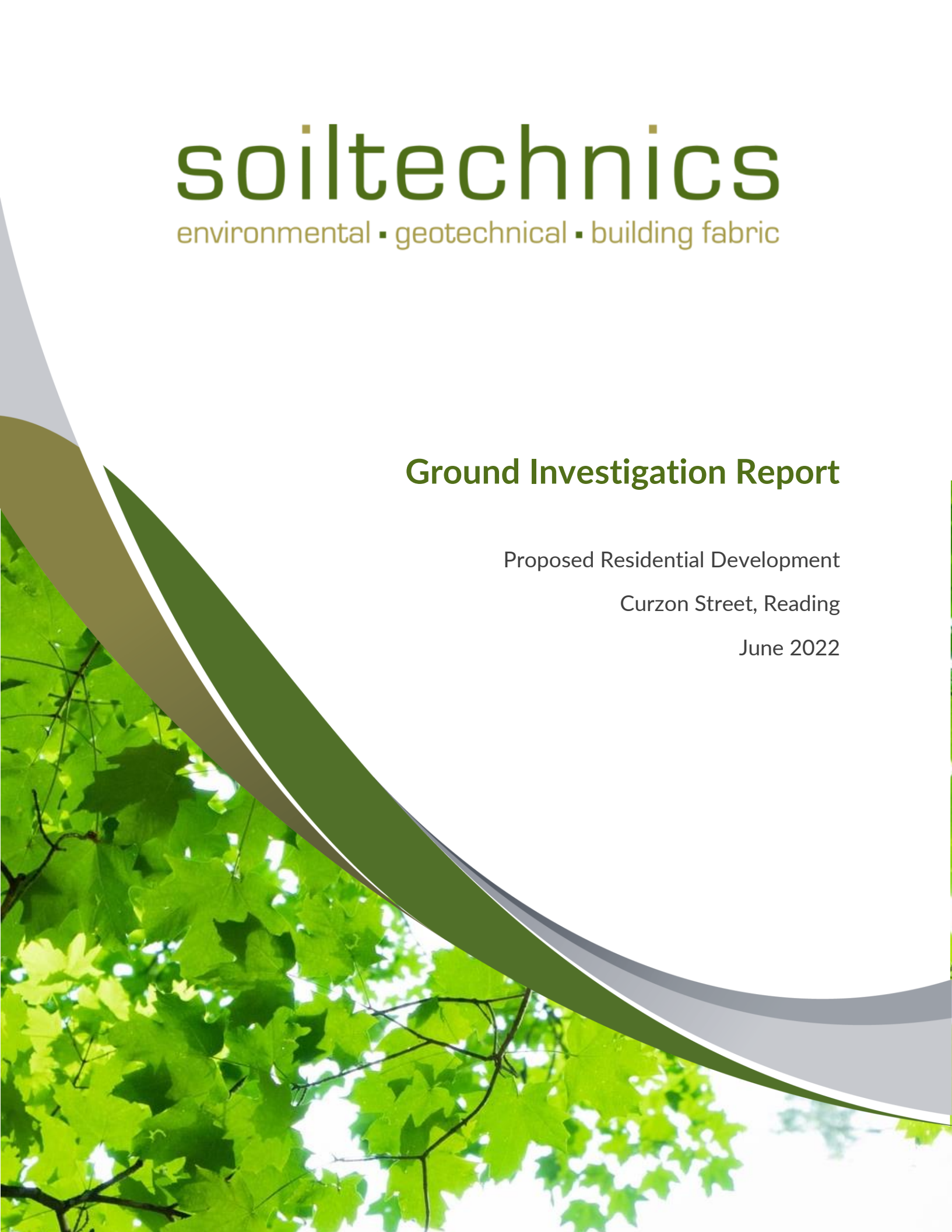




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Ground Investigation Report

Proposed Residential Development

Curzon Street, Reading

June 2022

Project Details

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1 Introduction

1.1 Scheme Outline

1.1.1 The proposed development includes a multi-storey residential building, holding between 26 and 28 residential units with associated car parking.

1.1.2 The approximate postal address is as follows:

Curzon Street,
Reading,
RG30 1DB.

1.1.3 We understand the proposed development is controlled under planning application reference 211787, by Reading Borough Council.

1.1.4 The report is based on the project proposals and information outlined above; should the scheme change then it will be necessary to review the conclusions and recommendations presented in this report.

1.2 Brief

1.2.1 This report has been prepared following instructions received from QED Structures Ltd, on behalf of our client, CBG Construction Ltd. The overall brief of works is to:

- i) Undertaking a supplementary phase of ground investigation works to investigate the risk of ground gases to the proposed development.
- ii) Support the planning application by assessing whether ground gas protection measures are required, or if the ground gases pose a minimal risk to the development.

1.2.2 The ground investigation works were carried out in general accordance with the recommendations outlined in the following documents.

Title	Document Reference	Publisher	Investigation Phase
Code of practice for ground investigations	BS 5930: 2015	British Standards Institution	Phase 2: Preliminary investigation
Investigation of potentially contaminated sites – Code of practice	BS 10175: 2011+A2:2017	British Standards Institution	Supplementary Investigation
Guidance on investigations for ground gas – Permanent gases and VOCs	BS 8576:2013	British Standards Institution	Investigation

Table 1-1: Summary of fieldwork undertaken

1.2.3 The objectives of the investigation are outlined below:

- i) Undertake intrusive ground investigation works to confirm the underlying ground conditions.
- ii) Install shallow ground gas monitoring wells.
- iii) Conduct a ground gas monitoring programme.
- iv) Complete a ground gas risk assessment and provide recommendations for the development.

1.3 Soiltechnics liability

- 1.3.1** Soiltechnics disclaims any responsibility to our Client and others in respect of any matters outside the scope of this report. This report has been prepared with reasonable skill, care and diligence in accordance with the terms of our contract, taking account of the manpower, resources, investigations and testing devoted to it by agreement with our Client. This report is confidential to our Client and Soiltechnics accepts no responsibility of whatsoever nature to third parties to whom this report or any part thereof is made known. Any such party relies upon the report at their own risk.

2 Desk Study

2.1 Site Description

2.1.1 The proposed development lies within Reading, approximately 1.5km west of the town centre and 300m northeast of Kensington Park. The site is accessed from Curzon Street which lies adjacent to the site's northern boundary.

2.1.2 An aerial image showing the approximate site boundary is presented below.



Figure 1: Aerial photograph and approximate site boundary

2.2 Previous Reports

2.2.1 Soiltechnics are aware of two previous ground investigation reports which have been undertaken at the site, as summarised below.

Author	Document Title	Date & Document Reference	Report Context
Phlorum Limited	Phase 1 desk study report	9879, September 2020	A Preliminary Risk Assessment for the proposed development.
ST Consult	Phase II Site Investigation & Risk Assessment Report	JT0420, August 2021	A geotechnical and geoenvironmental investigation for the proposed development. The scope of works excluded a ground gas risk assessment.

Table 2-1: Summary of previous reports

2.2.2 The desk study did not identify any potential land gas sources in the form of landfill sites within 250m of the site.

2.2.3 The intrusive investigation works undertaken by ST Consult comprised of 7 exploratory location. No visual or olfactory evidence of petroleum hydrocarbon contamination was at the site; however, Made Ground was encountered up to 3m in thickness.

2.2.4 Due to the depth of Made Ground deposits, the potential risk from ground gases could not be discounted, and therefore the report recommended ground gas monitoring is carried out targeting the Made Ground material, in order to refine the risk assessment.

3 Ground Investigation

3.1 Objectives

3.1.1 The ground investigation scope and location of exploratory holes was determined by Soiltechnics Ltd, based upon our overall brief and findings of the previous ground investigation report.

3.1.2 The objectives of the fieldwork were to:

- a) Confirm the underlying ground conditions.
- b) Install ground gas monitoring wells and undertake a programme of monitoring visits.

3.2 Fieldwork summary

3.2.1 Fieldwork was undertaken on the 10th May 2022. The works are summarised below and the exploratory logs are presented within Appendix A.

Method	Qty	Final Depth Range (m bgl)	Comments
Dynamic windowless sampling boreholes	3	3.00	WS01 to WS03 Boreholes terminated at scheduled depth.

Table 3-1: Summary of fieldwork undertaken

3.2.2 All soils encountered were described in accordance with BS EN ISO 14688 "Identification and Classification of soil". Rock was described in accordance with BS EN ISO 14689 "Identification and classification of rock".

3.2.3 An exploratory hole location plan is presented below.



Figure 2: Approximate Exploratory Hole Location Plan

3.3 Unexploded Ordnance (UXO)

3.3.1 To support the ground investigation works, CBG Construction Ltd requested a UXO Pre-Desk Study Assessment to be undertaken by Zetica Ltd.

3.3.2 The risk assessment concluded that no special precautions were required.

3.4 Monitoring Installations

3.4.1 Instrumentation installed within exploratory holes during the fieldwork are shown on the logs within Appendix A and are summarised below:

Installation type	Target Stratum	Qty	Exploratory hole ID
Gas monitoring well	Made Ground	3	WS01 to WS03

Table 3-2: Summary of monitoring installations

3.5 Monitoring visits and groundwater sampling

3.5.1 A summary of the gas and groundwater spot monitoring visits undertaken is outlined in the table below. Results of the post fieldwork monitoring are presented in Appendix B.

3.5.2 Overall, four ground gas monitoring visits were undertaken over a period of 4 weeks.

Date	Purpose
26/05/2022	Gas and groundwater spot monitoring
01/06/2022	
09/06/2022	
13/06/2022	

Table 3-3: Summary of post fieldwork spot monitoring

3.6 Investigation Constraints

3.6.1 No significant investigation constraints were encountered.

4 Ground Investigation Findings

4.1 Ground Model

- 4.1.1 Ground conditions encountered were relatively consistent across the site and were broadly in line with those anticipated from the previous ground investigation report.
- 4.1.2 The tables below present our generalised interpretation of geological conditions at the site based on the findings of both ground investigation phases.
- 4.1.3 Where relevant, further detail about the ground conditions encountered is provided in the relevant sub-sections below.

Stratum	Brief description	Top depth range (m bgl)	Adopted modelled top depth (m bgl)
Made Ground	Granular and cohesive fill.	1.20m to 3.00m	2.60m
Taplow Gravel	Sands and gravels	1.20m to 2.60m	2.60m
White Chalk Sub Group	Structureless chalk	8.00m to 12.00m	8.00m

Table 4-1: Ground Model

- 4.1.4 The Taplow Gravels intermittently underlay the Made Ground in some of the exploratory hole locations. However, the sands and gravels were observed to be absent in places, in which case the Made Ground was directly overlying the chalk.
- 4.1.5 At the time of the previous ground investigation, the standing groundwater level was noted to be lying at approximately 3.00m, though it was acknowledged seasonal variations would occur.

4.2 Made Ground

- 4.2.1 The Made Ground was generally found to be a granular strata of brown sands and gravels comprised of stone, brick, concrete and ceramic fragments. Occasionally inclusions of glass, ash, plastic and metal were also observed.
- 4.2.2 Clay fill soils were also encountered with similar anthropogenic inclusions.
- 4.2.3 The organic content of the Made Ground materials relatively low, with little putrescible material. Except for BH01 and BH02 in the original ground investigation phase which encountered an organic rich clay strata at depth of between 1.0 and 2.4m (BH01) and 0.8m to 1.6m (BH02).

5 Ground Gas Risk Assessment

5.1 Objectives

- 5.1.1 The objective of this ground gas risk assessment is to identify whether a potential ground gas contaminant linkage is present which could pose a risk to the proposed development.

5.2 Ground Gas Monitoring

- 5.2.1 3 gas monitoring wells were installed at the site, and a total of 4 visits were undertaken over a period of 4 weeks.

- 5.2.2 A summary of the gas monitoring results follows, with the full results detailed within Appendix B.

- Gas flow rates were detected up to 0.2 l/hr, and were generally observed at the limit of detection (0.1 l/hr).
- Steady concentrations of methane were recorded at or below the limit of detection of 0.1%.
- Steady concentrations of carbon dioxide ranged from between 15.4% and 21.3% within WS01 and WS02. Levels were below 5% in WS03.
- Where elevated levels of carbon dioxide were detected, a corresponding decrease of oxygen was observed, with levels below 5% in WS01 and WS02.

5.3 Updated Ground Gas Risk Assessment

- 5.3.1 Ground gas sources which were identified in the previous ground investigation report as potentially posing an unacceptable risk to development were as follows:

- Moderately thick Made Ground deposits (generally 2m to 3m)

- 5.3.2 All gas monitoring wells were installed within the Made Ground, and WS01 and WS02 also targeted BH01 and BH02, where some organic-rich material was observed in the previous ground investigation. It should be noted that whilst conducted in the same area, organic-rich materials were not observed.

- 5.3.3 Elevated levels of CO₂ and depleted oxygen have been detected in the two ground gas monitoring wells which were targeting organic-rich Made Ground. However, no elevated flow rates were detected.

- 5.3.4 Based on the CSM and observations of the ground conditions, it is suspected that the elevated carbon dioxide levels are likely to be arising from both, or one of the two following ground gas sources:

- Microbial respiration of organic matter in soils;
- Natural geochemical processes associated with the high carbonate content of chalk.

- 5.3.5 To support the discussion, we have utilised a ternary plot, see below. The use of ternary plots are outlined within the publication produced by Wilson S, Collins F and Lavery R (2018) 'Using ternary plots for interpretation of ground gas monitoring results'.

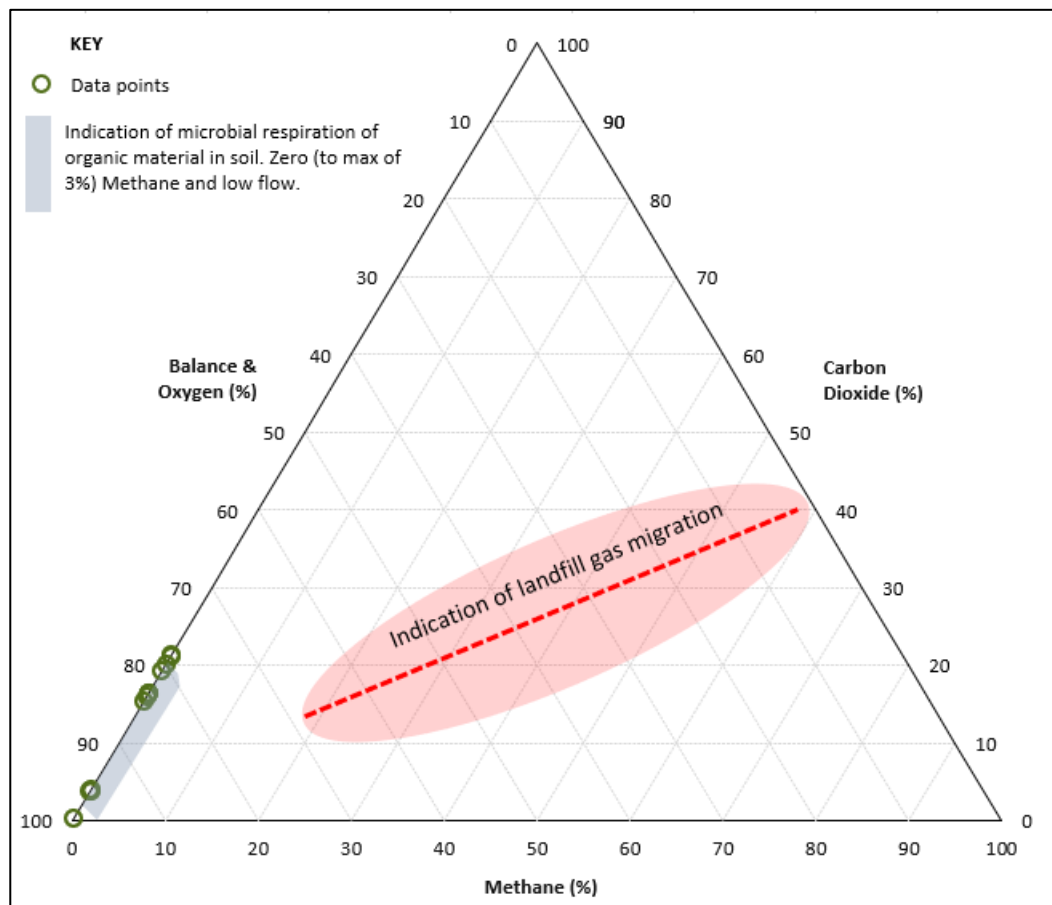


Figure 3: Ternary Plot, based on a Wilson, Collins and Lavery publication, 2018.

- 5.3.6 Where aerobic biological respiration oxidises organic material, oxygen is consumed and as the oxygen concentration reduces, the carbon dioxide concentration increases in the same proportion. The zone this occupies on the ternary plot above is depicted as the blue transparent area i.e. microbial respiration of organic material, minimal methane and low flow.
- 5.3.7 The 2018 technical paper indicates that microbial respiration of soils with a relatively low organic content can lead to carbon dioxide concentrations up to 21% v/v, and methane concentrations of up to around 3%, with minimal active gas generation. In such cases, the ground gases would be generated so slowly that it will not be emitted from the ground surface at a rate that is sufficient to pose a risk to an overlying development.
- 5.3.8 Similarly, the CL:AIRE RB17 document entitled '*A Pragmatic Approach to Ground Gas Risk Assessment*', highlights that elevated carbon dioxide levels can occur where chalk is encountered; however, this does not pose a risk to the development.
- 5.3.9 In both possible scenarios, the overall gas generation potential is low, and gas would not be expected to be generated at significant volume, thereby creating a pressure-driven flow pathway.

- 5.3.10 There are three main migration mechanisms to consider in ground gas risk assessment, specifically diffuse flow, pressure driven flow, and expansion of gas. Pressure driven flow is not plausible for the site given the reasons provided above and for gas expansion to be a viable migration mechanism, a large reservoir of gas and open pathway would need to exist, such as a worked coal seam.
- 5.3.11 In all of the gas monitoring visits undertaken gas flow rates were negligible. As no active gas generating sources have been identified, and based on the site's geological setting, diffusion is considered the primary gas migration pathway at the site.
- 5.3.12 The 2019 technical paper '*Risk and reliability in gas protection design – 20 years on*' (Card, Lucas, Wilson) further expands on this by stating '*when gas flow is by diffusion there is no unsafe concentration in the ground*'. This is due to the fact ground gases, even if present at elevated levels in the ground, will never migrate at a rate fast enough to create harmful concentrations within a structure.
- 5.3.13 Due to the absence of a significant actively generating ground gas source and open migration pathway, it is considered very unlikely that ground gases could migrate into the proposed structures on site at sufficient speed and volume to pose any viable risk.

5.4 Characteristic Gas Situation

- 5.4.1 Using test data obtained to date, and with reference to the conceptual site model and BS 8485, the site should be classified as Characteristic Gas Situation CS-1.

5.5 Gas Protection Measures

- 5.5.1 The installation of ground gas protections measures is not required.

Appendix A Exploratory Hole Records

Key to legends

Composite materials, soils and lithology					
	Topsoil		Made Ground		Boulders
	Clay		Coal		Cobbles
	Gravel		Limestone		Mudstone
	Sand		Sandstone		Silt
					Siltstone
					Chalk
					Concrete
					Peat

Note: Composite soil types are signified by combined symbols.

Key to 'test results' and 'sampling' columns

Test result		Sampling	
Depth	Records depth that the test was carried out (i.e.: at 2.10m or between 2.10m and 2.55m)	From (m) To (m)	Records depth of sampling
Result	PP – Pocket penetrometer result reported as an equivalent undrained shear strength (kN/m ²) by applying a factor of 50.		D Disturbed sample
	SV – Hand held shear vane result reported as an undrained shear strength (kN/m ²). Where multiple readings are taken at the same level the average value is shown on the log. * Signifies that instrument limit reached.		B Bulk disturbed sample
	SPT – Standard Penetration Test result (N value) (uncorrected) ^{1,2,3} SPT(c) – Standard Penetration Test result (solid cone) (N value) (uncorrected) ^{1,2,3}		ES Environmental sample
	UT – Undisturbed sample 100mm diameter sampler with number of blows of driving equipment required to obtain sample	Type	W Water sample
			U Undisturbed thick-walled sample 100mm diameter sampler
			UT Undisturbed thin walled sample 100mm diameter sampler
			UTF Failed undisturbed sample

Water observations

Described at foot of log and shown in the 'water strike' column.

-  Water level observed after specified delay in drilling
-  Water strike

Installation details

	Gravel filter		Bentonite
	Slotted pipe		Unslotted pipe
	Arisings		Grout
	Extensometer magnet		Vibrating wire piezometer

Density

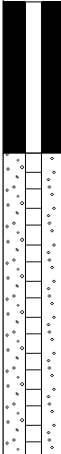
Density recorded in brackets determined by qualitative field assessment or inferred from density testing and soil descriptions from across the site (i.e.: [Medium dense]).

INSTALL	STRATA				WATER STRIKES	SPT TESTING				OTHER IN SITU TESTING		SAMPLING		
	DESCRIPTION	DEPTH (m)	REDUCED LVL (m OD)	LEGEND		TYPE / DEPTH (m)	RESULT	CASING DEPTH (m)	WATER LEVEL (m)	TYPE / DEPTH (m)	RESULT	FROM (m)	TO (m)	TYPE
	Grass onto brown slightly sandy GRAVEL of fine to coarse subrounded to angular flint, chalk and brick with occasional rootlets. (TOPSOIL - MADE GROUND)	0.20												
	Dark brown slightly gravelly clayey SAND. Gravel is fine to coarse subrounded to angular brick, asphalt, flint and ash. (MADE GROUND)													
	...from 0.8m depth, grading to gravel, with frequent flint.													
		1.50												
	Very soft to firm brown slightly gravelly slightly sandy CLAY. Gravel is fine to coarse flint, chalk and ash. (MADE GROUND)													
	Structureless CHALK composed of off-white slightly gravelly slightly sandy silt. Gravel is very weak and low density. (SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION - Grade Dm)	2.65												
	...at 2.7m depth, cobble of flint.	3.00												
	BOREHOLE TERMINATED AT 3.00m													

Notes Borehole terminated at scheduled depth.	Title Dynamic windowless sampling record			Date(s) 10/05/2022	
	Recovery details		Method Windowless sampler	Logged by SH	Sheet number Sheet 1 of 1
	Range (m)	Recovery (%)			
Groundwater observations No groundwater encountered.	0.00 - 1.00	100	Level (m OD) -	Compiled by KD	Revision 0
	1.00 - 2.00	50			
	2.00 - 3.00	70	Co-ordinates -	Checked by MOH	WS01

INSTALL	STRATA				WATER STRIKES	SPT TESTING				OTHER IN SITU TESTING		SAMPLING		
	DESCRIPTION	DEPTH (m)	REDUCED LVL (m OD)	LEGEND		TYPE / DEPTH (m)	RESULT	CASING DEPTH (m)	WATER LEVEL (m)	TYPE / DEPTH (m)	RESULT	FROM (m)	TO (m)	TYPE
	Grass onto light brown gravelly SAND. Gravel is fine to coarse subrounded to angular flint, chalk, timber and brick. (TOPSOIL - MADE GROUND)	0.30												
	Brownish grey slightly gravelly clayey SAND. Gravel is fine to coarse subrounded to angular flint, brick, concrete, ash and mudstone. (MADE GROUND)													
	Firm dark grey slightly gravelly CLAY. Gravel is fine to coarse subrounded to angular ceramic, flint, chalk, shell fragments and glass. (MADE GROUND)	1.30												
	Dark brown SAND. (TAPLOW GRAVEL MEMBER)	2.40												
	Firm brown slightly gravelly CLAY. Gravel is medium to coarse subrounded to angular flint. (TAPLOW GRAVEL MEMBER)	2.80												
	BOREHOLE TERMINATED AT 3.00m													

Notes Borehole terminated at scheduled depth.	Title Dynamic windowless sampling record			Date(s) 10/05/2022	
	Recovery details		Method Windowless sampler	Logged by SH	Sheet number Sheet 1 of 1
	Range (m)	Recovery (%)			
	0.00 - 1.00	100	Level (m OD) -	Compiled by KD	Revision 0
	1.00 - 2.00	90			
Groundwater observations No groundwater encountered.	2.00 - 3.00	80	Co-ordinates -	Checked by MOH	WS02

INSTALL	STRATA				WATER STRIKES	SPT TESTING				OTHER IN SITU TESTING		SAMPLING		
	DESCRIPTION	DEPTH (m)	REDUCED LVL (m OD)	LEGEND		TYPE / DEPTH (m)	RESULT	CASING DEPTH (m)	WATER LEVEL (m)	TYPE / DEPTH (m)	RESULT	FROM (m)	TO (m)	TYPE
	Grass onto gravelly SAND. Gravel is fine to coarse subrounded to angular chalk, flint and timber. (TOPSOIL - MADE GROUND)	0.20												
	Firm brown slightly sandy gravelly CLAY. Gravel is fine to coarse subangular brick, chalk, mudstone and ash. Occasional cobbles of brick encountered. (MADE GROUND)													
	Structureless CHALK composed of off-white slightly gravelly slightly sandy silt. Gravel is very weak and low density. (SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION - Grade Dm)	1.90												
	BOREHOLE TERMINATED AT 3.00m	3.00												

Notes Borehole terminated at scheduled depth.	Title Dynamic windowless sampling record			Date(s) 10/05/2022	
	Recovery details		Method Windowless sampler	Logged by SH	Sheet number Sheet 1 of 1
	Range (m)	Recovery (%)			
	0.00 - 1.00 1.00 - 2.00 2.00 - 3.00	90 90 90	Level (m OD) - Co-ordinates -	Compiled by KD Checked by MOH	Revision 0 WS03

Groundwater observations
No groundwater encountered.

Appendix B Ground Gas Monitoring Results

Ground gas and groundwater monitoring results

Notes

- 1) The instrument limit of detection has been adopted where no gas flows or concentrations have been recorded (indicated in grey italics).
2) Atmospheric temperature (*) data sourced from local weather station data.
3) CH4 = methane; CO2 = carbon dioxide; O2 = oxygen; PPM = parts per million CO = carbon monoxide; H2S = hydrogen sulphide.
4) Gas Screening Values (GSVs) are rounded to 3 decimal places.

Worst case scenario									<0.1	0.2	<0.1	21.7	21.3	0.1	0.1	2	1	0.00	0.00	0.00	0.00	TWO	
Average scenario									<0.1	<0.1	<0.1	13.5	13.2	7.2	7.5	1	1	0.00	0.00	-0.01	-0.01	TWO	
Date	Time	Location	Install Reference	Install Response Zone		Atmospheric Pressure (mB)	Atmospheric Temperature (°C) *	Depth to Water (m)	Gas Steady Flow	CH ₄ (%v/v)		CO ₂ (%v/v)		O ₂ (%v/v)		Other Gases (PPM)		GSV (CH ₄)		GSV (CO ₂)		Indicative CIRIA Characteristic Situation	Notes
				Response Zone (mBGL)	Flooded				l/Hr	Peak	Steady	Peak	Steady	Minimum	Average	CO	H ₂ S	Peak	Steady	Peak	Steady		
26/05/2022	13:26	WS01	1	1.00 - 3.00	No	1019	19	Dry	-0.1	<0.1	<0.1	15.4	15.4	4.9	4.9	1	1	<0.001	<0.001	0.013	0.013	ONE **	** Futher consideration requiried due to elevated CO2
01/06/2022	14:09				No	1014	17	Dry	<0.1	<0.1	<0.1	16.5	16.4	3.6	3.6	1	1	<0.001	<0.001	0.014	0.014	ONE **	
09/06/2022	12:08				No	1013	18	Dry	<0.1	<0.1	<0.1	16.6	16.0	4.1	4.5	1	1	<0.001	<0.001	0.014	0.013	ONE **	
13/06/2022	11:44				No	1023	18	Dry	-0.1	0.2	<0.1	17.5	16.4	3.3	3.5	1	1	<0.001	<0.001	0.015	0.014	ONE **	
26/05/2022	13:44	WS02	1	1.00 - 3.00	No	1019	19	Dry	<0.1	<0.1	<0.1	19.8	19.2	1.4	1.9	1	1	<0.001	<0.001	0.017	0.016	ONE **	
01/06/2022	14:20				No	1014	17	Dry	<0.1	<0.1	<0.1	20.1	20.1	1.1	1.1	1	1	<0.001	<0.001	0.017	0.017	ONE **	
09/06/2022	12:22				No	1013	18	Dry	<0.1	<0.1	<0.1	21.7	21.3	0.2	0.2	2	1	<0.001	<0.001	0.018	0.018	ONE **	
13/06/2022	12:03				No	1023	19	Dry	<0.1	<0.1	<0.1	21.5	21.2	0.1	0.1	1	1	<0.001	<0.001	0.018	0.018	ONE **	
26/05/2022	13:58	WS03	1	1.00 - 3.00	No	1019	19	Dry	<0.1	<0.1	<0.1	0.5	0.4	18.9	19.9	1	1	<0.001	<0.001	0.000	0.000	ONE	
01/06/2022	14:31				No	1014	17	Dry	<0.1	<0.1	<0.1	3.8	3.8	17.0	17.1	1	1	<0.001	<0.001	0.003	0.003	ONE	
09/06/2022	12:35				No	1013	19	Dry	-0.1	<0.1	<0.1	4.1	4.1	14.5	16.6	1	1	<0.001	<0.001	0.003	0.003	ONE	
13/06/2022	12:16				No	1023	19	Dry	-0.2	<0.1	<0.1	4.0	3.9	16.8	16.8	0	1	<0.001	<0.001	0.007	0.007	ONE	