - (e) Solution score total – 3.5. This exceeds the 2.5 score required by BS 8485
- 1.11. **Solution score, building Type C (external to warehouse footprint):** As outlined above a solution score of 0 is required to suitably protect these areas against ground gasses, this will be achieved as follows.
- (a) Barriers – These office spaces will be constructed on top of a traditional reinforced ground bearing slab. This form of construction in accordance with BS 8485 will conservatively achieve a point score of 0.5.
 - (b) Ventilation measures – None provided.
 - (c) Membranes – None provided.
 - (d) Pathway intervention – None provided.
 - (e) Solution score total – 0.5. This satisfies the 0 solution score required.
- 1.12. **Solution score, building Type D:** As outlined above a solution score of 1.5 is required to suitably protect these areas against ground gasses, this will be achieved as follows.
- (a) Barriers – These industrial open plan areas will be constructed using large bay (jointless) warehouse floor slab construction techniques. These floor slab will be reinforced with fibres to limit crack widths. Joints will be minimal and at an increased spacing to minimise openings within the slab. This form of construction in accordance with BS 8485 will achieve a point score of 1.5.
 - (b) Ventilation measures – None provided.
 - (c) Membranes – None provided.
 - (d) Pathway intervention – None provided.
 - (e) Solution score total – 1.5. This satisfies the 1.5 score required.
- 1.13. **Conclusion:** The proposed RDC development will be constructed generally in line with the recommendations of BS 8485. A conservative approach to gas classification has been adopted (CS2) based on significant site investigation works for within the warehouse footprint, additional testing externally has been undertaken allowing for the reduction in classification to CS1. Robust solution scores have been proposed that either conservatively satisfy the minimum required solution score or exceed this. Works will be carefully monitored under construction management procurement route with a high level of site attendance from the design team. No further actions are proposed and the steps taken are considered sufficient to address the low risk posed by natural ground gasses to the site and proposed development.

1.14.

Appendix A

Extract from ERM 2010 Report

Former Nailstone Colliery, Leicestershire

Geotechnical / Geo-environmental Report

Revision B | November 2015



12. Ground Gas Risk Assessment

12.1 Introduction

- 12.1.1 The current guidance for the assessment of risk associated with the presence of hazardous ground gases is provided in:
- Code of Practice for Design of Protective Measures for Methane & Carbon Dioxide Ground Gases for New Buildings (BS 8485: 2015);
 - Assessing Risks Posed by Hazardous Ground Gases to Buildings CIRIA (C665, 2007);
 - Radon Guidance on Protective Measures for New Buildings, BRE Digest 211(2007).
- 12.1.2 A ground gas risk assessment has been undertaken for the main hazardous gases of concern (carbon dioxide and methane) and is based on the above documentation.
- 12.1.3 According to the available information, no radon protection measures are required as the site is not located within a radon affected area.
- 12.1.4 The implication for gas protection measures for hazardous gases will be discussed following the ground gas risk assessment.
- 12.1.5 The gas monitoring undertaken by ERM (2008) indicated that there were no detectable concentrations of methane and the carbon dioxide concentration was less than 5% by volume in all but one location (MW06, 11%).
- 12.1.6 Capita's Geo-Environmental Assessment and Remediation Strategy report (2014) concluded that further assessment of ground gas conditions is recommended to confirm ERM's findings.

12.2 Gas Risk Assessment

- 12.2.1 The proposed development comprises 3 business/industrial type units (labelled as A, B and C) to be located in the central part of the site. In accordance with BS8485 this end use is classed as commercial "Type D" buildings but part of the development (offices) will fall into commercial "Type C" buildings. The Type D building designation applies to large industrial estate/retail type units and Type C is for small to large offices/retail premises. The sensitivity of the development (in respect of ground gases) is considered to be low.
- 12.2.2 The potential sources for ground gas generation are listed below:
- Made ground materials on site - there is between 2-5m of made ground comprising colliery spoil and capped lagoon slurry in the central area of the development
 - Colliery spoil in mounds surrounding the development area between 12-15m high.
 - Mine shafts and adit beneath the site – potential source of mine gas but the shafts have been capped and the adit is partially filled.

- Underlying geology – superficial deposits (glacial clays).

12.2.3 Four additional rounds of gas monitoring were undertaken at the site by Capita in July, August and September 2015 to provide data for a gas risk assessment. A summary of the gas monitoring results is presented in Table 8 below:

Table 8: Summary of Gas and Groundwater Monitoring Results⁹

Well Ref.	Response Zone/ Strata (m)	Evidence of Contamination	No. of Visits	Range of Results CHG					Flow (l/hr)	Water Depth (m)	Range of Atm. Pressure (mb)
				CH ₄ (%v/v)	CO ₂ (%v/v)	O ₂ (%v/v)	H ₂ S (ppm)	PID (ppm) *			
BH101	1 – 4 Superficial deposits	None	4	0	0 – 0.2	19.1 - 20.1	0	0	0	0.78 - 0.83	991 - 1001
BH102	1 – 3.8 Superficial deposits	None	4	0	0 – 0.2	20.0 - 20.3	0	0	0 - 0.1	1.87 - 1.98	991 - 1001
BH103	1 – 3.5 Superficial deposits	None	4	0	0 – 0.2	18.7 - 21.1	0	0	0	0.1 - 0.16	991 - 1001
BH104	3 – 15 Made ground & superficial deposits	None	4	0	0.2 - 0.8	20.3 - 21.0	0	0	0 - 0.1	13.92 - 14.0	991 - 1001
BH105	2.8 – 20.8 Made ground & superficial deposits	None	4	0 - 0.1	0.1 - 1.0	19.1 - 21.2	0	0	-0.03 - 0.7	19.08 - DRY	991 - 1001
BH106	3 - 20.8 Made ground & superficial deposits	None	4	0	0.3 - 14.4	14.0 - 21.4	0 – 1	0	0 - 0.1	10.25 - DRY	991 - 1001
BH107	2 – 20 Made ground & superficial deposits	None	4	0 - 0.2	1.9 - 14.3	9.8 - 19.0	0 – 4	0	0	12.6 - DRY	991 - 1001
BH108	2 – 13.5 Made ground	None	4	0	0.5 - 4.1	17.2 - 20.5	0	0	0 - 0.1	4.03 - 5.73	991 - 1001

⁹ Values in red exceed the methane value of 1% or the Carbon dioxide value of 5% for Characteristic situation 1.

Well Ref.	Response Zone/ Strata (m)	Evidence of Contami- nation	No. of Visits	Range of Results CHG					Flow (l/hr)	Water Depth (m)	Range of Atm. Pressure (mb)
				CH ₄ (%v/v)	CO ₂ (%v/v)	O ₂ (%v/v)	H ₂ S (ppm)	PID (ppm) *			
BH109	4 – 19.5 Made ground & superficial deposits	None	4	0	0.1 - 0.7	19.6 - 21.5	0	0	0 - 0.1	8.85 - 10.47	991 - 1001
BH110	1 – 7 Made ground, superficial deposits & bedrock	None	4	0 - 0.2	0.1 - 5.8	16.1 - 21.4	0	0	0 - 0.1	6.01 - 6.31	991 - 1001
BH111	2.8 – 15.8 Made ground & superficial deposits	None	4	0 – 0.2	0.1 - 10.7	2.6 - 21.6	0 – 1	0	0 - 0.1	10.57 - 10.67	991 - 1001
BH112	1 – 7 Made ground, superficial deposits & bedrock	None	4	0 – 0.6	0.1 - 0.2	20.9 - 21.3	0	0	0 - 0.1	5.87 - 6.09	991 - 1001
BH113	2 – 5 Superficial deposits & bedrock	None	4	0	1.6 - 3.0	15.4 - 19.1	0 – 1	0	0 - 0.1	2.41 - 3.48	991 - 1001
BH114	1 – 7 Made ground, superficial deposits & bedrock	None	4	0	2.9 - 7.4	17.3 - 19.3	0	0	0 - 0.1	2.39 - 2.83	991 - 1001
BH115	1 – 4 Made ground, superficial deposits & bedrock	None	4	0	0.1 - 1.7	18.5 - 21.2	0	0	-0.01 - 0.1	1.07 - 2.21	991 - 1001
BH116	2 – 8 Made ground, superficial deposits & bedrock	None	4	0 – 0.1	2.2 - 10.2	12.4 - 19.4	0	0	0	2.65 - 3.04	991 - 1001

Well Ref.	Response Zone/ Strata (m)	Evidence of Contamination	No. of Visits	Range of Results CHG					Flow (l/hr)	Water Depth (m)	Range of Atm. Pressure (mb)
				CH ₄ (%v/v)	CO ₂ (%v/v)	O ₂ (%v/v)	H ₂ S (ppm)	PID (ppm)*			
BH117	2 – 8 Made ground & superficial deposits	None	4	46.1	36	0.3	1 – 3	0	0	3.99	991
				-	-	-			-	-	-
				52.5	43.2	2.8			0.7	4.95	1001
BH118	1 – 9.5 Made ground & superficial deposits	None	4	0 – 0.1	0.4	5.6	0 – 1	0 – 1.1	0	2.67	991
					-	-			-	-	-
					11.8	20.9			0.1	4.28	1001
BH119	1 – 5.5 Made ground, superficial deposits & bedrock	None	4	0	3.7	9.7	0	0	0	4.45	991
					-	-				-	-
					5.0	10.5				5.22	1001
BH120	2 – 5 Superficial deposits & bedrock	None	4	0 – 0.1	8.8	5.7	0	0 – 0.9	0	DRY	991
					-	-			-		-
					20.6	14.1			0.1		1001
BH121	2 – 7 Made ground & superficial deposits	None	4	0 – 0.2	1.8	1.4	0 – 1	0	0	2.3	991
					-	-			-	-	-
					14.5	19.4			0.1	DRY	1001
BH122	1 – 3 Made ground, superficial deposits & bedrock	None	4	0	0.1	2.8	0 – 1	0 – 40	0	2.30	991
				-	-	-				-	-
				23.1	11.6	20.7				DRY	1001

12.2.4 The gas monitoring data indicates elevated methane concentrations in two boreholes (BH117 & BH122) which are located under proposed Unit B and to the south of proposed Unit A respectively. BH117 recorded very high concentrations of methane during all four rounds of monitoring, between 46.1% up to 52.5% by volume. The borehole was installed within the made ground and the superficial deposits but is also located within an area containing capped lagoon slurry. At BH122 methane was detected during one monitoring only, at a concentration of 23% by volume. The borehole was installed throughout the made ground, the superficial deposits and into the bedrock.

- 12.2.5 Elevated levels of carbon dioxide were recorded in half of the monitoring wells (5% - 43.2% v/v CO₂). The highest concentration was recorded in BH117 which is also where the highest methane levels were present. The majority of the boreholes were installed across the made ground, the superficial deposits and bedrock. Elevated levels of carbon dioxide were found within the colliery mounds (lagoons 4, 6, and 7) and within or close to the areas delineated as capped slurry lagoon material (proposed unit B and part of unit A).
- 12.2.6 Considerable oxygen depletion was noted on several occasions in BH111, BH117 to BH122 corresponding to elevated carbon dioxide and methane concentrations.
- 12.2.7 Flow rates were generally negligible ranging between 0.1l/h and 0.7l/h (BH105 & BH117). A Photo Ionization Detector (PID) was used during all monitoring visits, recording detectable concentrations in three wells only (BH118, BH120 and BH122). The highest concentration recorded in each well was 1.1ppm in BH118, 0.9ppm in BH120 and 40ppm in BH122. Hydrogen sulphide was noted at very low concentrations (1-4ppm) on one or more monitoring visit in over half the holes on the site and no carbon monoxide was recorded.
- 12.2.8 The gas results have been considered altogether because the majority of the holes were installed across both the made ground and the natural ground. Only BH108 was installed solely in the made ground and BH101-103, BH113 and BH120 were installed in the superficial deposits only.
- 12.2.9 The initial gas risk assessment is based on the measured flow rates and measured hazardous gas concentrations which are used to calculate an Individual "hazardous gas flow rate" (Qhg) for each monitoring point. From this the "site characteristic hazardous gas flow rate" (Qhgs), is derived and then the "Characteristic Situation" is determined. The results are summarised in Table 9 below and a copy of the gas risk assessment charts is shown in Appendix G.

Table 9: Summary of Calculated Hazardous Gas Flow Rates and Determined Characteristic Situation

Monitoring Well	Qhg Range ⁹ for CH ₄ (l/hr)	Qhg Range ⁹ for CO ₂ (l/hr)	Max Qhgs ¹⁰	Basic Characteristic Situation	Modified Characteristic Situation ¹¹
BH101	0.0001	0.0001 - 0.0002	0.0002	1	1
BH102	0.0001	0.0001 - 0.0002	0.0002	1	1
BH103	0.0001	0.0001 - 0.0002	0.0002	1	1

¹⁰ If no flow was measured the detection limit of the flow meter (0.1l/hr) has been used to calculate the Qhgmaximum

¹¹ If the methane concentration ≥1% and carbon dioxide concentration ≥5% for a characteristic situation 1 then the characteristic situation has been increased to characteristic situation 2 in accordance with BS 8485:2015.

Monitoring Well	Qhg Range ⁹ for CH ₄ (l/hr)	Qhg Range ⁹ for CO ₂ (l/hr)	Max Qhgs ¹⁰	Basic Characteristic Situation	Modified Characteristic Situation ¹¹
BH104	0.0001	0.0002 - 0.0008	0.0008	1	1
BH105	0.0001 - 0.0007	0.0001 - 0.0042	0.0042	1	1
BH106	0.0001	0.0003 - 0.0144	0.0144	1	2
BH107	0.0001 - 0.0002	0.0019 - 0.0143	0.0143	1	2
BH108	0.0001	0.0005 - 0.0041	0.0041	1	1
BH109	0.0001	0.0001 - 0.0007	0.0007	1	1
BH110	0.0001 - 0.0002	0.0001 - 0.0058	0.0058	1	2
BH111	0.0001 - 0.0002	0.0001 - 0.0107	0.0107	1	2
BH112	0.0001 - 0.0006	0.0001 - 0.0002	0.0006	1	1
BH113	0.0001	0.0016 - 0.003	0.003	1	1
BH114	0.0001	0.0029 - 0.0074	0.0074	1	2
BH115	0.0001	0.0001 - 0.0017	0.0017	1	1
BH116	0.0001	0.0022 - 0.0102	0.0102	1	2
BH117	0.0461 - 0.3556	0.036 - 0.3024	0.3556	2	2
BH118	0.0001	0.0004 - 0.0118	0.0118	1	2

Monitoring Well	Qhg Range ⁹ for CH ₄ (l/hr)	Qhg Range ⁹ for CO ₂ (l/hr)	Max Qhgs ¹⁰	Basic Characteristic Situation	Modified Characteristic Situation ¹¹
BH119	0.0001	0.0037 - 0.005	0.005	1	2
BH120	0.0001	0.0088 - 0.0206	0.0206	1	2
BH121	0.0001 - 0.0002	0.0018 - 0.0145	0.0145	1	2
BH122	0.0001 - 0.0231	0.0001 - 0.0116	0.0231	1	2

- 12.2.10 Based on the available information the site generally falls into Characteristic Situation 2 (CS2), due to elevated CO₂ exceeding 5% in boreholes BH106, BH107, BH111, BH114, BH116 - BH122 and elevated methane in BH117. BH122 also recorded elevated methane on one monitoring visit only, with zero concentrations having been recorded during all other visits. This may therefore be an erroneous reading.
- 12.2.11 A worse case check as recommended in BS8485 has been undertaken by calculating the gas screening value (GSV) and corresponding characteristic situation based on the highest concentrations of methane and carbon dioxide recorded, and the highest flow rate recorded irrespective of the borehole and monitoring date the readings were taken. For methane the GSV is calculated to be 0.37 (based on methane of 52.5% and flow rate of 0.7l/h). For carbon dioxide the GSV is calculated to be 0.3 (based on carbon dioxide of 43.2% and flow rate of 0.7l/h). For both of these gases the worst case scenario is still CS2.
- 12.2.12 It appears that there is gas generation within the vicinity of the colliery spoil mounds to the north of Unit C. The most elevated levels of carbon dioxide and methane appear to be associated with the capped lagoon slurry material which exists in the central and southern part of the site (beneath proposed units A and B). This area is where high organic matter values were also recorded.
- 12.2.13 It is proposed to excavate the capped lagoon slurry deposits for geotechnical purposes in the central area of the site (as it forms an unsuitable founding stratum) and this may remove this source of gas.
- 12.2.14 In respect of BH122, the clayey superficial deposits may be the source of the elevated concentrations of carbon dioxide but there appears to be no obvious reason for the elevated VOC reading. This area is not located beneath any proposed buildings and no elevated VOC readings were recorded elsewhere on the site.

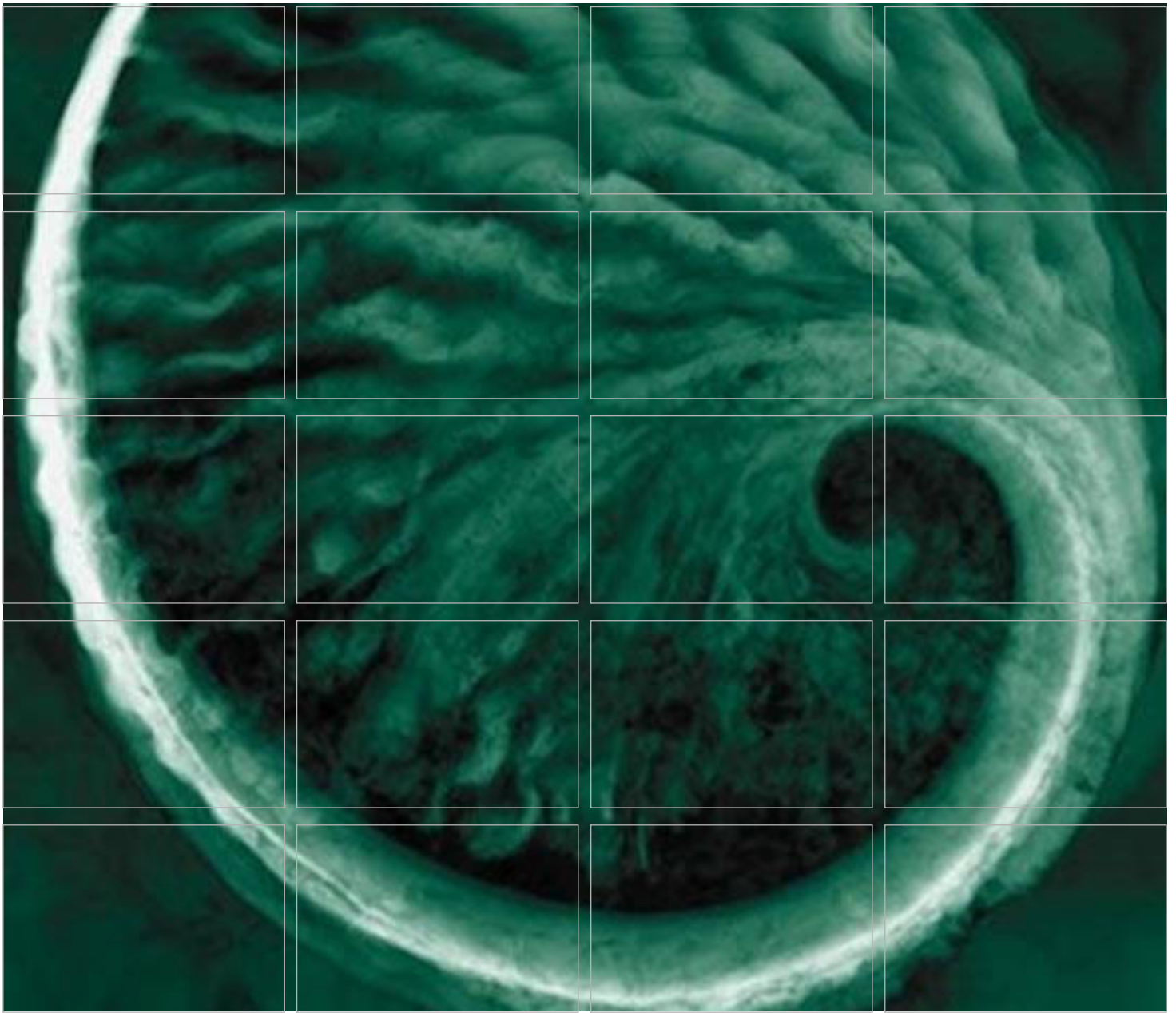
12.2.15 It is recommended that a Characteristic Situation CS2 is adopted for the whole of the site. The recommended score to be achieved by gas protection measures commensurate with this designation for Type C and Type D buildings is 2.5 and 1.5 respectively (Table 4 of BS8485 2015). This score may be achieved by a combination of gas protection measures from Tables 5, 6 and 7 in BS8485. Measures may include a combination of the following:

- Reinforced concrete suspended ground floor slab;
- Under all industrial area floors: A taped and sealed 1200g DPM installed to reasonable levels of workmanship/in line with current good practise with validation;
- Under all office/commercial area floors: A taped and sealed proprietary gas resistant membrane installed to reasonable levels of workmanship/in line with current good practise under independent inspection.

12.2.16 It should be noted that all joints and penetrations should be properly sealed. Validation of the works is necessary to ensure the effectiveness of the protection measures.

Appendix B

Extract from Capita 2015 Report



Nailstone Colliery, Leicestershire Site Investigation Report and Remedial Strategy

Final Report

March 2010

burn. Within this range there is likely to be a large number of potentially combustible materials”.

Three risk categories were therefore adopted for screening the analytical results:

- $<2 \text{ MJkg}^{-1}$: low combustion risk;
- $2 - 10 \text{ MJkg}^{-1}$: moderate combustion risk; and
- $>10 \text{ MJkg}^{-1}$: high combustion risk.

The calorific values of the seven samples representative of colliery spoil at the site were found to range between 2.995 and 3.781 MJkg^{-1} which is representative of the potential for a moderate combustion risk.

As discussed above, the calorific value test was developed to assess the energy produced by clean coal rather than *in situ* heterogeneous materials and as such may not directly predict combustion risk. Cairney and Hobson (1998)⁽¹⁾ present a detailed comparison of the various methods available to assess combustion risks. As the oxygen availability is critical to assessing fire risks in *in situ* material, the combustion potential test is suggested as a more appropriate method as it provides for control of air flow and a gradual build up of heat, therefore more closely mirroring site conditions. The authors provide details of six case studies where this test has been applied to identify areas of concern on sites where coal wastes were present. As the initial screening using calorific value testing did not indicate a low combustion risk, it is therefore recommended that additional testing be conducted within the development area utilising this test method once building footprints have been identified.

4.4.3 Soil Gas Assessment

Ground gas concentrations were assessed against the guidelines presented in CIRIA (2007)⁽²⁾. The CIRIA guidance uses both gas concentrations and borehole gas flow rates to define a characteristic situation for a site based on the limiting borehole gas volume flow for methane and carbon dioxide known as the Gas Screening Value (GSV). The GSV is calculated by multiplying the borehole flow rate (lh^{-1}) by the gas concentration.

In order to determine the limiting gas flow each location was individually assessed due to the wide spatial distribution on the site (see *Annex A* for full gas monitoring measurements). The results of the assessment are presented in *Table 4.4c*.

(1) Cairney and Hobson (Eds) (1998) Contaminated Land: Problems and Solutions, Ch7, pp158-176.

(2) CIRIA report C665 'Assessing Risks Posed by Hazardous Ground Gases to Buildings', 2007.

Table 4.4c Gas Screening Values

Location	Geology	CH ₄ (%)	CO ₂ (%)	Flow rate (Lhr ⁻¹)	GSV*	Risk class
MW01	Drift	<0.1	<0.1	0.4	0	Very low
MW02	Drift	<0.1	<0.1	1.1	0	Very low
MW03	Drift	<0.1	0.2	1	0.002	Very low
MW04	Drift	<0.1	0.3	1.2	0.0036	Very low
MW05	Made Ground	<0.1	1.3	0.9	0.0117	Very low
MW06	Made Ground	<0.1	11.9	0.9	0.1071	Low
MW07	Drift	<0.1	1.5	0.8	0.012	Very low
MW08	Made Ground	<0.1	0.6	0.8	0.0048	Very low
MW09	Drift	<0.1	0.2	0.8	0.0016	Very low
MW10	Drift	<0.1	3.5	0.7	0.0245	Very low
MW11	Made Ground	<0.1	0.5	0.9	0.0045	Very low

* - based on CO₂ concentration

MW06 had the highest calculated GSV based on one round of monitoring that was undertaken under falling pressure conditions. Based on one round of monitoring, risk classifications were determined to be 'very low' in both monitoring wells screened in natural strata and in areas of Made Ground, with the exception of MW06 which was classified as 'low'. Based on this data, no special precautions would therefore be recommended for protecting buildings from gas risks although further rounds of monitoring in line the requirements of CIRIA (2007) will be required prior to redevelopment. Furthermore, the Mercia Mudstone strata would be likely to form an effective barrier to the migration of any gases potentially generated from the disused mine workings at depth.

Samples were submitted to the laboratory for analysis on a standard 10-day turnaround. Groundwater samples were submitted for a range of analyses:

- pH
- Metals (As, Cd, Cu, Cr, Pb, Hg, Ni, Se, Zn)
- Inorganic parameters (chloride, chloride, cyanide, sulphide and sulphate)
- Total petroleum hydrocarbons with TPHCWG carbon banding (TPH)
- Polycyclic Aromatic Hydrocarbons (PAHs) (USEPA 16 suite)
- Phenols

A1.5

SOIL GAS MONITORING

Measurements of the gas flow rate, atmospheric pressure and concentrations of oxygen, hydrogen sulphide, methane, carbon dioxide and carbon monoxide were recorded at each of the 11 installations using a portable GA2000 soil gas monitor. Soil gas monitoring results are presented in *Table A15a*. All soil gas sampling was completed on 27 December 2008 and an atmospheric pressure falling from 992 to 988 mb was recorded during this monitoring event. Soil gas flow rates ranged between 0.4 and 1.2 Lhr⁻¹.

Table A1.5a Soil Gas Monitoring Results

Location	Geology	CH ₄ (%)	O ₂ (%)	CO ₂ (%)	H ₂ S (ppm)	CO (ppm)	Flow / Lhr ⁻¹
MW01	Drift	<0.1	21.0	<0.1	<0.1	<0.1	0.4
MW02	Drift	<0.1	21.1	<0.1	<0.1	<0.1	1.1
MW03	Drift	<0.1	21.0	0.2	<0.1	<0.1	1.0
MW04	Drift	<0.1	20.8	0.3	<0.1	<0.1	1.2
MW05	Made Ground	<0.1	19.7	1.3	<0.1	<0.1	0.9
MW06	Made Ground	<0.1	3.9	11.9	<0.1	<0.1	0.9
MW07	Drift	<0.1	20.4	1.5	<0.1	6	0.8
MW08	Made Ground	<0.1	20.8	0.6	<0.1	<0.1	0.8
MW09	Drift	<0.1	21.0	0.2	<0.1	<0.1	0.8
MW10	Drift	<0.1	19.2	3.5	<0.1	1	0.7
MW11	Made Ground	<0.1	20.9	0.5	<0.1	2	0.9

Generally the recorded gas concentrations are indicative of atmospheric concentrations. Oxygen levels of 19.2 and 21.1% were measured in all wells with the exception of MW06, where a reduced concentration of 3.9% was recorded. Carbon dioxide levels were generally low, ranging between <0.1 and 3.5%, with the exception of MW06 where an elevated concentration of 11.9% was recorded. Neither methane nor hydrogen sulphide were measured in any of the wells. Monitoring generally did not indicate elevated concentrations of gas with the exception of MW06 where reduced oxygen and elevated carbon dioxide were recorded.

Appendix C

Extract from Earth Environmental 2025 Report



EARTH ENVIRONMENTAL
& GEOTECHNICAL
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PHASE II GROUND
INVESTIGATION REPORT

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REPORT REF: R5322/26/Rev1

JANUARY 2026

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5.0 GROUND GAS CONTAMINATION RISK ASSESSMENT

A ground gas risk assessment has been completed for the assessment site based on monitoring data collected from the installations constructed as part of the recent ground investigation works. Monitoring wells were installed in WS1, WS2, WS3A, WS4A, WS5, WS7, WS8, WS9 and WS10 with response zones placed with the shallow underlying Made Ground or Natural Oadby Member.

A total of four full rounds of ground gas monitoring were completed between the 30th of October 2025 and the 11th of December 2025, with an additional round of monitoring undertaken from WS9 on the 18th of December 2025 (due to this location being obstructed on previous rounds). Wherever possible, monitoring rounds were targeted to coincide with falling atmospheric pressure events. Detailed results from the monitoring are provided within Appendix 2.

During monitoring the atmospheric pressure was recorded as between 984-1000mb and the following ranges of gas concentrations were identified: Oxygen (O₂) levels ranging from 8.3 – 20.8% by volume, 0% Methane (CH₄), Carbon Dioxide (CO₂) levels ranging from <0.1-4.6% by volume.

Photoionization Testing did not detect any VOC concentrations above the units limit of detection during monitoring.

Ground gas flow rates were also recorded; however, a general lack of flow was noted across all of the rounds of monitoring. A single elevated flow rate of 0.3l/hr was noted in WS7 during the second round of monitoring. During all other monitoring rounds, and at all other locations, no flow rates above the equipment limit of detection (0.1l/hr) was noted.

Elevated concentrations of Carbon Monoxide (CO) were identified ranging from <1.0-1360ppm and Hydrogen Sulphide (H₂S) ranging from <1.0-5190ppm.

When reviewing the elevated levels of H₂S during the third and fourth rounds, EEGSL concluded that it was unlikely that H₂S could have been present at such concentrations, and that either an instrument malfunction had occurred, or false readings were being generated by another gas present but not detected. At the time of the monitoring, EEGSL were not aware that the site had previously been in use as a colliery. Further ground investigation works have since been discussed with the client and are planned to be completed in January 2026. The risk associated with H₂S and CO will therefore be completed separately.

For the remainder of this assessment, the risks posed by Methane (CH₄) and Carbon Dioxide (CO₂) will be assessed and discussed in line with guidance set out within BS8485.

The potential risk associated with ground gases (whether from natural or man-made sources) is dependent on the concentration of gas and its flow rate to the surface. These factors are assessed by the monitoring of borehole installations over varying atmospheric conditions. The variable nature of gas generation and the effect of barometric pressure on gas flow, means that the volume of gas potentially reaching the ground surface can vary over time.

For the assessment of development sites, in terms of the potential for ground gas to present a hazard, the risk-based methodology detailed in BS8485 has been used. This is a risk-based approach that is intended to allow the design of gas protection measures for development by comparing hazardous gas flow rates (Qhgs) to Characteristic Situations as detailed within Table

1 of BS8485 (reproduced in Table 3 for reference). The Qhgs are calculated as the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered.

For the purposes of this evaluation, the calculations will be carried out for both Carbon Dioxide (CO₂) and Methane (CH₄). From the monitoring works the flow rate and gas concentration in each borehole from each round has been used to calculate Qhgs for each individual borehole for Carbon Dioxide and Methane. This analysis will give the best representative assessment of the risks posed by ground gasses at the assessment site. A table summarising the Qhgs and the associated Characteristic Situations is presented in Table 2.

Table 2: Ground Gas Risk Screening Table

Monitoring Round	Ground Gas data	WS1	WS2	WS3A	WS4A	WS5	WS7	WS8	WS9	WS10
1	Max Flow	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max CO2	1.0	2.6	<0.1	<0.1	<0.1	0.6	3.9	<0.1	0.3
	Max CH4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Qhgs CO2	0.001	0.0026	0.0001	0.0001	0.0001	0.0006	0.0039	0.0001	0.0003
	Qhgs CH4	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	Characteristic Situation	1	1	1	1	1	1	1	1	1
2	Max Flow	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	N/A	<0.1
	Max CO2	1.1	3.4	<0.1	<0.1	<0.1	0.2	1.9	N/A	<0.1
	Max CH4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	N/A	<0.1
	Qhgs CO2	0.0011	0.0034	0.0001	0.0001	0.0001	0.0006	0.0019	N/A	0.0001
	Qhgs CH4	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.0001	N/A	0.0001
	Characteristic Situation	1	1	1	1	1	1	1	N/A	1
3	Max Flow	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	N/A	<0.1
	Max CO2	1.1	3.5	<0.1	<0.1	<0.1	0.4	4.5	N/A	0.2
	Max CH4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	N/A	<0.1
	Qhgs CO2	0.0011	0.0035	0.0001	0.0001	0.0001	0.0004	0.0045	N/A	0.0002
	Qhgs CH4	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	N/A	0.0001
	Characteristic Situation	1	1	1	1	1	1	1	N/A	1
4	Max Flow	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1*	WF
	Max CO2	0.6	3.5	<0.1	<0.1	<0.1	0.2	4.6	<0.1*	WF
	Max CH4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1*	WF
	Qhgs CO2	0.0006	0.0035	0.0001	0.0001	0.0001	0.0002	0.0046	0.0001*	WF
	Qhgs CH4	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001*	WF
	Characteristic Situation	1	1	1	1	1	1	1	1*	WF

N/A – Well inaccessible WF – Well Flooded with water. * Round 5 data due to the hole not being accessible in Round 4.